

Stakeholder engagement and ecosystem services for mine closure

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Abstract

Mine rehabilitation presents complex challenges that require balancing ecological restoration with community needs and expectations. This study explores the use of ecosystem services frameworks and community engagement approaches in mine rehabilitation planning, focusing on a case study at the Padcal mine site in the Philippines. As part of the Philippines Remediation of Mine Tailings (PROMT) project, we conducted a community workshop to assess local perceptions of ecosystem services and mine rehabilitation potential. Activities included educational presentations, focus groups and a questionnaire on ecosystem services. Results showed that 88% of participants understood the concept of ecosystem services after our introduction, with 62% perceiving negative mining impacts on these services. Importantly, 65% believed tailings could be rehabilitated to provide services such as agriculture or ecotourism. Gender differences emerged in perceptions, with women more likely to recognise mining impacts but also more optimistic about rehabilitation possibilities. Our participatory approach provides insights for developing mine rehabilitation strategies that integrate ecosystem service frameworks with community perspectives, potentially enhancing social acceptance and the long-term sustainability of rehabilitation efforts.

Keywords: community engagement, ecosystem services, mineral extraction, mine rehabilitation, mine tailings, stakeholder engagement

1 Introduction

The global increase in mineral demand presents economic opportunities for resource-rich countries but raises significant concerns about impacts on local communities and ecosystem services (i.e. benefits for human society from nature) (Kenter et al. 2019). Mine rehabilitation, a critical phase in the mining lifecycle, aims to mitigate these impacts and restore ecological and social values post-mining (Tibbett et al. 2024). However, effective rehabilitation requires a nuanced understanding of both environmental processes and community needs to move towards successful mine closure.

Ecosystem service frameworks offer a promising approach for bridging the gap between rehabilitation science and community engagement in mine closure planning. These frameworks highlight the multifaceted benefits nature provides to humans, highlighting more holistic and socially acceptable rehabilitation outcomes (Kenter et al. 2019). However, the application of ecosystem service concepts in mine rehabilitation contexts, particularly in the Global South, remains limited. Few ecosystem service approaches holistically combine the natural and the social sciences (Neves et al. 2016), with Indigenous people and local communities losing out because human dimensions are inadequately considered. In the Philippines,

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Indigenous people's lands overlap with mining areas and this can cause conflicts over land rights (Holden et al. 2016). This complex socio-ecological landscape requires rehabilitation approaches that are not only technically sound but also culturally appropriate and community-driven.

The Philippines Remediation of Mine Tailings (PROMT) project aims to address these challenges by integrating ecosystem service frameworks with community engagement in employing novel technologies in mine rehabilitation planning (Jenkin et al. 2024). This paper presents findings from our initial community engagement efforts at the Padcal mine site in Benguet, Philippines. Our objectives are to:

1. assess community understanding and perceptions of ecosystem services in the context of mine rehabilitation
2. identify priority ecosystem services that communities believe are impacted by mining and could potentially be restored through rehabilitation
3. explore gender-based differences in perceptions of mining impacts and rehabilitation potential so as to inform more inclusive mine rehabilitation strategies
4. evaluate community perspectives on the potential for rehabilitated mine tailings to provide ecosystem services.

By focusing on these objectives, we aim to contribute to more effective, community-centred approaches to mine rehabilitation that balance ecological restoration with social and cultural considerations while also addressing gender-specific concerns and perspectives.

2 Materials and methods

2.1 Research area

On 22 March 2022 we hosted the first community workshop event at the Philex Mining Corporation (Padcal mine site) in Benguet. Benguet Province is situated in the Cordillera Central mountain range, with elevations ranging from 120 to 2,930 metres above sea level. This region contains rugged mountains, rivers and forests. The native vegetation is tropical pine forests containing some metal-tolerant plants (Duddigan et al. 2023). Agriculture is a major land use, with crops like vegetables and coffee grown on mountain terraces. Philex is one of the largest copper and gold producers in Southeast Asia. The Padcal mine, established in 1958, spans an area of 95 hectares (Jenkin et al. 2024). The mine site supports a community of 2,000 employees from diverse ethnic backgrounds and is located on the ancestral domains of the Igorot tribes, who are paid royalties for their land rights.

