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Potential Impacts of Mining to Resources along Carac-an Watershed, Eastern Mindanao, Philippines: Total Economic Value Estimates

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ABSTRACT

Mining extracts minerals are important in the technological advancements of humanity. This leads to a progressive society, address relevant medical issues, food-security problems, and even creates various jobs. However, the externalities of mining activities like land-use changes are inevitable that could affect the resources and various users. Hence, this study was conducted to obtain an estimate of the total economic value of resources that are adversely impacted by mining activities, particularly the basic goods and services used by the people. Estimating the total economic value, includes computing the use and non-use values and the existence and bequest values. The study sites covered were within the Carac-an Watershed along the Municipalities of Cantilan, Madrid, and Carrascal. Primary and secondary data were obtained and used as basis in estimating the total economic value. Results showed that the total economic value of use and non-use goods and services along the Carac-an Watershed had amounted to PhP 4,569,224,709.00 per year. This can be considered as an environmental asset that would be lost as a consequence of mining operations. However, this economic value is too huge to be compromised by the externalities (e.g. pollution, deforestation, land use change and siltation) out of mining activities thereby putting the community and the environment at risk. While this finding was only based on estimated values, it is still imperative to revisit the implementation of mining operation. Further, relevant comprehensive study is recommended to fully capture the values of other resources not considered in this study.

INTRODUCTION

Mining extracts precious minerals that are important in the technological advancements of human history. This leads to a progressive society, addressing relevant medical issues, food security problems and even creation of various jobs (Bainton, 2020). The externalities of mining activities like pollution and changes in landscapes are inevitable. Pollution problems and land-use change affect the most marginalized and vulnerable sectors of society like the indigenous communities (Shiquan et al., 2022). Other adverse impacts of mining include displacement human rights violation (e.g. property destruction), and loss of culture and identity. Oftentimes, mining created conflict of interests among the resource users for those who benefit and from those who oppose it. This consequence may result into a fragmented cultural heritage and natural resource uses (Wetzlmaier, 2002; Loayza and Rigolini, 2016; Bebbington et al., 2008).

Efforts to do responsible mining are often exercised by concerned concessionaires. This includes reclamation of mined sites and ecological restoration programs. This is in response to mining consequences that destroy biodiversity, loss of species and habitat integrity. Efforts to do reclamation of mined sites may result into simplification of the environment and an altered predator-prey relationship. This is because only few species may survive given the environmental conditions of reclaimed mined sites. Ecosystem simplification is simply a result of altered habitat structure and composition like presence of bare ground, herbaceous land cover, rock outcrops, and woody debris (Larkin et al., 2008; Dudka and Adriano, 1997; Haddaway et al., 2019). Therefore, the species of high environmental values like wild pigs, deers, eagles, and tarsiers could no longer be restored. Some of these species are said to be found in the areas surrounding the mining site along Carac-an Watershed. Other impacts include acid which is drained into waterways thereby contaminating the surface and ground water resources (Gray, 1996; Gray, 1998). This consequence, in turn, inhibits the ecological relationships of aquatic biota and domestic uses of water. Hence, the ultimate consequence of mining activities may be the alteration of quality of life among plants, animals and human beings (Appleton et al., 2006; Sonter et al., 2014).

Mining and its consequent externalities are unavoidable, yet it must be done to augment socio-economic development. Hence, this study was conducted to obtain an estimate of the total economic value of resources (i.e. use and non-use values) impacted on by mining. This is the environmental cost as a consequence of mining operations. The initial findings obtained from this study will serve as a baseline information to guide decision-makers in undertaking more extensive research to assess mining operations and their adherence to national and local laws, ensuring sustainability and benefits for the present and future generations.

MATERIALS AND METHODS

The Study Site

The Carac-an Watershed, which the Carac-an River drains its waters, is covered by the municipalities of Cantilan, Madrid and Carrascal in the Province of Surigao del Sur, Philippines. The Carac-an River is covered by Proclamation No. 1747, s. 2009, which declares "the portions of the public domain of Alamio, Buyaan, Carac-an, Panikian Rivers and Sipangpang Falls, situated in the municipalities of Carrascal, Cantilan and Madrid, Province of Surigao Del Sur and in the municipalities of Jabonga, Santiago, and Cabadbaran, Province of Agusan Del Norte, as Watershed Forest Reserves" (Proclamation No. 1747, s. 2009). Cantilan, situated at coordinates 9°20'8''N; 125°58'36''E, is primarily a rural coastal town. Approximately, 20,652 individuals, constituting 68% of the overall municipal population, reside in rural areas, while around 9,579 individuals, making up 32%, reside in urban settlements. The primary sources of livelihood are agriculture and fishing, with mining, logging, and the timber industry having only recently flourished. This information was gathered from the Comprehensive Land Use Plan (CLUP) of the Municipal Planning and Development Office of Cantilan. Within this municipality, three randomly selected barangays served as sampling sites of the study, namely: Cabangahan (9°16'34''N; 125°53'18''E), Cabas-an (9°16'34''N; 125°53'18''E) and Magasang (9°20'27''N; 125°57'14''E). With relatively similar environmental and socio-economic conditions with Cantilan, two other municipalities were considered as study sites as well. In the Municipality of Carrascal (9°22'6''N;

