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Building a Community's Adaptive Capacity for Post-Mining Plans Based on Important Performance Analysis: Case Study from Indonesia

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Abstract: Preparing communities around mines to face the impacts of mine closures is crucial in order to reduce disruptions to their livelihoods. Building the adaptive capacity of these communities will alleviate the burden on governments or mining companies in the future. Unfortunately, adaptive capacity has not yet been integrated into post-mining planning policies. This research aims to develop an adaptive capacity framework for post-mining planning in local communities, focusing on a case study conducted in Indonesia. We developed this framework using the Importance Performance Analysis (IPA) method. The findings indicate that the adaptive capacity framework provides a comprehensive approach to building the capacity to adapt and thrive in post-mining situations. This highlights the importance of continuing to disseminate post-mining plan information, prioritizing access to capital and former mine sites, fostering collaboration, and creating job opportunities. Simultaneously, efforts to increase skills should be reduced, and reallocation of efforts towards community institution building, establishing information centers, and improving community bonds should be prioritized in more important fields and programs. By adopting this framework, communities around mines in Indonesia are expected to enhance their resilience and ability to effectively respond to changing circumstances.

Keywords: adaptive capacity; post-mining behavior; community empowerment; livelihood security; adapt to change; sustainable mining practices; mine closure

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1. Introduction

Post-mining activities can have severe adverse effects on local communities [1]. The loss of jobs for the local community, particularly for those whom the mining company employed, can lead to economic instability and poverty. Mining can also expose local communities to harmful chemicals and pollutants [2], leading to adverse health effects such as respiratory problems and skin rashes. In addition, environmental degradation caused by post-mining activities can leave behind large open pits, tailings ponds, and contaminated waterways, leading to soil erosion and water pollution [3]. This can impact the local ecosystem and biodiversity, affecting local livelihoods such as fishing and agriculture. Furthermore, mining activities can also lead to social conflicts between the mining company and the local community [4,5], particularly if the company does not involve the community in decision-making or adequately compensate them for the impacts of mining. Therefore,

mining companies need to engage with local communities and ensure that they are involved in decision-making and adequately compensated for any adverse impacts of mining.

Local communities often depend on mining activities for their livelihoods, and the closure of mines can have severe economic consequences [6]. Therefore, these communities must adapt to any adverse impacts of mining and build their resilience to help them transition to a sustainable future. Adaptation can involve implementing sustainable livelihood programs that provide alternative sources of income and employment opportunities [7]. In addition, adaptation can involve strengthening the community's capacity to manage its natural resources sustainably [8]. This can involve reforestation, sustainable water, and environmental management programs [9].

To apply the adaptive capacity framework to help local communities adapt to the adverse impacts of mining, it is essential to consider the five key components of the framework: asset, flexibility, organization, learning, and agency [10,11]. Previous research studies may have focused on the adverse impacts of mining on local communities [12–14]. Still, there may be gaps in understanding the specific mechanisms that influence the adaptive capacity of local communities to these impacts. Moreover, there may be gaps in knowledge about how to effectively implement the adaptive capacity framework to help local communities adapt to the adverse impacts of mining. For example, previous studies may not have fully explored the role of social networks and community participation in building adaptive capacity. Furthermore, there may be a lack of research on the long-term effects of implementing adaptive capacity strategies and the sustainability of community preference interventions. Additionally, research studies may have focused on specific contexts and may not be generalizable to other mining-affected communities.

Importance Performance Analysis (IPA) is a helpful tool for identifying and prioritizing issues [15,16] related to the adaptive capacity of mining-affected communities. Using IPA, researchers and practitioners can identify areas where the community perceives their adaptive capacity is low and prioritize interventions to improve those areas. Therefore, identifying gaps in IPA can help guide future studies and help researchers and practitioners develop more effective strategies for enhancing the adaptive capacity of mining-affected communities.

2. Contextual Framework

2.1. Post-Mining Management

Post-mining management refers to the processes and activities put in place after mining operations are completed to ensure long-term environmental, social, and economic sustainability [17]. Managing and restoring the land and environment after mining operations have been completed is known as post-mining management [18]. This phase follows full decommissioning implementation and includes actions such as monitoring, maintenance, and social programs aimed at achieving closure objectives [19]. "Post-mining is a planned, systematic, and continuing activity after the end of part or all of mining business activities to restore the natural environment and social functions according to local conditions throughout the mining area" [20].

Mine closure does not mark the end of the mining industry. Rather, it is the beginning of post-mining reclamation and rehabilitation, which is the responsibility of the mining company. Post-mining reclamation aims to restore the mined-out areas to their initial state before mining [21] or to a comparable alternative that provides ecological and social benefits. In most cases, post-mining reclamation is planned based on the initial setting before mining, such as a forest [22], and involves the restoration of soil, water, and vegetation. The objective is to restore the ecosystem's functions and services, such as water conservation, soil stabilization, and carbon sequestration. However, in some cases, post-mining reclamation can be rearranged into other forms that provide social and economic benefits to the community. For example, the mined-out areas can be transformed into parks, tourist attractions, mining geology education and training centers, settlements, museums, or other uses that contribute to the local economy and well-being [23].

On a global scale, the final declaration of the Rio+20 Conference United Nations Conference on Sustainable Development, titled "The Future We Want", on post-mining closure was also highlighted. "We recognize the importance of strong and effective legal and regulatory frameworks, policies and practices for the mining sector that deliver economic and social benefits and include effective safeguards that reduce social and environmental impacts, as well as conserve biodiversity and ecosystems, including during post-mining closure", paragraph 228 states (2012) [24].

The application of post-mining activities is not only necessary to rehabilitate the mined-out areas but also to ensure a sustainable and long-term development outlook for the mining industry. These activities are crucial to meet the 2030 Sustainable Development Goals (SDG), which highlights the importance of responsible and sustainable mining practices [25]. The mining industry significantly impacts the environment, economy, and social structures of the communities where it operates. The SDG emphasizes the importance of responsible resource management, sustainable economic growth, and social development. Therefore, the mining industry needs to implement post-mining activities that are environmentally sustainable, socially responsible, and economically viable. The mining industry can minimize its environmental impact and enhance its social license to operate by rehabilitating the mined-out areas and restoring them to a healthy and productive state. The post-mining activities must be designed to integrate the needs and interests of the local communities and involve their participation in decision-making processes [26–28]. Moreover, the post-mining activities must be economically viable and contribute to the sustainable development of the mining region. This involves developing alternative livelihood opportunities, promoting local economic growth, and creating employment opportunities for the local communities.

2.2. Adaptive Capacity

Adaptive capacity is the capacity of social systems to learn and adapt in the aftermath of a tragedy, as well as to multiple, long-term, and future dangers [29]. This adaptive capacity refers to a system's latent capability to respond proactively and favorably to stressors or opportunities [30]. Adaptive capacity is also related to the ability to adapt to environmental changes in order to survive; it is a function of resilience [31], including the ability of a person or organization to recognize a threat or an opportunity and take the necessary steps to successfully change, also called adaptive capacity [32].

The functions of adaptive capacity are to enable systems, institutions, humans, and other species to react to possible damage, seize opportunities, and respond to consequences. High adaptive capacity is typically regarded as beneficial for humans because it confers resistance to disruption and allows ecological and social systems to reorganize themselves with minimal function loss [33]. It has been discovered that greater well-being is connected with greater adaptive capacity, which allows individuals to cope with adversity [34]. Increasing the adaptability of humans can lower their susceptibility to natural hazards [35]. A system with a high adaptive capacity would be capable of adapting to and even profiting from change.