2.2 Stakeholder mapping

To identify relevant stakeholders, we held meetings between the PROMT team and the Community Development Officer from Philex. The Community Development Officer is an Indigenous person who has a longstanding relationship with local Indigenous communities. We constructed a stakeholder matrix to visually categorise stakeholders impacted by, or interested in, a project (Figure 1), which informed the invitees' list. As this was the first event we focused on engaging stakeholders in the 'Manage Closely' section of the stakeholder matrix. We concentrated on the Itogon and Ampucao Indigenous communities due to the complex relationship between mining companies and Indigenous communities. All participants are Indigenous, with four participants from the Ampucao and Itogon Local Government Unit.

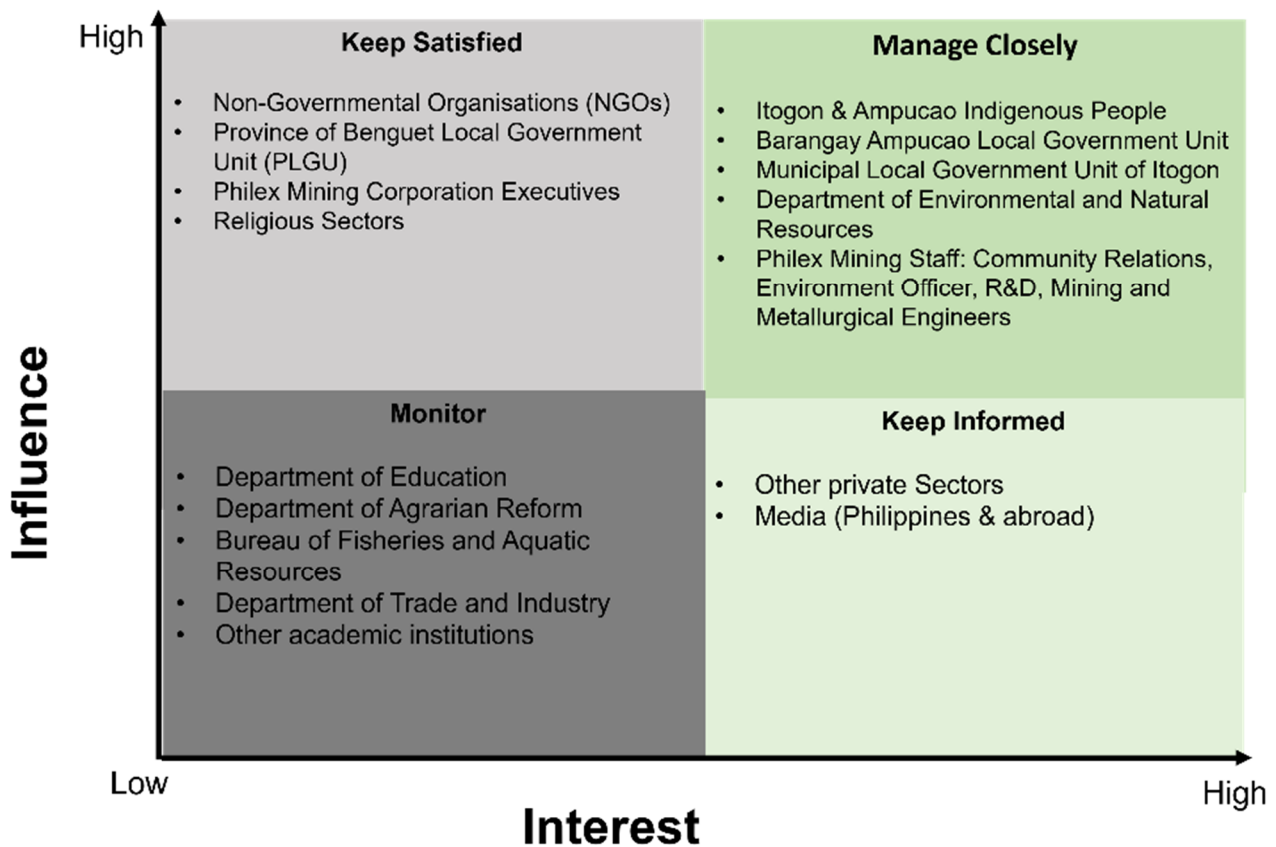


Figure 1 A stakeholder matrix showing differences in influences and interest in the Philippines Remediation of Mine Tailings (PROMT) project

2.3 Workshop activities

The workshop activities included video presentations, a questionnaire, focus group discussions and a question-and-answer session. We engaged experts from the PROMT project through pre-recorded videos explaining the project. The first author provided a pre-recorded video that introduced ecosystem services using accessible language rather than focusing on mining.