125°56’58’’E), Barangay Gamuton (9°21’54’’N; 125°56’16’’E) was selected since this is a coastal barangay which may have also been adversely impacted by the mining activities. Lastly, in the Municipality of Madrid (9°15’41’’N; 125°57’50’’E), there were three randomly selected barangays namely: San Antonio (9°15’6’’N; 125°59’40’’E), San Juan (9°14’51’’N; 125°58’41’’E) and Patong-Patong (9°15’48’’N; 125°56’51’’E) (Fig. 1).

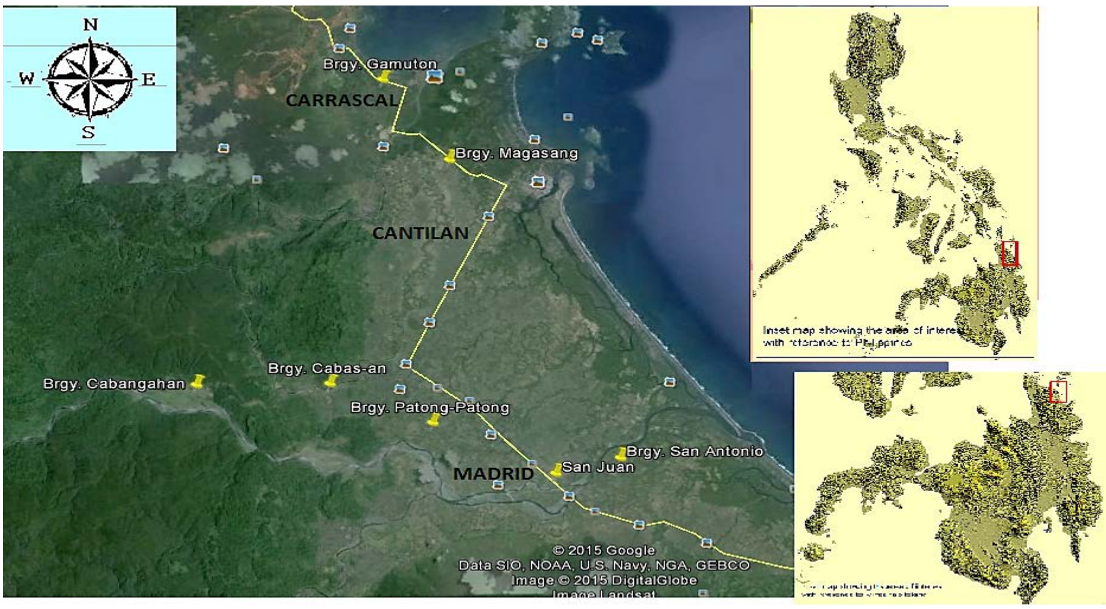

Figure 1. The sampling sites at Cantilan, Madrid and Carrascal municipalities, Surigao del Sur (Source: Google Earth).

After all preliminaries (entry protocol visits, meetings and discussions, acquisition of permits and prior informed consents) were done, conduct of in-person interviews using survey schedules (pilot tested) and focus group discussions (FGD) followed in the study sites identified. A total of 623 participants, equally distributed among the barangays, were randomly selected to be surveyed in this study. Each participant should be the household head or a representative aged 20 year or older, regardless of gender. Secondary sources of data were also obtained from any relevant offices like Municipal Planning and Development Office, Municipal Agricultural Office, Municipal Tourism Office, and Barangay offices.