Adaptive capacity is comprised of dynamically interrelated components, including structural and functional diversity, connectivity and feedbacks between system components, social capital, and learning processes [36]. Cinner et al. [37] identify five dimensions of adaptive capacity: (1) assets that people can use when needed; (2) flexibility to change strategies; (3) the ability to organize and collaborate (social organization); (4) learn to recognize and respond to change (learning); and (5) institutions to determine whether to change or not (agency).

2.3. Dimensions of Adaptive Capacity for Post-Mining Communities

Adaptive capacity is important for systems to react to possible damage, seize opportunities, and respond to consequences. High adaptive capacity is considered beneficial for humans because it confers resistance to disruption and allows ecological and social

systems to reorganize themselves with minimal function loss. There are several dynamically interrelated components of adaptive capacity, including structural and functional diversity, connectivity and feedbacks between system components, social capital, and learning processes. We incorporated five dimensions of adaptive capacity [37]—assets, flexibility, social organization, learning, and agency—into this research.

2.3.1. Asset That People Can Draw upon in Times of Post-Mining

The asset dimension refers to resources that are available to individuals or communities, such as finance, technology, and services [37]. These resources are expected to be easily accessible as social capital for adaptation in a changing situation. Communities near mines that have closed require capital for business. Similarly, technology must be adaptable to changing circumstances. Additionally, they may need services such as health care when they become ill as a result of the changes that occur.

2.3.2. Flexibility to Change Strategy in Facing Post-Mining

As a form of adaptation, flexibility refers to a person's or group's ability to change strategies in response to existing changes [37,38]. After the mine closed, communities that had previously worked as miners could become farmers, for example. This is an example of flexibility: the more options there are, the more flexible the system is, and the easier it is to adapt.

2.3.3. Social Organization (Ability to Organize and Act Collectively in the Face of Post-Mining)

The social organization dimension is a type of adaptive capacity that examines how society is structured to make it easier or more difficult for people to collaborate, act collaboratively, and share knowledge [39]. Social bonds are forms of social capital that will aid in the adaptation process.

2.3.4. Learning to Recognize and Respond to Change When Facing Post-Mining

The learning dimension refers to people's ability to generate, absorb, and process new information about climate change, adaptation options, and how to live with and manage uncertainty [40]. Learning can occur experimentally or experientially, at a variety of organizational, spatial, and temporal scales, as well as across them [41].

2.3.5. Agency (Institutions to Determine Whether to Change or Not Face Post-Mining)

The agency dimension refers to a person's or a community's ability to exercise free will in adapting to environmental change [42]. It is founded on people's belief that they can do and manage things in the future, as well as control what happens to them, and includes aspects of empowerment, motivation, and cognition [43]. By comprehending these dimensions of adaptive capacity, individuals and groups will be better prepared to face the challenges posed by disturbance, not only for climate change in this case but also for the community facing post-mining.

3. Methods

3.1. The Importance Performance Analysis

IPA was created as a market research tool to provide and advise management [44]. IPA's main goal is to evaluate products or attributes while also providing interpretation services and practical management advice [45]. IPA develops a point of view on which product or service should be chosen by identifying the most important characteristics, namely strengths and weaknesses [46].

The IPA technique is used in this study to interpret the data collected from respondents. It combines the measures of respondents' performance and importance and plots them on a two-dimensional graph. This graph helps to determine the location of the data points in

the four quadrants, which in turn can be used to set objectives for allocating resources. The four quadrants are as follows:

1. Q1 (keep up the good work): This quadrant indicates that the respondents are performing well and consider the indicator important. It suggests that the current practices should be continued and maintained to sustain good performance.
2. Q2 (concentrate here): This quadrant indicates that the respondents are performing poorly but consider the indicator important. It suggests that efforts should be concentrated to improve the performance of the indicator.
3. Q3 (low priority): This quadrant indicates that the respondents are performing well but consider the indicator unimportant. It suggests that the indicator should be given low priority and not allocated many resources.
4. Q4 (probably overkill): This quadrant indicates that the respondents are performing poorly and consider the indicator unimportant. It suggests that the indicator should not be given too much attention as it may not be worth the resources invested.

By using this technique, the study can easily identify the areas that need improvement and allocate resources accordingly. It can also help prioritize the indicators based on their importance and performance, ensuring that resources are allocated efficiently. Figure 1 provides a visual representation of the four quadrants and how they relate to the data collected from the respondents [42]. The first quadrant is the ideal quadrant, with high interest and high performance. It is recommended to continue working well in this area. Hence, follow-up action is needed. The second quadrant is important but has low performance value. This is known as the "concentration here" zone. In terms of follow-up, the position of this area is given the highest priority. The third quadrant is classified as a "low priority" area. The low performance value and degree of importance are also low. This indicates that reallocating resources to this indicator is not urgent. The fourth quadrant performs well, but its significance is limited. It is called "possible excess", indicating the potential for wasting limited resources when they are used inefficiently and allocated elsewhere [45]. Each quadrant of the standard IPA plot represents a different strategy to identify areas of concern and actions to be taken [45].

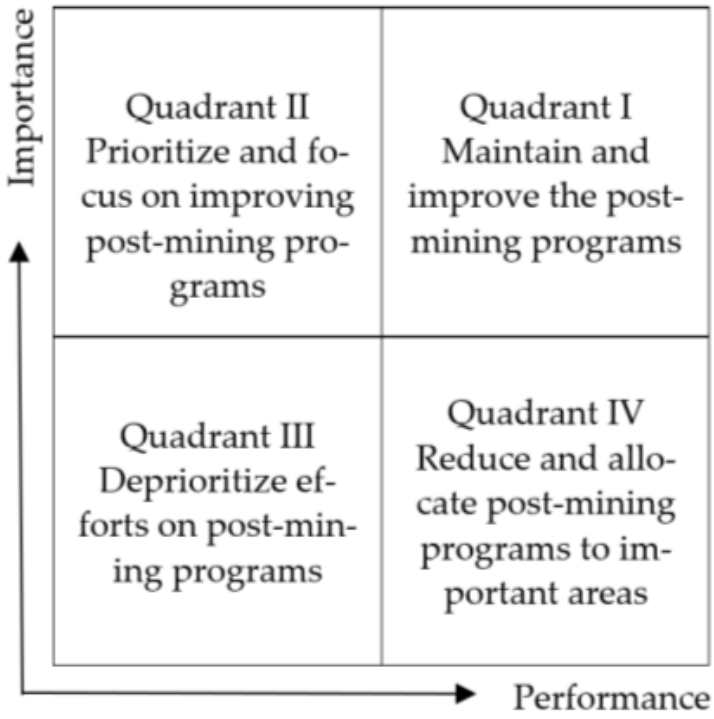

Figure 1. Grid of IPA Quadrant.

IPA were initially developed for marketing purposes but are now used in a variety of fields—for example, tourism [45,47], health [46], public administration [48], education [49], waste management [50], disaster management [51], forest management [52], and national park management [53]. This study will also look for the level of importance and performance based on local people's perspectives on post-mining conditions.

3.2. Study Area

The research conducted on the community around Antam Pongkor Gold Mining in Bantar Karet Village, Nanggung Subdistrict, Bogor Regency, West Java Province, Indonesia (Figure 2). The majority of local mining workers live in the village of Bantar Karet [54,55].