Following this video, participants were asked to fill in a short questionnaire related to ecosystem services). The questionnaire gauged participants' understanding of the video and their ecosystem services perspectives around mining. The questionnaire had a mixture of open- and close-ended questions. We then conducted focus group discussions to understand participants' opinions of the PROMT project using three questions:

1. What do you like about the proposed PROMT project?
2. What do you dislike about the proposed PROMT project?
3. What would you change/add to the proposed PROMT activities?

These questions were written on flipchart paper, and participants wrote their responses on post-it notes and stuck them on the wall.

2.4 Ethics procedures

All participants gave prior informed consent to participate, with explanations about the workshop being provided by local collaborators. The community was engaged in collaboration with a Philippines-based researcher who has a long-term working relationship with the community. Her knowledge of local protocols ensured that we carried out this consultation process in line with local practice. This included direct

engagement with community elders and recognised community leaders. After this initial consultation, all following research activities have been approved by UK institutional ethics committees.

2.5 Data analysis

Local researchers recorded and translated questionnaires and focus group comments into English. The questionnaire data was coded using the qualitative data analysis software NVivo (Version 20.6.1) to conduct thematic analysis. Using the FactoMineR package in the statistical program R, multiple correspondence analysis (MCA) was used to visualise and identify underlying patterns in the questionnaire data (multidimensional categorical data).

3 Results

3.1 Participant demographics

There were 26 participants and their occupations varied from housewives and small-scale miners to environmental coordinators and civil engineers. The group is well-balanced in gender representation (54% female, 42% male, 4% undisclosed), with an age range from 30 to 65 years old. Half of the participants are educated to a Bachelor's degree level or above, 23% are educated to senior high school level and 19% are educated to junior high school level or lower.

3.2 Ecosystem services and gender perspectives

Despite the detailed video introduction on ecosystem services there was not a 100% 'yes' response to the question, 'Do you know what ecosystem services are?' Only 88% of the participants knew what ecosystem services are. Participants agreeing with the statement 'I know a lot about environmental protection' were more likely to know what ecosystem services are (60%, $n = 26$).

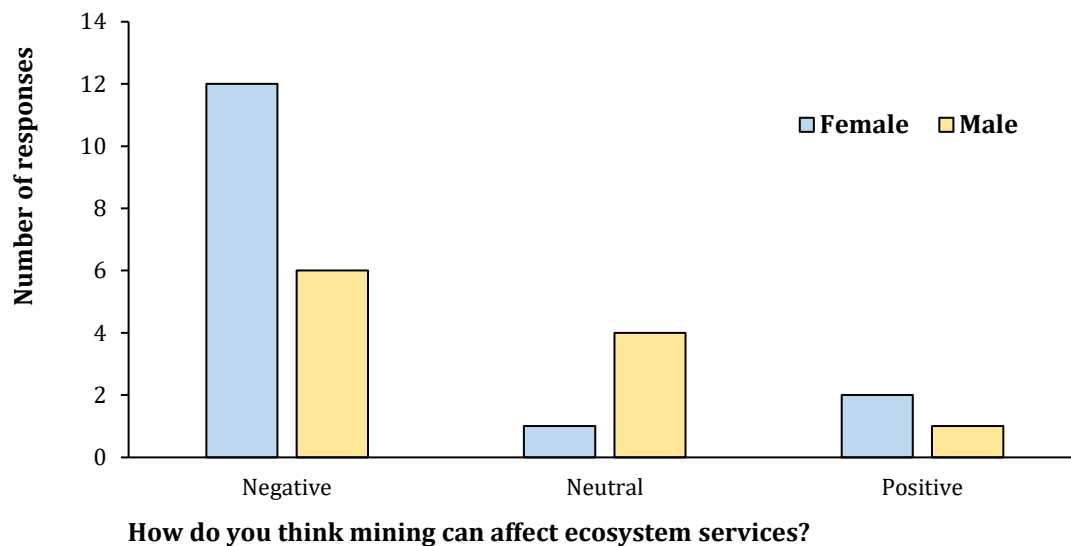


Figure 2 Female and male participant responses to 'How do you think mining activities can affect ecosystem services?' at the community workshop at the Padcal Mine Site in Benguet, Philippines ($n = 26$)

Most participants (62%) thought that mining activities negatively impacted ecosystem services. More females (80%) compared to males (55%) thought this (Figure 2; $p = 0.2$, Fisher's exact test). An open-ended question then asked which ecosystem services participants thought to be impacted. The results were thematically

sorted into provisioning, regulating and cultural services. Focus was placed on provisioning (50%) and regulating services (38%), whereas cultural services were mentioned in passing (13%).

