Governance processes and sustainability impacts of the extractive industries: Generating transformation knowledge in the biodiversity hotspot of Madagascar

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Executive Summary

The legal and policy framework governing Environmental and Social Impact Assessments (ESIAs) plays a crucial role in identifying, assessing, and mitigating potential environmental and social impacts of large-scale extractive investments (LEIs). Although the current framework in Madagascar (as of 31 December 2022) demonstrates many strengths, it also has limitations that hinder the industry's contribution to sustainable development. To address these limitations, we propose several key actions: eliminating or reducing the scope of stabilization clauses, centralizing the technical advice from the National Office for the Environment in the licensing process, making environmental permits mandatory for operating permit applications, and strengthening inclusive public involvement throughout the ESIA process.

Additionally, we discovered a discrepancy between theory and practice within ESIA governance, where theory emphasizes central governance while practice exhibits more decentralized approaches. This misfit reveals power dynamics and shifts among the actors governing extractive industries in Madagascar. For instance, mining companies might prioritize voluntary activities over mandatory ones. Our research used agency and social network analysis to identify potential agents of change within the mining sector, highlighting mining companies and government representatives as key players. The former possesses resources and a high relational profile, while the latter demonstrates sustainability aims, has a relational profile, but lacks resources.

The impacts on land use, livelihoods, wellbeing, and security were predominantly perceived as negative by smallholder farmers and agropastoralists surveyed. Pollution from mining sites, primarily operational areas, led to reduced access to water and fish resources. Dam breach modeling near Ambatovy Tamatave revealed potential flooding scenarios affecting downstream buildings and industrial areas. Additionally, nickel and cadmium sediment concentrations found in the sediments of surrounding villages' drinking water sources exceeded WHO thresholds. Access to natural forests was also lost and households perceived a decrease in forest size. Using satellite data, we were able to confirm deforestation and forest degradation around the Ambatovy Moramanga site. Common complaints from households included decreased productivity due to soil, water, and air pollution, impacting their health, especially those living near operational sites. However, certain mining projects, like Ambatovy, showed positive effects on healthcare and infrastructure. It is important to note that mining impacts were evident in both operational and exploratory sites, emphasizing the need for understanding mining effects throughout all project stages. For example, the Ranobe project led to social unrest and conflict among surrounding communities, making many households feel unsafe due to the mining activities. The economic and political dynamics that arise from the socio-economic changes associated with LEIs drive political mobilization and contestation, shaping the security situation in the urban “service hubs” of the mining regions.

To address these challenges and find sustainable solutions, we organized a three-day workshop, bringing together key stakeholders to co-design transformative pathways. The insights gained will support future updates of the recently revised mining code, ensuring a more effective and sustainable approach to managing extractive investments in Madagascar.

1. Initial problem statement

1.1. Literature discussion

Global mineral resource extraction has been growing rapidly and is primarily driven by increasing consumption in the Global North[1]. The global extent of above-ground mines active between 2000 and 2017 amounted to an area of nearly 60,000 km^2 (13% in Africa)[2] and a recent update by Tang and Werner[3] arrived at 65,585 km^2. Due to the distance between local extraction and international consumption, this increase in mining has led to growing resource, financial and knowledge flows between different social-ecological systems[4], a phenomenon termed telecoupling[5]. Within these interconnected systems, the positive and negative impacts of extractive industries on the environment and people's livelihoods are distributed unevenly across scales[6]. The socio-ecological transformations and burdens associated with large-scale mining activities also often result in processes that reinforce inequities and injustices[7]. These injustices have led to widespread conflicts[7], raising concerns about host countries' ability to achieve the 2030 Agenda's Sustainable Development Goals (SDGs).

While large-scale extractive investments (LEIs) have the potential to drive national-level economic development, direct[8] and indirect negative environmental, sociocultural and local economic impacts continue to pose serious challenges[9]. For example, mining is a significant direct (e.g. creation of roads, mine sites, and settlements) and indirect driver of deforestation and forest degradation (e.g. opening up previously inaccessible areas to illegal logging or agricultural expansion)[10]. Clearing large areas of forest to access mineral resources also disrupts and destroys key habitats and ecosystems, leading to a loss of biodiversity[11,12]. Surrounding forests and ecosystems are further affected by mining operations due to soil erosion, sedimentation of water bodies and contamination of rivers and streams[13].