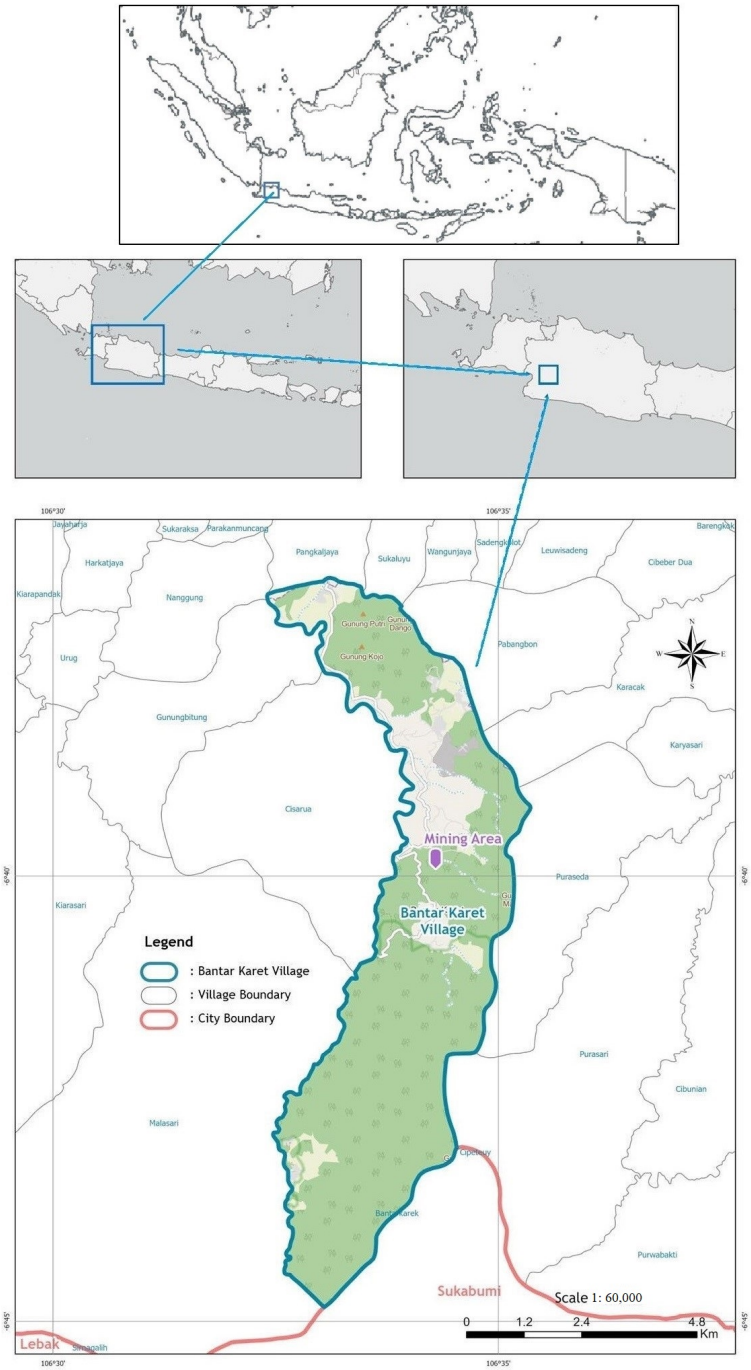

Figure 2. The study area of research.

The total population of Bantar Karet Village has a population of 11,870. Based on Bogor Regency Statistical Bureau data, Nanggung subdistrict residents who work in Pongkor gold mining numbered 789 people, all from Bantar Karet Village [56]. Antam has been conducting exploration activities since 1974 and commenced gold mining production in 1994 [57]. The existence of this company is economically and socially beneficial to the neighborhood. Before there was a mining company, road access was still in the form of land. With the mining company, the road becomes a paved road. In addition, food stalls, grocery stores, laundry services, and other small businesses emerged. In summary, this mining company's existence makes the surrounding community's economic life grow [58].

In 2018, the mine closure plan began to be socialized to the community, as the mining license was set to expire in 2021. The former mining area will be transformed by Antam into a GeoEcoEduTourism site. The concept aims to develop the former mining area into the Cikaret tourist area (Kawaci) and establish an underground mining museum as an educational tourism attraction. Both will be integrated with the Pongkor National Geopark. Through this program, the company also aims to achieve the objectives of providing educational functions, enhancing the local economy, and promoting social and tourism development to strengthen the Pongkor Geopark, which is a candidate for the UNESCO Global Geopark Network [59]. Currently, both have been realized [60]. The Kawaci Park is already open for tourism, while the mining museum is not fully operational yet due to ongoing mining activities. Mining activities are still ongoing because Antam has applied for an extension of the mining license until 2031 [61] as the exploration results indicate the continued prospectivity of the location [57].

3.3. Research Design

This research uses the IPA method with several stages. First, we used a topic-based literature review. Second, we adopted Cinner's [37] concept of adaptive capacity following the literature review. Third, we conducted a series of interviews with stakeholders regarding Cinner's [37] five adaptive capacity practices in the form of assets, flexibility, social organization, learning, and agency. Finally, to what extent is it currently being implemented, we have detailed the adaptive capacity formulation based on the recommendations of the stakeholders (Table 1).

Table 1. Dimension of adaptive capacity on post-mining plan.

Dimension	References
Assets that people can draw upon in times of post-mining	
- access to ex-mining facility assets (ACCESS FACILITY/AF)	[62–64]
- access to financial capital (ACCESS CAPITAL/AC)	[35,65,66]
Flexibility to change strategy in facing post-mining	
- increase knowledge and skills (INCREASE SKILLS/IS)	[62]
- job opportunities (JOBS OPPORTUNITIES/JO)	[67–69]
Ability to organize and act collectively in the face of post-mining	
- community members bonding (COMMUNITY BONDING/CB)	[35]
- collaborating with other organizations or communities (COMMUNITY COLLABORATION/CC)	[35,70]
Learning to recognize and respond to change when facing post-mining	
- wide spreading of information (SPREADING INFORMATION/SI)	[35,71]
- post-mining information and communication center (INFORMATION CENTER/IC)	[72,73]
The agency to determine whether to change or not face post-mining	
- be involved in post-mining policy (INVOLVE POLICY/IP)	[35,63]
- post-mining community agency initiation (COMMUNITY AGENCY/CA)	[37,42]

To gather data on the dimensions and details of post-mining reclamation, a questionnaire was designed using a Likert scale of 1–5 to measure the importance and performance of each dimension. The importance value scale ranges from 1, which means very unimportant, to 5, which means very important. The performance value scale ranges from 1, strongly dissatisfied, to 5, strongly satisfied. Along with the data on importance and performance, information was also collected on the social behavior and background of the respondents. The sample was randomly selected but limited to respondents over 20. By collecting data on both importance and performance, the study can identify the gaps between what is considered important and what is being delivered regarding post-mining reclamation. This information can help the mining company and stakeholders prioritize their efforts and allocate resources more effectively to improve the post-mining reclamation process. Additionally, the social behavior and background data can provide insights into the unique needs and perspectives of the local community, which can help inform the design of more effective and inclusive post-mining reclamation strategies.