When asked, 'do you think mine tailings can be restored to provide ecosystem services?', 65% of participants answered 'yes' and 35% answered 'unsure'. The MCA factor plot shows that male and female participants are split into two distinct clusters (Figure 3). 73% of female participants believe that restored mine tailings could provide ecosystem services, compared to 55% of males. 45% of male participants were unsure whether restored mine tailings could provide ecosystem services, compared to 27% of females.

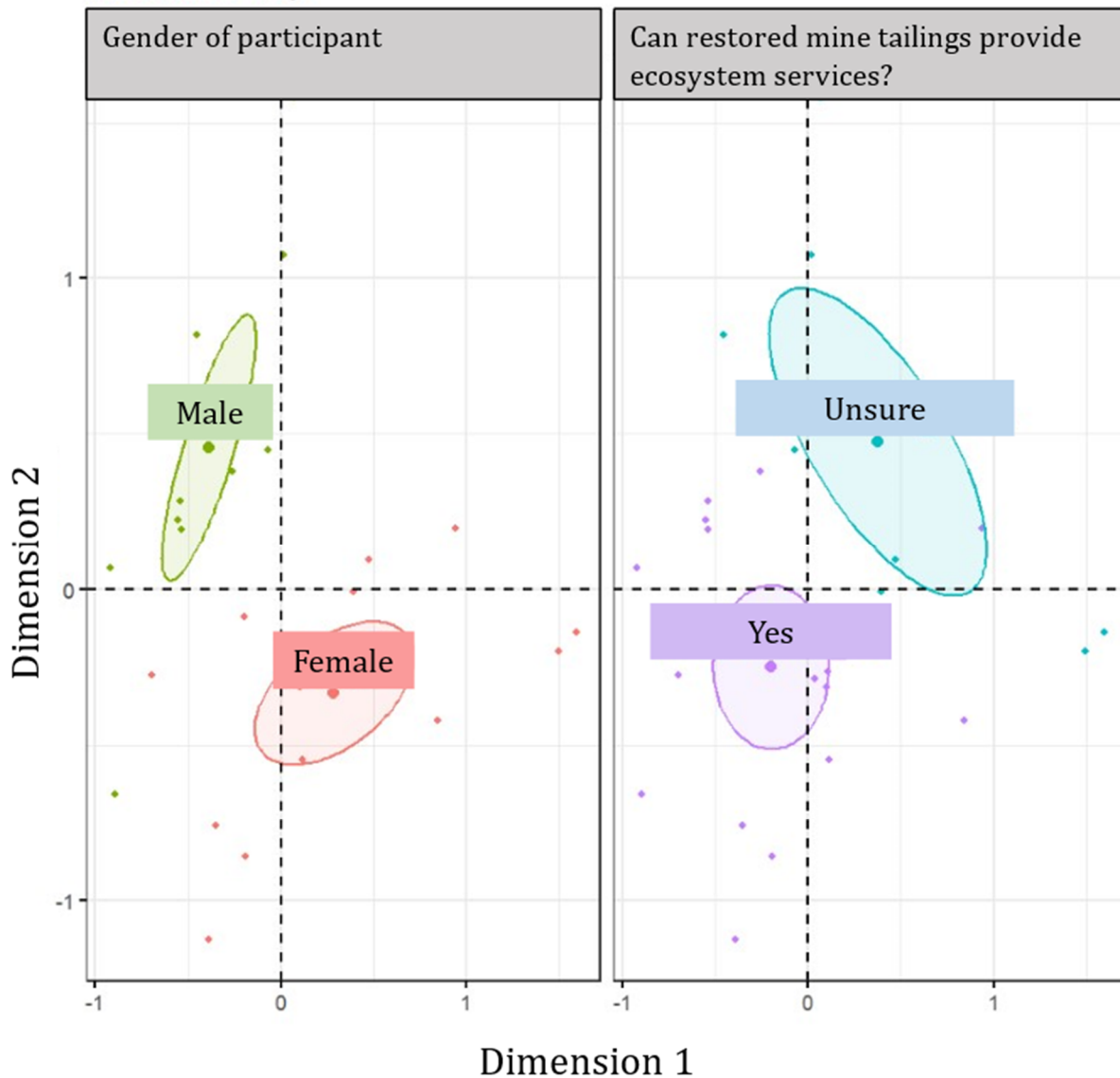


Figure 3 A multiple correspondence analysis factor plot showing the variance distribution of male and female participants (left panel) and whether they thought restored mines could provide ecosystem services (right panel), from a community workshop at the Padcal mine site in Benguet, Philippines (n = 26)

Participants answering 'yes' referred to provisioning services (food) and cultural services (tourism and recreation) as potential services. Some comments included:

'You can use it for agricultural land or as a tourism spot.'