Estimating the Total Economic Value

The survey interviews and FGDs used were designed to obtain monetary values of the resources along the Carac-an watershed. This is to fill-in information needed for the use and non-use values of the resources. All monetary values obtained were expressed in Philippine Peso (PhP) per year. Active use values comprised the direct and indirect values expressed in monetary terms using market price method, surrogate market price method, travel cost method, damaged cost method, and benefit transfer method (e.g. actual project cost of the Cantilan research). The passive use values include the bequest and existence values, wherein the average monetary values where obtained using the willingness to pay (WTP) of the participants. WTP is influenced by the understanding, knowledge, perception and attitude of the participants, a personal monetary value placed for the resources or based on an economic status. Mean values were obtained and expressed in Philippine peso per year based on the current market prices in the localities of Surigao del Sur. Below described the attributes of the valuation techniques used following Costanza et al. (1997):

Market Price Method

This primary valuation method often used in estimating the economic value of ecosystem products or services that are bought and sold in commercial markets. It uses the prevailing market prices for particular goods and services to be valued. In this study, the market price method was used to compute economic values of extractive products derived from socio-economic assessment and watershed ecosystem. Prices are based on the local markets of goods.

Travel Cost Method

This method often used to estimate benefits from recreation in natural sites whose value cannot be obtained through market prices. It is computed by determining the willingness to pay to visit the site through the travel and opportunity costs incurred in a trip. The value of the recreation and ecotourism of the watershed resource was estimated using this approach.

Benefit Transfer Method

Benefit transfer method is a secondary means of estimating the value of environmental goods or services through the previously conducted similar studies but subject to some adjustments. It was applied to estimate the value of the following use and non-use values of the watershed resources like the wildlife products, forest products, flood/erosion control, research and education, and fishes.

Damage Cost Method

This approach is one of the cost-based valuation techniques that used to estimate value of lost ecosystem services through the costs to be incurred in avoiding damages. It was applied in the study to determine the value of protection function of the watershed ecosystem.

Contingent Valuation Method

This is the most widely used method in estimating the non-use values of the particular ecosystem. It applies the concept of willingness to pay of the community for specific environmental services. It was used to determine the option value of the watershed ecosystems.

RESULTS AND DISCUSSION

Total Economic Value

The method to determine the relative value of different habitats is to rank them according to different criteria as sum of its direct, indirect, option, and existence values (Torras, 2000). It can be intrinsic like flora and fauna diversity, or extrinsic like cost for acquisition. The economic importance of ecosystem services can be measured by their contribution to production, consumption and employment (Navrud and Pruckner, 1997). In this study, the total economic value of the resources in the seven sampled barangays in the three municipalities was PhP 4,569,224,709.00. Foremost, direct use value was estimated at PhP 66,256,593.00, which was described below (Table 1):

Table 1. The estimated TEV (direct use value) of the resources within the Carac-an Watershed.

Goods/ Services	Cantilan			Carrascal	Madrid			Total
	Cabangahan	Cabas-an	Magasang	Gamuton	San Antonio	San Juan	Patong-Patong	
Agricultural crops	1,787,700.00	4,342,923.00	6,564,682.00	2,650,000.00	6,207,019.00	6,508,228.00	6,115,542.00	**34,216,095.00**
Livestock	2,233,950.00	4,672,401.00	3,905,318.00	2,390,000.00	3,909,561.00	4,064,218.00	4,865,310.00	**26,040,758.00**
Fishes	16,080.00	2,560.00	2,760.00	8,500.00	7,690.00	3,500.00	5,670.00	**46,760.00**
Wildlife	68,750.00	0	0	85,000.00	0	0	0	**153,750.00**
Minerals	2,457, 000.00	0	1,000,000.00	850,000.00	42,560.00	1,296,787.00	152,883.00	**5,799,230.00**
Total	**6,563,480.00**	**9,017,884.00**	**11,472,760.00**	**5,983,500.00**	**10,166,830.00**	**11,872,733.00**	**11,179,406.00**	**66,256,593.00**

Agricultural crops

Agriculture plays a critical role in the economy providing food, raw materials, and employment opportunities. Given its economic relevance, it is imperative to sustain agroecosystems to optimize its productivity, stability, autonomy and equitability (Marten, 1988). Along the Carac-an Watershed, the three municipalities had grown several crops including the staple rice and corn, fruit and leafy vegetables and various fruits. Rice and corn grains were sold to buyers and some were left for consumption of the family. Based on the current market price in the municipalities, agricultural crops and vegetables had an average value of PhP 34, 216, 095.00. Direct market prices of these agricultural crops ranged from PhP 1.7 to 4.9M/year within the seven barangays sampled. The participants perceived that this income derived from agricultural crops could be lost when uncontrolled silt influx coming from mining activities continue to flow and damage their farmlands. Consequently, there could be future food security issues, including the possibility of increased market prices for rice and corn, which are staple cereals for the communities. The findings in this study align with those of Mishra and Pujari (2008), affirming their analysis that indicated a decline in agricultural activity attributed to mining activities.