4. Results

4.1. Demographic Characteristic

The demographic characteristics of the respondents in this study reveal important insights into their gender distribution, marital status, age groups, educational backgrounds, monthly income, and occupations (Table 2). The number of male and female respondents was approximately the same, with 213 males (50.7%) and 207 females (49.3%). The majority of respondents were already married (319 people, or 76%), and the rest (101 people, or 24%) were unmarried. Based on age, most of respondents were aged between 40–49 years (44%), 30–39 years (40%), 50–59 years (10.7%), and 20–29 years (3.1%), and the remaining 7% were over the age of 60. The educational level of the respondents was mostly secondary school (49.3%), followed by high school (44.7%), and only 6% had undergraduate education. Monthly income of the respondents was between USD 67 and 201 (39.6%), between USD 201 and 335.6 (30.2%), between USD 335.6 and 469.8 (11.2%), and less than USD 67 (19%). The jobs of respondents were dominated by those of farmers (52.6%), followed by those of small businesses (21.9%), housekeepers (15%), mining employees (7.6%), and jobs in other sectors (2.9%).

The study categorized the 420 respondents into two groups based on their tendency to face post-mining in the future. The first group, which comprised 320 respondents, desired a change, while the second group, which comprised 100 respondents, tended to maintain the current condition. The researchers used this division to compare the two groups and analyze their responses to the questionnaire. In terms of their concern for adaptive capacity building in the post-mining plan, the majority of respondents (91.8%) knew information about it. Additionally, 18.1% of respondents had attended a training program held by the mining company, 76.6% had joined social-community organizations, and 35.7% were active in them. More than half of the respondents (63.6%) had changed jobs, and 52.4% of the respondents had accessed financial capital experience.

This information can be used to identify the gaps in knowledge and access to resources between the two groups of respondents. By understanding these differences, stakeholders can design more targeted and effective interventions to improve adaptive capacity building and support the transition to a sustainable future for the community affected by post-mining.

4.2. Comparison of Importance and Performance Levels for Adaptive Capacity Dimensions

Table 3 presents the results of the mean importance and performance scores, along with the difference between the two scores, t-score, and level of significance. The data are presented for all respondents, as well as for the two groups categorized based on their tendency to face post-mining in the future. The average score for each dimension is also provided. The findings show that all dimensions have the same score ranking, with AS (assets), LN (learning), and FL (flexibility) being the most important dimensions,

followed by AG (agency) and SO (social organization). The highest performance score is for LN, followed by AG and SO, while the lowest performance scores indicating the most unsatisfactory performance are for AS and FL. However, the average score for the least important and most dissatisfied performance is a minimum of 3. In addition, the difference between the value of importance and performance is positive, indicating the need for improvement in all dimension.

Table 2. Respondent demographics and characteristic.

Characteristics	Respondent		Desire a Change		Tend to Maintain the Current Condition	
	Freq.	%	Freq.	%	Freq.	%
Total Number	420		320		100	
Male	213	50.7	181	85	32	15
Female	207	49.3	139	67.1	68	32.9
Single	101	24	67	66.3	34	33.7
Marriage	319	76	253	79.3	66	20.7
Age (years)						
20–29	13	3.1	13	100		
30–39	171	40.7	140	81.9	31	18.1
40–49	185	44	130	70.3	55	29.7
50–59	44	10.5	30	68.2	14	31.8
>60	7	1.7	7	100		
Education						
Secondary School	207	49.3	133	64.3	74	35.7
High School	188	44.7	167	88.8	21	11.2
Undergraduate	25	6	20	80	5	20.0
Monthly Income (USD)						
<67	80	19	39	48.8	41	51.3
67–201	166	39.6	126	75.9	40	24.1
201–335.6	127	30.2	110	86.6	17	13.4
335.6–469.8	47	11.2	45	95.7	2	4.3
Occupation						
Agriculture	221	52.6	179	81	42	19
Small business	92	21.9	71	77.2	21	22.8
Mining employees	32	7.6	31	96.9	1	3.1
Housekeeper	63	15.0	28	44.4	35	55.6
Other's	12	2.9	11	91.7	1	8.3
Post-mining plan awareness						
Know about post-mining plan information	398	94.8	301	75.6	97	24.4
Involved in the company training program	76	18.1	63	82.9	13	17.1
Join a community organization	322	76.7	243	75.5	79	24.5
Active in community organization	115	35.7	102	88.7	13	11.3
Experience in job changes	267	63.6	219	82	48	18
Experience in financial access	220	52.4	176	80	44	20

4.3. Comparison of Importance and Performance Levels for the Adaptive Capacity Indicator

Table 4 presents the mean scores and paired-sample t-test results of the importance (I) and performance (P) levels of adaptive capacity indicators, categorized into three groups: all respondents, respondents who desire change, and respondents who tend to maintain the current situation. The indicators are listed in order of importance mean rank, and the t-test results indicate the statistical significance of the difference between the mean scores of importance and performance. In terms of performance, the highest mean score was for the indicator of social-organizational capacity (SO), with a score of 3.632 (rank 1), indicating a satisfactory level of performance. The indicator with the lowest mean score was access to financial capital (AC), with a score of 2.554 (rank 5), indicating a dissatisfactory level of performance. The paired-sample t-test results indicate that there is a significant difference between the importance and performance levels of all indicators ($p < 0.05$).

Table 3. Mean scores and paired-sample t-test of I-P levels of respondents.

Code	Dimensions	Importance Mean (Rank)	Performance Mean (Rank)	Difference (I-P)	*t*-Value	Sig. (2-Tailed)
All respondents						
AS	Assets	4.469 (1)	3.101 (5)	1.368	35.97	0.000
FL	Flexibility	3.932 (3)	3.131 (4)	0.801	17.45	0.000
SO	Social Organization	3.806 (4)	3.208 (3)	0.598	15.82	0.000
LN	Learning	4.335 (2)	3.349 (1)	0.986	23.45	0.000
AG	Agency	3.552 (5)	3.223 (2)	0.330	12.60	0.000
Desire a change						
AS	Assets	4.467 (1)	3.133 (5)	1.334	30.63	0.000
FL	Flexibility	3.972 (3)	3.156 (4)	0.816	14.97	0.000
SO	Social Organization	3.800 (4)	3.230 (3)	0.570	13.03	0.000
LN	Learning	4.348 (2)	3.405 (1)	0.944	22.14	0.000
AG	Agency	3.563 (5)	3.230 (2)	0.333	10.81	0.000
Tend to maintain the current conditions						
AS	Assets	4.475 (1)	3.000 (5)	1.475	19.08	0.000
FL	Flexibility	3.805 (3)	3.050 (4)	0.755	9.13	0.000
SO	Social Organization	3.825 (4)	3.140 (3)	0.685	9.25	0.000
LN	Learning	4.290 (2)	3.530 (1)	0.760	8.96	0.000
AG	Agency	3.520 (5)	3.200 (2)	0.320	6.53	0.000

Table 4. Mean Scores and Paired-Sample *t*-test of I-P Levels of Respondents.