'It can be restored if it is no longer operational for the company. Convert it to a park or a farm.'

Participants who were 'unsure' highlighted that the findings of the PROMT project would help in their understanding. Below are some quotes:

'There is a need to research regarding mine tailings.'

'Because I haven't seen an example exactly in our municipality.'

3.3 Focus group discussion

Most participants applauded the team for finding more responsible solutions for mine site rehabilitation. Some liked the potential ecosystem services that reclaimed mine tailings could provide. However, participants emphasised that the project is still new and theories are yet to be proven effective. Some participants were sceptical about whether the work of PROMT can bring community benefits. All emphasised that they wanted to be kept informed and involved in the project.

4 Discussion

Our research demonstrates a framework of early engagement between researchers and Indigenous communities for the environmental stewardship of ecosystem services (Heller et al. 2023). The complex relationship between Filipino Indigenous communities and mining provides an important backdrop for our research. Although colonisation impacted lowland groups, remote Indigenous Filipinos maintained greater cultural distinctness and ownership of ancestral lands than their counterparts in other colonised countries (Chaloping-March 2006). Communities initially welcomed mining but there is now dissatisfaction with the environmental costs and uneven distribution of economic benefits (Holden et al. 2011). The feedback from our workshop was positive and participants emphasised the knowledge that they had learned. Our project will build trust, avoid exploitative practices and provide pathways for communities to benefit long-term. This situation, where Indigenous communities retain land rights but face development pressures in an impoverished but mineral-rich region, demands context-specific research attentive to power dynamics and environmental justice. By engaging early with communities through participatory dialogues, researchers can build trust and identify priority ecosystem services aligned with community needs. This collaborative approach should be applied globally to uphold the stewardship responsibilities of mining projects when operating on Indigenous lands.

4.1 Community understanding of ecosystem services

Globally, the ecosystem services framework will play an important role in mine closure planning as many regions now require rehabilitation. A challenge is ensuring communities understand the concept. Despite providing an accessible video introduction to ecosystem services, we found that not all participants fully grasped the concept, with 88% reporting understanding. This aligns with findings from Asah et al. (2014), who noted challenges in communicating ecosystem service concepts to stakeholders. Our results suggest that while the ecosystem services framework can be a useful tool for engagement, care must be taken to ensure its accessibility.

Although we provided an accessible video introduction, some participants still found it confusing. In future activities, we should use real examples of ecosystem services at mine sites rather than the terminology of 'ecosystem services'. In future activities, we recommend using tangible, site-specific examples of ecosystem services rather than abstract terminology. This approach has been successful in other contexts, where individuals may understand the concept without using the formal terminology (Delorme et al. 2021). Understanding local contexts and adapting research language will likely lead to more successful engagement in mine rehabilitation planning.

4.2 Perceived mining impacts on ecosystem services

Our finding that 62% of participants perceived negative impacts of mining on ecosystem services aligns with other studies examining community perceptions of mining (Younger et al. 2005). Participants focused

primarily on provisioning and regulating services, with less emphasis placed on cultural services. This distribution of concerns reflects patterns observed in other mining-impacted communities (Lechner et al. 2017), highlighting the importance of addressing tangible, immediate ecosystem benefits in rehabilitation planning.

During the focus group there was discussion surrounding the project's environmental impacts. This included whether it would affect groundwater integrity and how the project will benefit the community. Team members provided detailed answers and were honest that some answers can only be provided as the project progresses. Transparency is vital for resolving conflicts over mining's environmental impacts through shared dialogues.

4.3 Gender perspectives in mine rehabilitation

Our findings revealed significant gender differences in perceptions of mining impacts and rehabilitation potential. Women were more likely to perceive negative impacts of mining on ecosystem services but were also more optimistic about rehabilitation possibilities. This aligns with broader research on gender and environmental risk perception (Subiza-Pérez et al. 2020). Women perceive greater environmental risk, which likely influences their stronger belief that mining degrades ecosystem services. However, the tendency of women towards empathy and commitment to environmental stewardship explains their greater confidence in the restoration of ecosystem services. This highlights the importance of gender-inclusive approaches in mine rehabilitation planning. These gender differences highlight the need for diverse representation in community engagement processes. Incorporating both male and female perspectives can lead to more comprehensive rehabilitation strategies that address a wider range of community concerns and priorities (Lahiri-Dutt 2015).