Immediate and localized negative environmental impacts are serious, yet the indirect impacts resulting from infrastructure and socio-economic changes associated with the extractive industry are likely far more wide-ranging[14–19]. Health and social problems related to LEIs can also be pronounced at the local level[20]. Indirect and cumulative impacts have received little attention in the literature. The utilization of novel satellite imagery and spatial modelling could prove beneficial in addressing this matter. Additionally, a more holistic understanding of the impacts of external investments can be achieved by combining quantitative spatial assessments of environmental impacts with qualitative research on social impacts[21–26].

Social and local economic impacts of extraction activities are complex and controversial[27]. Physical displacement of communities from their ancestral lands leads to the most severe social impacts, such as loss of livelihoods, marginalization, food insecurity, poor health and psychological trauma[28]. LEIs attract migrants to the mining area and adjoining towns, putting additional pressure on public services. Such "frontier urbanization"[29] has a potentially destabilizing effect on local societal and political processes[30], particularly in the security sector. State security personnel are often caught between their law enforcement duties and efforts to protect mining installations. Increased levels of crime, drug and alcohol abuse and teenage pregnancies have also been observed by communities living close to mines[31].

Investments in extractive industries are rising in Africa, which holds nearly two-thirds of the world's mineral reserves[14,32], many of which are critical for the production of clean energy[20]. In Madagascar, there are different estimates of how many large-scale mining investment projects are operational, depending on the criteria used[33,34]. Artisanal and small-scale mining activities (gold, and precious and semi-precious stones) also actively contribute to the sector[34]. The mining sector in Madagascar continues to grow; in 2018, mining accounted for almost 5% of Madagascar's GDP[33]. Madagascar is a key global biodiversity hotspot[35], but the expansion

of LEIs threatens its biodiversity-rich landscapes. Between 2001-2021, Madagascar lost 29% of its forests[36] and could lose 38-93% of the forests present in 2000 by 2050[37]. Madagascar has a low human development index[38] and the political system is unstable[29]. Various government efforts to attract foreign direct investments to boost national budgets have led to a political crisis. The mining code has also undergone various revisions; most recently, it was partially revised in 2020 and a new text has since been approved[39,40]. Given the past political and social turmoil caused by large-scale international investments, there is an urgent need to improve the industry's contributions towards the 2030 Agenda.

1.2. Research gaps

To address sustainability concerns in the extractive industry, jurisdictions commonly mandate Environmental and Social Impact Assessments (ESIAs) for large-scale projects. However, the implementation of ESIAs in the context of LEIs has yet to be studied in Madagascar. There is also limited research on the strengths and weaknesses of the framework governing ESIAs in Madagascar's extractive sector. It is crucial to gain a deeper understanding of actors' decision-making, as well as the interconnections and power dynamics among them, to identify change agents for improving ESIA processes in line with international best practices. Applying social network analysis to identify potential change agents and leverage points for enhancing the extractive sector's contribution to sustainable development would constitute an innovation.

Few studies in Madagascar explore the impacts of LEIs and those that do, mainly provide a partial understanding of the environmental and/or social impacts of two active mine sites, Ambatovy[41–44] and QMM/Rio Tinto[25,45,46]. A spatially explicit and in-depth understanding of the wide-ranging impacts of LEIs is lacking, e.g. those on land use and land management of surrounding populations, or on the security dynamics of adjoining urban areas. Furthermore, we have no information on impacts that might occur in the exploration phase of LEIs. Assuming that this might precede the governmental request for an ESIA, it is all the more important to be aware of potential impacts in order to prevent social injustices and environmental damage during these early stages. Overall, a holistic understanding of social-ecological impacts is needed to mitigate trade-offs and contribute towards the SDGs.