Code	Indicator	Important Mean (Rank)	Performance Mean (Rank)	Difference (I-P)	*t*-Value	Sig. (2-Tailed)
All Respondents (n = 420)						
AF	access to ex-mining facility assets (ACCESS FACILITY)	4.214 (4)	2.981	1.233	20.031	0.000
AC	access to financial capital (ACCESS CAPITAL)	4.724 (1)	3.221 (3)	1.502	38.571	0.000
IS	increase knowledge and skills (INCREASE SKILLS/IS)	3.848	3.112	0.736	10.111	0.000
JO	job opportunities (JOBS OPPORTUNITIES)	4.017 (5)	3.150 (4)	0.867	16.655	0.000
CB	community members bonding (COMMUNITY BONDING)	3.200	3.286	−0.086	−1.376	0.170
CC	collaborating with other organizations or communities (COMMUNITY COLLABORATION)	4.412 (3)	3.131	1.281	29.278	0.000
SI	wide spreading of information (SPREADING INFORMATION)	4.688 (2)	3.131	1.557	43.487	0.000
IC	post-mining information and communication center (INFORMATION CENTER)	3.981	3.567 (1)	0.414	7.711	0.000
IP	be involve in post-mining plan policy (INVOLVE POLICY)	3.379	3.310 (2)	0.069	4.524	0.000
CA	post-mining community agency initiation (COMMUNITY AGENCY)	3.726	3.136 (5)	0.590	12.122	0.000

Table 4. *Cont.*

Code	Indicator	Important Mean (Rank)	Performance Mean (Rank)	Difference (I-P)	*t*-Value	Sig. (2-Tailed)
Respondents who desire a change (n = 320)						
AF	access to ex-mining facility assets (ACCESS FACILITY)	4.212 (5)	3.012	1.200	17.514	0.000 *
AC	access to financial capital (ACCESS CAPITAL)	4.722 (1)	3.253 (4)	1.469	31.376	0.000 *
IS	increase knowledge and skills (INCREASE SKILLS)	3.822	3.206 (5)	0.616	7.080	0.000 *
JO	job opportunities (JOBS OPPORTUNITIES)	4.123 (4)	3.106	1.017	17.784	0.000 *
CB	community members bonding (COMMUNITY BONDING)	3.253	3.338	−0.085	−1.172	0.242
CC	collaborating with other organizations or communities (COMMUNITY COLLABORATION)	4.346 (3)	3.122	1.224	23.398	0.000 *
SI	wide spreading of information (SPREADING INFORMATION)	4.688 (2)	3.256 (3)	1.432	27.112	0.000 *
IC	post-mining information and communication center (INFORMATION CENTER)	4.01	3.553 (1)	0.457	7.464	0.000 *
IP	be involve in post-mining plan policy (INVOLVE POLICY)	3.403	3.341 (2)	0.062	3.861	0.000 *
CA	post-mining community agency initiation (COMMUNITY AGENCY)	3.722	3.119	0.603	10.291	0.000 *
				Respondents who tend to maintain the current situation (n = 100)		
AF	access to ex-mining facility assets (ACCESS FACILITY)	4.220 (4)	2.880	1.340	9.765	0.000 *
AC	access to financial capital (ACCESS CAPITAL)	4.730 (1)	3.120 (5)	1.610	24.780	0.000 *
IS	increase knowledge and skills (INCREASE SKILLS/IS)	3.930 (5)	2.810	1.120	9.399	0.000 *
JO	job opportunities (JOBS OPPORTUNITIES)	3.680	3.290 (2)	0.390	3.638	0.000 *
CB	community members bonding (COMMUNITY BONDING)	3.030	3.120	−0.090	−0.721	0.473
CC	collaborating with other organizations or communities (COMMUNITY COLLABORATION)	4.620 (3)	3.160 (4)	1.460	19.984	0.000 *
SI	wide spreading of information (SPREADING INFORMATION)	4.690 (2)	3.450 (1)	1.240	13.443	0.000 *
IC	post-mining information and communication center (INFORMATION CENTER)	3.890	3.610	0.280	2.500	0.014
IP	be involve in post-mining plan policy (INVOLVE POLICY)	3.300	3.210	0.090	2.377	0.019
CA	post-mining community agency initiation (COMMUNITY AGENCY)	3.740	3.190 (3)	0.550	6.698	0.000 *

* = Significant $p < 0.005$.

For the respondents who desire a change (n = 320), the most important indicator was still access to financial capital (AC), with a mean score of 4.728 (rank 1), while access to ex-mining facility assets (AF) was ranked third with a mean score of 4.234. In terms of performance, the highest mean score was for the indicator of social-organizational capacity (SO), with a score of 3.663 (rank 1), while the lowest mean score was for the indicator of access to financial capital (AC), with a score of 2.552 (rank 5). The paired-sample

t-test results indicate that there is a significant difference between the importance and performance levels of all indicators ($p < 0.05$).

For the respondents who tend to maintain the current situation ($n = 100$), access to ex-mining facility assets (AF) was the most important indicator with a mean score of 4.34 (rank 1), followed by access to information and knowledge (IK) with a mean score of 4.31 (rank 2). In terms of performance, the highest mean score was for the indicator of learning capacity (LN), with a score of 3.5 (rank 1), while the lowest mean score was for the indicator of social-organizational capacity (SO), with a score of 3.08 (rank 5). The paired-sample t-test results indicate that there is a significant difference between the importance and performance levels of all indicators ($p < 0.05$). The *t*-test results in the last two columns indicate the statistical significance of the difference between the mean importance and performance scores. All indicators have statistically significant differences with *p*-values less than 0.05, except for community members bonding (CB) which has a *p*-value of 0.170, indicating that the difference between importance and performance mean scores for this indicator is not statistically significant.

For all respondents ($n = 420$), access to financial capital (AC) was the most important indicator, with a mean score of 4.724 (rank 1). Access to ex-mining facility assets (AF) was the fourth most important indicator with a mean score of 4.214 (rank 4). All indicators have statistically significant differences between importance and mean performance scores, except for community members bonding (CB) with a *p*-value of 0.170.

The most important indicators for respondents who desire change are access to financial capital (AC) and the wide spreading of information (SI), with mean scores of 4.722 and 4.688, respectively. Access to ex-mining facility assets (AF) and job opportunities (JO) are also highly important, with mean scores of 4.212 and 4.123, respectively. The least important indicator is involvement in post-mining plan policy (IP), with a mean score of 3.403. The highest-rated indicators of performance are access to financial capital (AC) and collaborating with other organizations or communities (CC), with mean scores of 3.253 and 3.122, respectively. The indicator with the lowest performance is increase knowledge and skills (IS), with a mean score of 3.206. Table 4 displays the mean scores of the importance and performance levels of adaptive capacity indicators and the *t*-test results for the difference between these scores. The table is divided into three sections for all respondents, respondents who desire change, and respondents who tend to maintain the current situation. For all respondents, the indicators are listed in order of importance mean rank, with access to financial capital (AC) being the most important indicator, followed by the wide spreading of information (SI), access to ex-mining facility assets (AF), and job opportunities (JO). The least important indicator is involvement in post-mining plan policy (IP). The t-test results indicate that all indicators, except for community members bonding (CB), have statistically significant differences between their importance and performance scores, indicating the need for improvement in their implementation. For the group who desires change, the most important indicators are access to financial capital (AC) and the wide spreading of information (SI), while the least important indicator is involvement in post-mining plan policy (IP). The indicators with the highest performance ratings are access to financial capital (AC) and collaborating with other organizations or communities (CC), while the lowest-rated indicator is increasing knowledge and skills (IS). For the group who tends to maintain the current situation, all indicators, except for community members bonding (CB) and the post-mining information and communication center (IC), have significant differences between their importance and performance scores, indicating room for improvement in their implementations.