4.4 Potential of rehabilitated mines for ecosystem services provision

The optimism expressed by 65% of participants regarding the potential for rehabilitated mine tailings to provide ecosystem services is noteworthy, particularly given the often-observed scepticism towards mining company promises (van der Plank et al. 2016). This positive outlook may reflect our participatory approach that emphasised long-term community benefits. It also suggests that framing rehabilitation outcomes in terms of ecosystem services could enhance social acceptance of rehabilitation efforts.

Participants' focus on agricultural and tourism potential for rehabilitated sites aligns with global trends in post-mining land use (Bainton & Holcombe 2018). However, the feasibility of these options depends on site-specific factors and requires careful consideration of ecological and social constraints (Zipper et al. 2011). The concept of ecosystem services can be a good narrative to engage communities. Some participants mentioned liking the idea that reclaimed mines could provide ecosystem services, indicating potential social acceptance. Local communities find it hard to conceptualise future mine closure because the mine brings economic benefits. If researchers can help communities envision scenarios where former mines generate tangible benefits for communities, this can enable better mine closure planning. If appropriately framed, the ecosystem services framework can serve as a compelling environmental stewardship narrative to foster social acceptance.

By directly integrating local feedback to inform project planning, our research offers a collaborative stewardship model rather than a top-down approach. Traditional mine site rehabilitation is based on a Eurocentric worldview that separates humans and nature. Ecological restoration does not automatically lead to societal benefits (Rosa et al. 2020). This approach can be unsuitable for Indigenous communities, who have their own ways of relating to ecosystems. Culturally appropriate approaches should recognise existing relationships that Indigenous peoples have with their lands (Domínguez & Luoma 2020), which is highlighted by the concept of relational values in the ecosystem services framework (Klain et al. 2017). Our approach succeeds at community engagement by adapting to the Philippines' unique context. The ecosystem services concept successfully links ecological restoration with community social benefits. This holistic framing encourages community support for collaborative environmental stewardship.

4.5 Implications for mine rehabilitation

The ecosystem services framework shows promise as a tool for engaging communities in mine rehabilitation planning. By highlighting tangible benefits that rehabilitated landscapes can provide, this approach may help communities envision positive post-mining futures by addressing a common challenge in mine closure planning (Bainton & Holcombe 2018).

Globally, the ecosystem services framework is gaining traction in mine closure planning, driven by increasing regulatory requirements for comprehensive rehabilitation (Rosa & Sánchez 2016). For instance, jurisdictions such as Western Australia now require consideration of post-mining land uses and ecosystem functions in closure plans (Government of Western Australia 2020). Similarly, the International Council on Mining and Metals (ICMM) has incorporated ecosystem service considerations into its mine closure guidance (ICMM 2019). However, the application of ecosystem service frameworks in mine rehabilitation contexts remains low, particularly in the Global South. Our study contributes to addressing this gap by demonstrating a practical approach to integrating ecosystem service concepts with community engagement in a Philippine context. In the future, mine rehabilitation practitioners should consider: adopting participatory approaches that use accessible language and local examples to explain ecosystem services; addressing gender-specific concerns and perspectives; focusing on tangible, community-prioritised ecosystem benefits; and engaging communities early and continuously throughout the rehabilitation process.

5 Conclusion

This study demonstrates the value of integrating ecosystem service frameworks and early participatory engagement in mine rehabilitation planning. Our findings reveal that community members, when provided with accessible information, can meaningfully engage with ecosystem service concepts and apply them to mine rehabilitation contexts. The identified gender differences in perceptions highlight the importance of inclusive engagement strategies that capture diverse community perspectives. Our results show cautious optimism among community members regarding the potential for rehabilitated mine tailings to provide valuable ecosystem services. This finding suggests that framing rehabilitation outcomes in terms of tangible ecosystem benefits may enhance community support and social acceptance of rehabilitation efforts. Moving forward, mine rehabilitation practitioners should consider adopting ecosystem service frameworks as a tool for facilitating dialogue between researchers and local communities. Such approaches can help align rehabilitation goals with community priorities, potentially leading to more socially beneficial outcomes.

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