1.3. Objective and research questions

The **main objective** of our project is to produce scientific knowledge on governance processes and sustainability impacts of the extractive industry in order to identify transformative pathways that can enhance the contribution of the extractive industry to sustainable development in Madagascar and in other developing countries. It has been successfully addressed through these **research questions**: **RQ1** – What is the legal and procedural framework governing ESIA processes in the extractive industries in Madagascar, and how could this framework be strengthened so that it contributes more to sustainable outcomes? **RQ2** – What is the role of different stakeholders' decision-making and power relations in governance processes surrounding ESIAs? **RQ3** – What are large-scale extractive industries' spatially explicit and societally relevant impacts on local rural and urban social-ecological systems? **RQ4** – What innovative actions could improve social-ecological impacts of LEIs and thereby enable them to enhance their contribution towards the 2030 Agenda?

1.4. Methods

In this project, we produced scientific and practical transformation knowledge to help improve the sustainability outcomes of the extractive industry. While **RQ1** was addressed at the national and international levels, **RQ2** was initially addressed through a locally grounded case study-based approach using the following five sites: Ambatovy Moramanga, Ambatovy Tamatave

(both part of the same LEI), QMM/Rio Tinto, Ranobe and TREM. From there, we used flow-based analysis to establish links across the different governance levels up to the national level. We followed flows of resources, finances, services and knowledge that link local LEIs to stakeholders at different levels and to land use change caused or resulting from LEIs. For the assessment of social-ecological LEI impacts under **RQ3**, we selected villages "near" to and "far" from the mining sites, using a counterfactual approach, based on propensity score matching. We then collected household survey data from 223 households living "near", and 226 households living "far" from the mining sites. Furthermore, in the case of Ambatovy Moramanga, which is located in one of the last remaining biodiversity-rich humid forests, we collected remotely sensed data on deforestation and forest degradation. For Ambatovy Tamatave, we analyzed water and sediment samples for chemical pollutants. We then linked these data with household survey information to produce spatial data layers representing land use change dynamics. We also analyzed hydrological networks, potential dam breach models and dam movements for Ambatovy Tamatave. To do so, we applied state-of-the-art spatio-temporal optical and radar satellite data analysis methods (i.e. CODED time series analysis[47]), differential InSAR[48] and a dam breach model[49]. Additionally, to study urban governance processes and ramifications of ESIAs close to both Ambatovy sites and QMM/Rio Tinto, we used extensive desk research of secondary sources, document analysis, and qualitative in-depth interviews with government officials, civil society representatives, and members of the police, gendarmerie and armed forces. Finally, for **RQ4** we conducted an exhaustive literature review.

2. Data gathered, data analysis and main results

2.1. Legal and policy frameworks governing ESIAs in the extractive industry

For the literature review, IISD relied on two documents[50,51] previously prepared by the Intergovernmental Forum on Mining, Minerals, Metals, and Sustainable Development (IGF). IISD also interviewed Malagasy government officials to understand local ESIA practices better. Based on document analysis, interviews and a fieldtrip through partners, IISD composed a report which reviewed and assessed the legal Malagasy mining frameworks that were in force as of 31 December 2022. This report shows that although the Malagasy legal and institutional framework on ESIA has many strengths, such as the inclusion of instruments committed towards sustainable development and the requirement of an environmental management plan to mitigate, manage and control impacts, some gaps and weaknesses remain[52]. While most aspects are regulated and competent authorities are responsible for implementation, there are limitations that hinder the industry's contribution to sustainable development. Specifically, two broad stabilization clauses in the mining and investment codes prevent the state from applying the most current laws and regulations, affecting fundamental human rights. Moreover, the ministerial authority responsible for granting environmental permits can override the technical opinion of the National Office for the Environment (ONE). This raises concerns about the legitimacy of the environmental permit. Also, an environmental permit may be granted after the operating permit, possibly rendering it a mere formality. Lastly, public involvement in the ESIA processes is insufficient, particularly in the initial phases. These limitations can be addressed by: eliminating or reducing the scope of stabilization clauses; ensuring that technical advice from ONE is central in the licensing process; making environmental permits a mandatory requirement for operating permit applications; and strengthening inclusive public involvement throughout the ESIA process.