4.4. IPA Matrix of Adaptive Capacity Dimensions

Based on the means of the importance and performance data of the adaptive capacity dimension, we plotted the data on the IPA matrix and the results are represented in Figure 3. According to this figure, the first quadrant (keep up the work) is represented by "LN (learning)" for all respondents, respondents who desire a change, and respondents

who tend to maintain the current situation. This indicates the need to maintain and improve the ability to recognize and respond to changes when facing post-mining challenges.

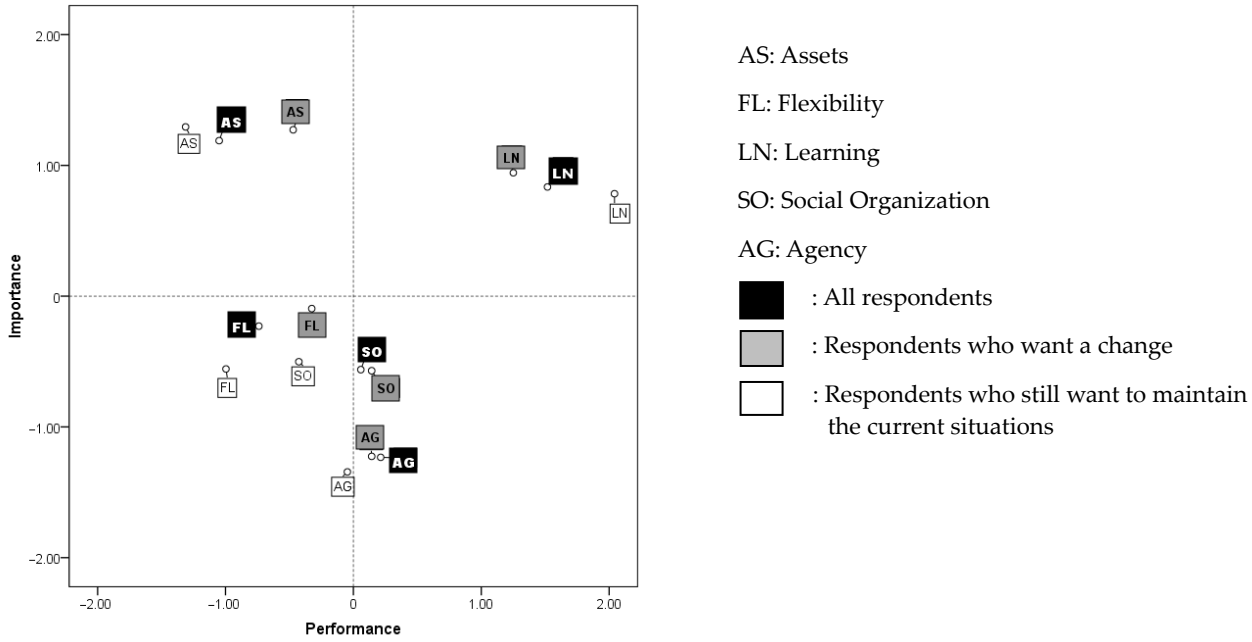

Figure 3. IPA Matrix of Adaptive Capacity Dimensions.

The second quadrant (concentrate here) is represented by "AS (assets)" for all respondents, respondents who desire a change, and respondents who tend to maintain the current situation. This means there is a need to prioritize and focus on improving access to assets that people can draw upon in post-mining.

The third quadrant (low priority) is represented by "FL (flexibility)" for all respondents, respondents who desire a change, and respondents who tend to maintain the current situation. Additionally, "SO (social organization)" and "AG (agency)" are also in this quadrant for respondents who tend to maintain the current situation. This indicates that flexibility to change strategy in the face of post-mining, agency to determine whether to change or not, and the ability to organize and act collectively in the face of post-mining are considered low-priority areas for improvement.

The fourth quadrant (possible overkill) is represented by "SO (social organization)" and "AG (agency)" for all respondents and for respondents who desire a change. Again, this suggests the need to reduce effort and allocate it to other areas that are more important in post-mining.

4.5. IPA Matrix of Adaptive Capacity Indicators

We are putting the data on the IPA matrix based on important performance indicators of adaptive capacity. The result is represented in Figure 4. The data consist of all respondents, respondents who desire a change, and those who tend to maintain the current situation. The first quadrant (keep up the work) is represented by "AC (access capital)" for all respondents and "AC (access capital) and SI (spreading information)" for respondents who desire a change. Meanwhile, respondents who tend to maintain the current situation prioritize "SI (spreading information)" in this quadrant. This indicates that maintaining and improving access to financial capital and spreading information are important areas that need to be sustained.

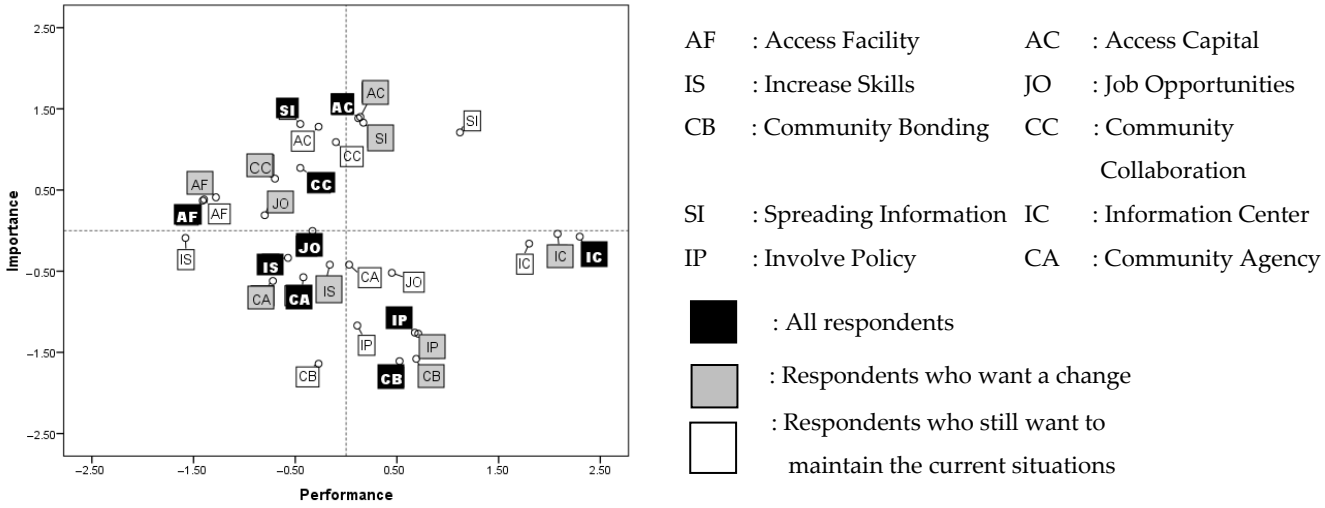

Figure 4. IPA Matrix of Adaptive Capacity Indicators.

The second quadrant (concentrate here) is represented by "AF (access facility), CC (community collaboration), and SI (spreading information)" for all respondents, while "AF (access facility), JO (job opportunities), and CC (community collaboration)" are the priority areas for improvement for respondents who desire a change. On the other hand, for respondents who tend to maintain the current situation, "AF (access facility), AC (access capital), and CC (community collaboration)" are the areas that require more attention. This suggests that there is a need to prioritize and focus on improving access to ex-mining facility assets, community collaboration, and spreading information.