A shift in livelihood from agriculture to mining related work happened and this social change is an indicator of rural development in the mining area, in spite of a reduction in agricultural productivity. Similar findings of unlikely impacts of mining were also observed by Kitula (2005).

Livestock

Livestock are considered by the residents as capital assets of the family that include pigs, cows, carabaos and even poultry (i.e. chickens and ducks). The total monetary value of livestock in the three municipalities was PhP 26,040,758.00. This monetary value was based on their current market prices when those livestock were either sold as a whole and live or as meat carcasses. The average value per barangay is as follows: Cabangahan (PhP 2,233,950.00), Cabas-an (PhP 4,672,401.00), Magasang (PhP 3,905,318.00), Patong Patong (PhP 4,865,310.00), San Juan (PhP 4,064,218.00), San Antonio (PhP 3,909,561.00), and Gamuton (PhP 2,390,000.00). According to the participants, livestock could not be directly affected by mining activities except for noise disturbance of the cruising heavy equipment, dust emissions along the roads, and turbid drinking water in waterways. The findings of the study might conform to the study of Uyanga (2013) such that, increase in mining activities are associated with higher mortality of livestock indicating negative environmental externalities.

Fishes

Fishing in the rivers was regularly done by the residents for food and some high commercial value fishes caught were sold in the market at relatively higher prices. In particular, these were freshwater eels and mullets sold at PhP 300.00 per kilo. Some fishes were used as food items as substitute for buying commercial marine fishes like tuna and sardines. Fishing and the fishes caught were affected by the turbidity of the water due to continuous influx of silts from mining activities as perceived by the participants. They also had noticed their dwindling catches over time. Consequently, this reduced their added income and the benefit they derived from the fishes in the river system. Generally, it incurred a total monetary value of PhP 46,760.00 within the seven barangays sampled. These findings are in line with the research by Fontaine et al. (2023), indicating that heavy metal contaminants bioaccumulation induces oxidative stress to fishes.

Wildlife Species

Wildlife ensures balance of the predator-prey relationships in healthy ecosystems. Wildlife species of plants and animals were present in the terrestrial areas of the three municipalities like rattan, wild pigs, snakes (e.g. python, king cobra), deer, birds and giant fruit bats. The consequent impact was the dwindling number of individuals in the wild due to loss of prey species, habitat destruction and hunting. All of which were attributed to the operation of mining activities. In the study of Rehman et al. (2021), habitat destruction and hunting are major threats to wildlife. Local animals depend on the local jaws as they are the only source of food and shelter. The degradation of flora results in the death of fauna. Mining pushes the fauna of concerned area towards extinction. Consequently, the human presence in the mining area multiplies the human urge to hunt and human settlement. The total monetary value based on the market prices of the wildlife products sold had amounted to PhP 153,750.00 for Barangays Cabangahan (PhP 68,750.00) and Gamuton (PhP 85,000.00), respectively.

Minerals (Sand and Gravel)

Sand and gravel quarry comprised the bulk of monetary income among the communities. These were roughly sold at PhP 1,500.00 per full dump truck load. Income derived from this activity incurred a total of PhP 5,799,230.00. These sand and gravel quarries were present in all barangays except in Brgy. Cabas-an of the Municipality of Cantilan. According to the participants, the impact of mining activities was the good quality of sand and gravel quarried due to indiscriminate presence of silt particles.

Indirect Use Values

Indirect use values of the resources within the Carac-an Watershed were obtained and the values were translated into the ecological, socio-cultural, protection, research and education values. Overall, this had a total average value of PhP 341,568,116.60 (Table 2). These were the various collective programs and projects of the local governments of the three municipalities provided to the seven barangays considered in this study.

Table 2. The estimated TEV of the indirect use values of the resources within the Carac-an Watershed**.**

Items	**PhP/year**
Flood control	401,709.00
Typhoon/disaster control	3,676,500.00
Habitat rehabilitation programs	1,748,010.00
Human health services	30,166,144.80
Waste management programs	1,037,142.00
Faunal biodiversity and conservation	19,180,315.97
Floral biodiversity and conservation	13,396,732.00
Soil fertility/production	211,890,210.00
Provision of clean water	48,605,423.76
Eco-tourism potential	8,765,929.07
Research and education	2,700,000.00
Total	**341,568,116.60**

The monetary equivalent from indirect use values were based on the annual budget of the LGUs of the three municipalities for the seven barangays. Specifically, these programs and projects were for flood control, typhoon and disaster control, habitat rehabilitation, human health services, and waste management. Values on the diversity of fauna and their conservation initiatives were based on the values derived from the studies conducted by the Secretariat to the Convention on Biological Diversity (2001) and Kling (1993). Soil fertility and its production function values were based on the study of Pimentel (1995), which were translated into the loss of soil nutrients and fertility that affect its productivity function. Likewise, values derived for floral diversity and conservation were based on the study of Carandang (2008). Provision of clean water was derived from the study of Young (1986). Research and education values were derived from the actual project cost incurred for this study.