2.2. Social networks, agency and power of large-scale extractive industry stakeholders

Between August 2021 and February 2022, we conducted focus group interviews and actor surveys in the five study sites to gather information on land uses, organizational actors, and their interactions through flows of e.g. goods, money, information, and services. Actors

involved in various land-related activities were invited to join the focus groups. We prepared the actor survey by: identifying the main land uses and changes caused or resulting from the LEI, listing actors influenced by these changes, and compiling a comprehensive list of actors involved in them. We identified additional relevant actors through snowball sampling. We then narrowed down the survey population to only include actors involved in key flows and actors changing the path of flows; 144 actors were identified. We conducted the surveys through face-to-face and online interviews. Data collection occurred in three phases, starting from the village level and moving up to regional and national levels. The international level was not included due to access and time limitations. Flows were analyzed as relational networks among actors, shedding light on governance structures applying to the LEI cases.

Our analysis shows misfit between theories and practices in ESIAs in the extractive industries in Madagascar (Andriamihaja et al., forthcoming). Theories assume a more central governance structure, while practices show more polycentric or decentralized structures. Specifically, the "cahier de charge[1]", financial regulations, and Corporate Social Responsibility (CSR) highlight this misfit. The misfit shows the power relations and shifts among the actors governing the extractive industries in Madagascar. Mining companies are able to choose voluntary activities, such as CSR, against mandatory ones, such as the ones highlighted in the "cahier de charge".

2.3. Identification of change agents for the extractive industry

We combined agency and social network analysis to identify agents of change in the mining sector in Madagascar. To do so we used actor survey data for the actor attributes and social network. Agents of change ideally have social, economic, and environmental aims, access to resources, and a wide social network they can use to advocate sustainability thinking. We therefore identified potential agents of change based on an analysis of actors' agency (aims and resources) and social network (relational profile). We found no ideal agents of change within the actors surveyed. Instead, we identified two potential agents of change. First, mining companies could become agents of change due to their high relational profile and their access to resources. Yet, these companies first and foremost aim at financial profits. Second, government representatives, mostly related to the environment, have the necessary relational profile and sustainability aims, but usually lack resources.

2.4. Spatial assessment of on- and off-site environmental impacts – Ambatovy

Ambatovy Moramanga: We spatially assessed annual deforestation, forest degradation, and other forest disturbances that occurred between 2004–2020 on the mine lease, in several protected areas and land inhabited by local communities surrounding the mine lease area. For this analysis, we used historical Landsat satellite data time series and a novel time series algorithm implemented in a cloud computing environment. The mining site is close to several rivers that are important water sources for local communities' livelihoods. For an improved understanding of which communities might be affected most by the dams constructed by Ambatovy, we generated a spatial hydrological network analysis using an open-source digital surface model. The generated data allowed us to assess potential effects of the mining activity on water availability and quality. The third environmental effect we analyzed through satellite image analysis was reported urbanization caused by in-migration of mining laborers. We generated a spatiotemporal annual urbanization dataset for the time period 2001–2019.

Approximately 15% of the forest conservation zone surrounding the mine lease experienced forest degradation at least once between 2004 and 2020, despite the obligation to safeguard these areas from disturbances[53]. Spatiotemporal analysis indicates that forest disturbance

[1] environmental, social and community Terms of Reference (ToR)

(deforestation and forest degradation) peaked within the mining perimeter during the mine's construction phase (2007-2011). In the surrounding region, disturbances increased sharply shortly after operations in 2012, peaking between 2013 and 2017. The spatiotemporal results also indicate that spillover effects increase pressure on the remaining little available land and forest resources around the mine site and conservation zone. While deforestation could be reduced substantially within the mine-managed biodiversity offsetting conservation zones, forest degradation is still widespread within and particularly outside conservation zones. Our results suggest that land and forest degradation processes are mostly ignored or neglected by the mandatory biodiversity offsetting measures (Eckert et al., forthcoming). A second study based on spatiotemporal satellite data suggests that urbanization in Moramanga and nearby villages has increased by 44% since the start of construction (2007-2019). The urbanization increase is steady and regular with peaks in 2008, 2012 (start of production), 2017 and 2019.