The third quadrant (low priority) is represented by "IS (increase skills), JO (job opportunities), and CC (community collaboration)" for all respondents, and "IS (increase skills) and CA (community agency)" for respondents who desire a change. Respondents who tend to maintain the current situation consider "IS (increase skills), CB (community bonding), and IS (increase skills)" as low-priority areas for improvement. This means that effort on increasing knowledge and skills, job opportunities, community bonding, and agency initiation are deprioritized.

The fourth quadrant (possible overkill) is represented by "CB (community bonding), IC (information center), and IP (involve policy)" for all respondents, while "CB (community bonding), IC (information center), IP (involve policy), and CA (community agency)" are the areas that need to be reduced and allocated to more important areas for respondents who desire a change. Respondents who tend to maintain the current situation consider "JO (job opportunities), IC (information center), IP (involve policy), and CA (community agency)" as possible overkill areas. This suggests that efforts on community bonding, information center, policy involvement, and agency initiation need to be reduced and redirected towards other more important areas.

5. Discussion

Based on Table 3, overall, the results show similarity, in which respondents perceive the importance of having a high adaptive capacity. Still, there is a gap between perceived importance and actual performance. This indicates the need for interventions to improve community adaptive capacity in responding to their challenges. Based on the data presented in Table 4, there are similarities and differences in the importance and performance ratings of post-mining programs or indicators between the group who desires change and the group who tends to maintain the current situation.

The similarities are that both groups rated access to financial capital and the wide spread of information as the most important post-mining programs, while increasing knowledge and skills was rated as the least important program for both groups. In terms of performance, both groups rated access to financial capital and collaborating with other

organizations or communities as the highest-performing programs, while post-mining information and communication centers were rated as the lowest-performing programs for both groups.

The differences between the two groups are that the group who desires change rates access to ex-mining facility assets and job opportunities as highly important. The group that tends to maintain the current situation rates collaborating with other organizations or communities and access to ex-mining facility assets as highly important. Additionally, the group who desires change rates involvement in post-mining plan policy as the least important program, while the group who tends to maintain the current situation rates increasing knowledge and skills as the least important program.

The I-P scores for each program reveal that there is a need for improvement in the implementation of post-mining programs. All programs, except for bonding between community members and the post-mining information and communication center for the group who tends to maintain the current situation, have significant differences between their importance and performance scores. Therefore, policymakers should focus on improving these programs to better meet the needs and expectations of both groups.

The study suggests that policymakers should prioritize post-mining programs related to access to financial capital and the wide spreading of information, as they are highly important and highly performing. Policymakers should also consider the differences in importance ratings between the two groups and tailor their policies accordingly. Efforts should be made to improve the implementation of post-mining programs with significant differences between importance and performance scores to ensure that they meet the needs of both groups. The IPA matrices of adaptive capacity dimensions indicate that both groups in the study recognize the importance of learning to recognize and respond to change, as shown in the first quadrant. This suggests that awareness of the need for ongoing learning and adaptation is critical for post-mining adaptive capacity. Therefore, policymakers and mining companies should support communities in building knowledge for change and provide them with the necessary resources to enhance their adaptive capacity [74,75].

In the second quadrant of the IPA matrices, it is clear that both groups recognize the importance of having assets that they can rely on during post-mining periods. This suggests that such assets are essential for adaptive capacity. Therefore, policymakers and mining companies should collaborate with communities to identify and develop these assets, such as financial capital, infrastructure, and social capital [76], to leverage assets for livelihood transitions and community development.

In the third quadrant of the IPA matrix, it is observed that the desire for change group places more importance on flexibility than the status quo group, while social organization/agency is also less emphasized by the latter. This difference indicates that the groups have varying perspectives on the value of being able to change strategies and determine their own changes. In light of this, it is recommended that policy makers and mining companies should understand these differences and facilitate discussions on how flexibility and agency can support adaptive capacity. This may help in developing tailored policies that cater to each group's specific needs and expectations [37].

In the fourth quadrant, the desire for change group places less emphasis on social organizations and agencies, indicating that they do not necessarily need to focus on building new agency as community cohesion and self-determination are already recognized as valuable. Policymakers and mining companies do not need to prioritize creating complex systems, and communities can work with existing networks. On the other hand, the status quo group also does not prioritize social organizations or agencies, but further discussions may reveal worthwhile investments. Regular review of priorities and progress can help determine if more focus on these areas would be valuable. Based on adaptive capacity matrices, the key ways to increase community adaptive capacity are as follows: learning and responding to change; leveraging resources and partnerships; understanding and reconciling perspectives on flexibility/agency; and reviewing/adjusting priorities as needed. By working together on these, post-mining planning can support resilience [77].

The final findings suggest that both the desire for change group and the status quo group recognize the importance of learning to recognize and respond to change and the assets that they can draw upon in post-mining situations. However, the desire for change group places greater importance on flexibility and social organization/agency, while the status quo group places less emphasis on these factors. Based on these findings, policymakers and mining companies should prioritize supporting communities in building knowledge for change and providing access to assets that can be drawn upon in post-mining situations. Additionally, facilitating discussions on the value of flexibility and agency for adaptive capacity may be useful, particularly for the desire for a change group. Regularly reviewing priorities and progress can help determine if more focus on building social organizations and agencies would be valuable for both groups.

In the first quadrant of the IPA matrices of adaptive capacity indicators, the local community prefers to keep up the work in maintaining access to financial capital (AC) and spreading information (SI). Both groups consider these factors important for capacity building. This indicates the significance of ensuring continued access to resources and transparent communication, which policymakers and mining companies should facilitate. Providing regular updates on plans, challenges, opportunities, and progress can help communities make informed decisions and take necessary actions and investments. In regard to the second quadrant (concentrate here), for groups who desire change, focusing on utilizing assets (AF), building partnerships (CC), and creating jobs (JO) drives progress toward desired change. Policymakers and mining companies should work with this group to leverage assets/funding and connect them with partners for new ventures and employment options. For the status quo group, focusing on utilizing assets (AF), building partnerships (CC), and securing funding (AC) maintains the existing situation. Policy makers and mining companies should work with this group to ensure access to assets, relationships, and financial access to support continuity.

As for the third quadrant (low priority), for groups who desire change, deprioritizing education/training (IS) and creating new agencies (CA) could limit capacity if the change is substantial. Some investment may still be needed to build skills/knowledge for successful adaptation [37] and strengthen governance. Policy makers and mining companies should consider whether reduced focus poses risks and determine appropriate levels of support. For the status quo group, deprioritizing education/training (IS) could limit their capacity to adapt to any changes. Some continued learning/training opportunities may benefit this group in maintaining/enhancing its adaptive potential, even with a scheme for continuity. Policy makers and mining companies should consider the risks of a reduced focus on learning and advocate for at least moderate investments in this area.

Lastly, for the fourth quadrant (possible overkill), excessive focus on community building (CB), policy involvement (IP), information centers (IC) could be counterproductive for either group's goals. Policy makers and mining companies should discuss priorities with stakeholders and help determine adequate effort levels in different areas based on key objectives and constraints. Some coordination and information access level is important for capacity, but "overkill" should be avoided.

Building adaptive capacity requires providing access to assets and resources, open communication/information, supporting priorities, considering the risks of reduced focus areas, enabling compromise, and helping groups achieve balance. Policy makers and mining companies must carefully consider both "keeping up the work" of existing adaptive capacity potential and "concentrating" new efforts to drive change or continuity. Flexibility support that adapts to communities needs and priorities will be most helpful for developing the adaptive capacity vital to resilience. The proper allocation of adaptive capacity indicators can help increase the community's adaptive capacity as needed to face post-mining.

6. Conclusions

This research aims to develop an adaptive capacity framework into post-mining plans based on IPA and integrate it into post-mining planning policies and action plans. Based on the discussion above, we develop an adaptive capacity framework that can guide organizations and communities to enhance their ability to adapt and thrive in the face of changing circumstances (Figure 5). The framework consists of the following: learning (LN)—this dimension emphasizes the importance of recognizing and responding to change. It includes learning from experience, acquiring new knowledge and skills, and effectively disseminating and applying this knowledge across the organization or community. The IPA matrices showed that LN was consistently identified as a critical dimension across all studies, indicating the importance of building and maintaining this capability.

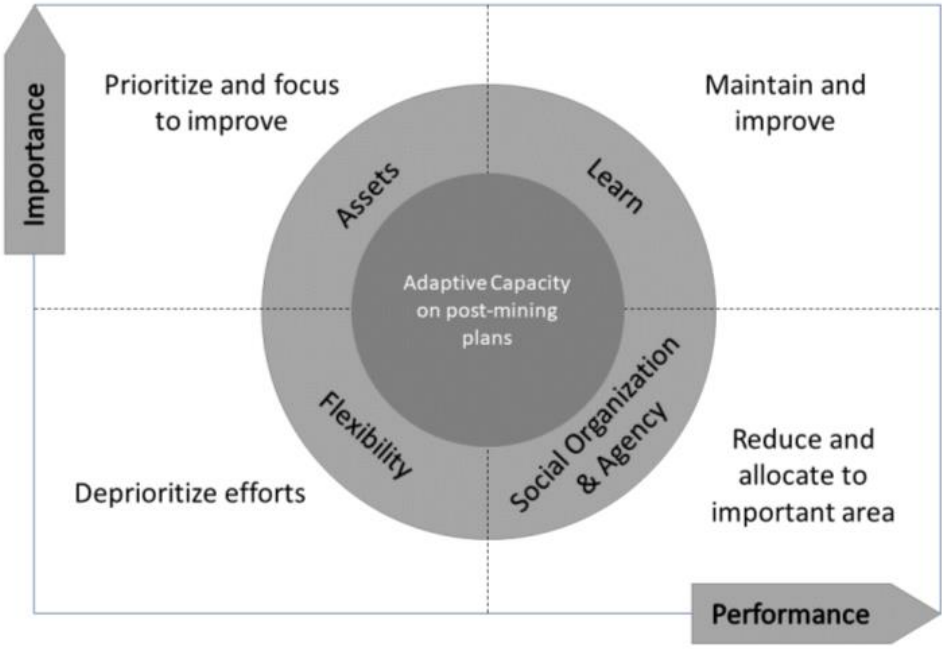

Figure 5. Adaptive capacity framework in post-mining plans based on IPA.

Second, assets (AS)—this dimension relates to drawing upon and utilizing resources effectively in post-mining situations. This includes financial resources, physical assets, and partnerships and collaborations with other organizations. The IPA matrices showed that AS was a critical dimension for both groups, which highlights the importance of maintaining access to resources to achieve desired change or maintain the status quo.

Third, flexibility (FL)—this dimension highlights the importance of adapting and changing strategies in response to changing circumstances. It includes being flexible and nimble, adjusting plans and activities as needed, and continuously assessing and revising approaches to achieve desired outcomes. The IPA matrices showed that FL was a critical dimension for both groups, underscoring the importance of adaptability in post-mining situations.

Fourth, social organization and agency (SO/AG)—this dimension emphasizes the importance of social capital, agency, and governance structures in achieving desired change. This includes community participation and engagement, the ability to mobilize resources, and the capacity to influence decision-making processes. The IPA matrices showed that SO/AG was less critical than the other dimensions, but it still played a role in achieving desired change or maintaining the status quo.

To integrate the adaptive capacity framework into post-mining plan policies, policy-makers and mining companies should prioritize learning and flexibility. In addition, both groups must recognize the need to remain open and adaptable to changing conditions to

respond effectively. This can be achieved by investing in training and education programs for workers and being open to new ideas and strategies for sustainable mining practices. Access to assets and resources is critical for groups wishing to maintain the current situation and those who desire change. Policymakers should support mining companies to ensure access to financial capital and ex-mining facility assets. Mining companies should build partnerships with other organizations and create job opportunities to drive change.

The widespread dissemination of information is important for both groups wishing to maintain the current situation and those who desire change. Policymakers should ensure that information about sustainable mining practices is widely available to all stakeholders. Mining companies should also focus on communicating their sustainability efforts to stakeholders. Policy makers and mining companies should be aware of low-priority indicators, such as post-mining community agency initiation and bonding between community members. While these indicators are still important, they should not be prioritized over more critical indicators, such as access to assets and resources.

It is essential to avoid overkill in areas such as policy involvement, setting up information and agencies, and creating jobs. While these are important indicators, excessive investment in these areas could lead to inefficiencies and the waste of resources. Instead, the focus should be placed on critical indicators most important for achieving sustainable mining practices. Finally, policymakers and companies can carry out the following action plan: identify and prioritize the adaptive capacity dimensions by analyzing the local context and engaging with stakeholders. This will enable a better understanding of the critical areas that need investment and support to ensure sustainable mining practices.

To effectively integrate the adaptive capacity framework into post-mining plan policies, policymakers and mining companies should work collaboratively to identify the most critical dimensions and prioritize their efforts accordingly. Once these dimensions have been identified, strategies can be developed to improve adaptive capacity. These strategies may involve investing in education and training programs, promoting community engagement and collaboration, and investing in physical infrastructure and assets that can be leveraged in post-mining scenarios. It is important to monitor and evaluate progress to ensure that implemented strategies have the desired effect. Policymakers and mining companies should foster an environment that encourages experimentation, innovation, and learning. They can promote knowledge sharing and collaboration among stakeholders, provide resources for research and development, and support the development of new technologies and practices that can improve adaptive capacity.

Building resilience is also critical for effective adaptation. Therefore, policymakers and mining companies should prioritize efforts to build resilience among communities and ecosystems. This may involve investing in natural resource management practices, promoting sustainable livelihoods, and working to build social capital and community cohesion. This study does not explicitly state which Sustainable Development Goal (SDG) it has achieved. However, it aligns with several SDGs, including Goal 8 (Decent Work and Economic Growth), Goal 10 (Reduced Inequalities), and Goal 17 (Partnerships for the Goals).

The study's findings can help policymakers and mining companies to develop and implement sustainable mining practices that promote economic growth, reduce inequalities, and build partnerships with local communities. By prioritizing adaptive capacity dimensions, such as access to assets and resources, and ensuring the widespread dissemination of information, mining companies and policymakers can create a more sustainable post-mining scenario. As for future research recommendations, this study suggests that further research is needed to develop more specific strategies to improve adaptive capacity in post-mining scenarios. It recommends that future studies focus on exploring the relationship between adaptive capacity and sustainable livelihoods and the role of partnerships and collaboration in building adaptive capacity. Additionally, the study suggests the need for more research on the long-term effectiveness of strategies to improve adaptive capacity in post-mining communities.

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