Hydrological network analysis overlaid with optical (Sentinel-2) and radar (Sentinel-1) satellite data confirms the presence of water sources within the actively mined area. Besides the threat of water pollution, the company manages and stores water in dams, thereby controlling water flow and affecting local communities' health and agricultural livelihoods.

Ambatovy Tamatave: Ambatovy built a huge tailing lake area that required the relocation of more than 3,000 people and the construction of five dams. Since the area is prone to hurricanes, there is risk of dam breaches. Thus, we performed a dam breach modelling study based on various dam breach scenarios using a numerical model. For this analysis we used open-source digital elevation and surface models, modelled several breach scenarios in a spatially-explicit way, and generated map outputs. Another threat of the tailing dam is water pollution; locals reported and observed personal and livestock health issues since the construction of the tailing lake. Thus, 11 water and sediment samples were collected, from villages downstream, and analyzed for a range of parameters (i.e., lead, nickel, cadmium and zinc).

Based on InSAR analysis of Sentinel-1 radar satellite data, we found that the five Ambatovy tailing dams experienced substantial spatial movements ranging between -2.8 cm and 1.7 cm between December 2017–May 2018. During this period, Toamasina experienced a hurricane, a frequent natural hazard in the region that are expected to become more severe in the near future due to climate change. Thus, locals reported fears of the tailing dam overflowing or breaking. The dam breach modelling analysis we conducted indicates that none of the modelled scenarios predicted a flood wave reaching the city center of Toamasina. However, all buildings situated downstream of the tailing lake, as well as the industrial area located southwest of the city, would be flooded. The tailings also pose a risk of water and soil pollution. Laboratory results indicate that the water quality was satisfactory at the time of sampling (only one sampling date) with all required parameters below official thresholds. Instead, the measured values for nickel and cadmium in the sediments exceeded the thresholds.

2.5. LEI Impacts on smallholder land use and livelihoods

A total of 459 small-scale farming households completed a survey across the five sites between August 2021–January 2022. Households were selected from villages that were either "near" (within a 5 km buffer zone) or "far" from a site (within a 10 km buffer zone or, if no villages existed, then within a 20 km buffer zone). We obtained information on household characteristics, land use, land management, livelihoods, wellbeing and perceived changes to these variables, as well as perceived mining impacts related to these changes. Survey responses were translated from Malagasy to French, transferred to Microsoft Excel and qualitative responses were coded. Data cleaning and additional coding of qualitative data was performed in R before frequencies of responses were calculated[48]. Due to small sample sizes, Fisher's Exact Tests were used to test for a significant association between perceived LEI site impacts

in “near” and “far” villages. Two-proportion z-tests were used to test whether the proportions of “near” and “far” responses for all other variables significantly differ from each other.

Changes in land use, livelihoods and wellbeing are occurring and large-scale extractive industries are an important, but not only, driver of these changes. Perceived impacts of LEIs on these changes are predominantly negative and they can be widespread, where households living as far as 20 km away from an extractive site perceived impacts on land use and management, livelihoods and wellbeing (Zaehringer et al., In prep.). Furthermore, impacts of LEIs are not only perceived once extraction starts, they are also perceived during exploration.

For the assessment of LEI impacts on security assemblages, qualitative interviews were undertaken during a field visit to Madagascar in March 2023 with 22 different stakeholders. Together with document analysis, this confirmed the significant impact LEIs have not only on the surrounding (and mostly rural) communities, but also on regional towns (i.e., Moramanga, Toamasina, Taolagnaro) that constitute the industry’s “service hubs”. These sprawling urban areas are the site of “boom and bust” economics, attracting people in search of employment and business opportunities: formal and informal, legal and illicit. Consequently, these towns become sites of political mobilization and contestation, involving supporters and opponents of mining activities and their societal and environmental impacts. These economic and political dynamics shape the security situation in these rapidly growing urban areas, often involving collaboration and collusion between the mining company and the police/gendarmerie, who may receive direct payments for security-related services.

2.6. Assessment of innovations towards more sustainable development in the EI sector worldwide

We conducted a comprehensive literature review based on key search terms related to the topic of transformation pathways to achieve more sustainable large-scale mining. We screened references according to their relevance to the main topics of action for transformative pathways that we selected, i.e. socio-economic impacts, corporate social responsibility, nature conservation and in-situ coping strategies. Establishing effective and accountable institutions to manage the extractive sector is key for achieving inclusive development while empowering affected communities, preserving fragile environments and supporting climate action. Binding and clearly defined regulations to ensure mining companies comply with existing policies, initiatives, conventions and best practices is lacking. Better cooperation between companies and governments is necessary. Redefining indigenous leaders’ participation in natural resource governance, as well as building alliances with state actors, neighboring communities and local participatory institutions can provide alternative economic models to mining. Integrating green supply chain practices can either fully or partially achieve sustainable performance. Granting legal status to social licenses to operate could also encourage more accountability and better sustainability outcomes. Once mining operations cease, remediation can be used to remove heavy metals from soils to improve soil properties after mine closures. Promoting circular economy principles, adopting cleaner energy sources, improving water management strategies and exploring alternative, innovative materials and technologies are other transformative actions that merit exploration.

2.7. Co-design with change agents of transformative pathways

We brought together key players, such as ministry representatives, civil society organizations, and mining companies, in transformative spaces, i.e. collaborative environments where diverse actors can interact to reframe problems in ways that enable the co-creation and co-realization of innovative solutions. We shaped these spaces by a series of workshops, including a national one. Our intervention logic broadly states that by fostering dialogue between different actors

in transformative spaces, actors will influence and empower each other through joint social learning, resource transfer and the creation of social networks. We therefore supported actors with distinct claims on mining investments to align their visions and objectives regarding the search for an equitable compromise. Successful transformative spaces can ultimately lead to long-term commitment and collaboration for sustainable development[54]. The lessons learnt from this workshop will directly support future updates of the recently revised mining code[40].

Discussions at the national workshop resulted in setting a theory of change (see section 5) for the mining industry to benefit local communities. In addition, the discussion highlighted four sets of outcomes for mining operations to be beneficial for the local population. To achieve those, workshop participants recommend that mining sector stakeholders have to: 1) implement a monitoring and assistance strategy, based on the results of in-depth research, to ensure stakeholders benefit from LEIs; 2) set up a compensation system for local communities to ensure sustainable livelihoods; 3) share information on mining operations transparently and deliver related educational activities; and 4) adapt global regulations and structures governing mining operations in Madagascar to the Malagasy context.

3. Conclusion and outlook for further exploration

Our research project provides a comprehensive overview of: 1) the policy and legal frameworks governing Environmental and Social Impact Assessments (ESIAs) of large-scale extractive investments (LEIs) in Madagascar; 2) the different stakeholders involved in the extractive industry and their level of agency and power within the system; and 3) the social-ecological impacts of exploratory and operational mining activities. Interestingly, contradictions arose between the findings from the assessment of the policy and legal framework governing ESIAs and those from the actor surveys and workshops, as well as local researchers' experiences. For example, the IISD report found that the ESIA legal provisions are coherent and institutions exist for the implementation of these texts, yet this was not fully supported by mining sector stakeholders who attended the national-level workshop. Instead, most stakeholders pointed out a lack of coherence and institutional coordination with regards to the ESIA texts and the legal framework which governs them. Exploring such differences further could provide valuable insights to identify where policy or implementation gaps lie and why these gaps arise.

Furthermore, our assessment of social-ecological LEI impacts revealed far more different and wide-reaching impacts than an ESIA, even if properly implemented, could detect. Additionally, our study confirms for the first time that not only do operational LEIs damage the environment and human wellbeing, but so do those in the exploratory phase. Positive impacts of the LEIs we assessed are mostly limited to a few infrastructural benefits of the operational LEIs.

Improving public consultation to ensure inclusive and equitable engagement, and strengthening grievance mechanisms for local communities are key recommendations we identified through this project's different research activities. Although these recommendations are clear, what remains challenging is translating them into practice. Co-designing these solutions with local stakeholders would be a step forwards in addressing these recommendations and may also lead to transformative actions in the large-scale mining sector in Madagascar.

This project only focused on LEIs in Madagascar, however, artisanal and small-scale mining activities also contribute towards the mining sector. Exploring the connections, similarities and differences between mining activities at different scales would provide a holistic overview of the entire mining sector in Madagascar as well as insights into the cumulative impacts of these activities. Such an overview is needed to understand where the greatest needs for change are and what actions have the most potential to transform the mining sector in Madagascar so that it contributes towards the country's sustainable development.

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5. Appendix: Theory of Change

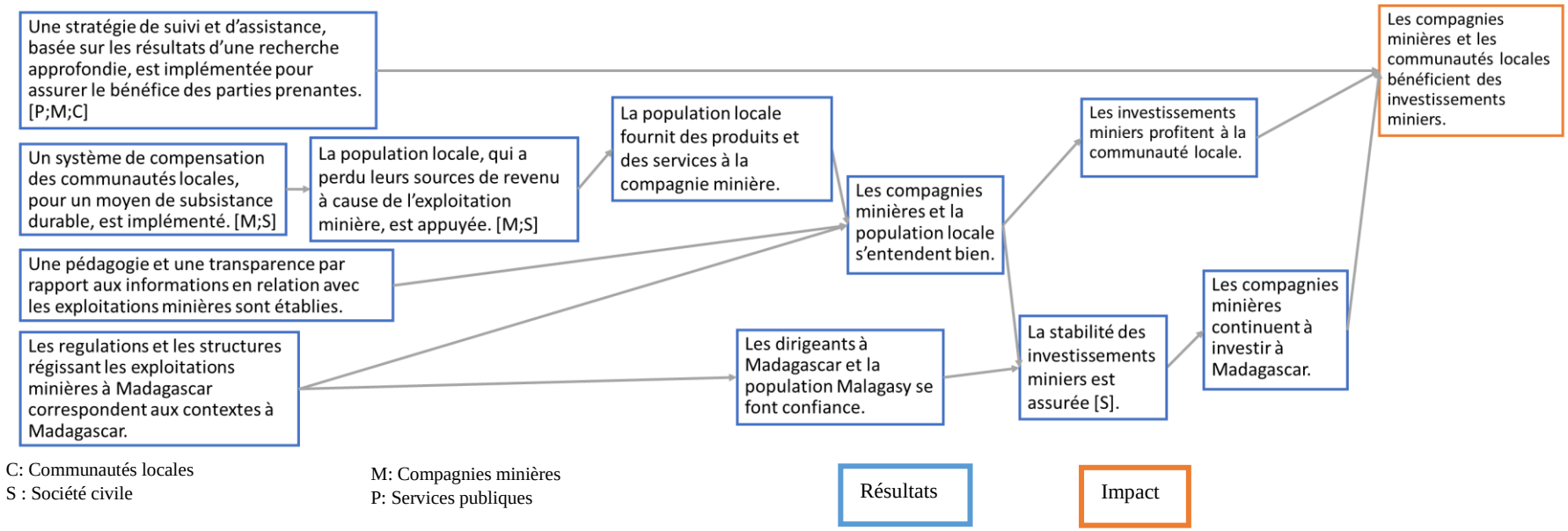

Figure 1: Une partie de la théorie du changement présentant les résultats (encadrés en bleu) et les liens entre les résultats, ainsi que l'impact final (encadrés en orange). Les lettres M, P, C, S correspondent aux entités qui assument la responsabilité des résultats ou de l'impact.