The socio-economic and ecological significance for these indirect use values of the resources could be impaired upon the operations of mining as perceived by the participants. The adverse impacts that were assumed by the participants might be influenced by corresponding prices of the natural resources present that are highly volatile over time as a function of labor force, income distribution and public spending (Alvarado et al., 2021). Once these resources are lost, these would take several periods of time to recover, and therefore, could pose serious deleterious impacts for the benefits of the present and future generations (Bebbington et al., 2008). Theoretically, some potential consequences foreseen in the future would be the impaired functions to regulate local and global climate, ameliorate weather events, regulate hydrological cycle, protect watersheds and their vegetation, water flows and soil quality, and provide vast genetic information. Looking beyond, the growing population in the area might have no choice but to adapt to the changing landscapes driven down by environmental disturbances in mined sites (Dou et al., 2023). For some farmers, opportunity costs were given to them through jobs in mining activities for their food and cash income (Olsen et al., 2011).

Existence Value

Existence values are an unusual and somewhat controversial class of economic value that reflect the benefit people received from a particular environmental resource. They did not require that utility be derived from direct use of the resource, instead the utility comes from simply knowing that the resource exists. The existence value of the resources was obtained by the average willingness to pay of the participants for the existence of an environmental resource without an on-site use, and was motivated only by the ecological ethics, altruism toward others or bequests to future generations.

The data revealed that the existence value of the resources placed by the participants in the three municipalities was PhP 109,600,000.00. This value was distributed as follows: San Juan (PhP 100,000,000), Cabas-an (PhP 4,000,000), Magasang (PhP 2,300,000), Patong Patong (PhP 1,800,000), San Antonio (PhP 1,000,000) and Gamuton (PhP 500,000).

Bequest Value

Bequest values represented the values attached to preserving a good or service for the use of the future generations. This was determined by a person's concern that future generations should have access to resources and opportunities. It indicated a perception of benefit from the knowledge that resources and opportunities would be passed to descendants either cultural, artistic, aesthetic, intergenerational and historical importance.

The data revealed the total bequest value of PhP 4,050,800,000.00 obtained from the seven barangays, distributed as follows: Patong-Patong (PhP 1,500,000,000), Magasang (PhP 950,000,000), Cabas-an (PhP 800, 000,000), Cabangahan (PhP 400,000,000), San Antonio (PhP 300,000,000), San Juan (PhP 100,000,000) and Gamuton (PhP 800,000).

The bulk of monetary amounts placed by the participants in the existence and bequest values of the resources present in the Carac-an Watershed are simply derived from their respect and love for the resources. In this regard, the resources cannot be valued solely based on the income they generated. There is a genuine fear that they could be permanently lost if mining operations are not sustainably managed.

Economic Benefits from Mining

In like manner, based on the data acquired from the Municipal Planning and Development Offices of the three municipalities, their constituents also benefit from mining operations that amounted to PhP 198,710,593.28 annually, which was distributed into: Social development management program (PhP 84,209,817.37), monetary benefit given to the total number of scholars supported (PhP

2,102,650.00), total salary paid to local employees (PhP 11,903,598.21), total tax given to the three municipalities (PhP 80,494,527.70) and the royalty given to the indigenous communities per year (PhP 20,000,000.00).

The total economic value of the resources (i.e. PhP 4,569,224,709.00) is considered an environmental asset that can be lost as a consequence of unsustainable mining activities. While the amount of PhP 198,710,593.28 was derived from mining activities, this was still undermined by the economic and ecological benefits that might be lost at around 4.3 billion pesos per year These initial findings from the study could align with the research conducted by Shiquan et al. (2021) that mining caused 18.5% and 13.6% of income and health loss among the communities. However, this could be masked by the income and other vital socio-economic benefits that mining has provided for the people. Therefore, it is imperative for the decision-makers and various resource-users in the mining area to understand how various concepts of economic and ecological values are structured, how they relate to each other, and how they can guide them (Bingham et al., 1995) to achieve a more sustainable means of mining for the benefits of the present and future generations.

CONCLUSION AND RECOMMENDATIONS

Mining operations in Cantilan, Madrid, and Carrascal, which are all situated within the Carac-an Watershed, have considerably improved the lives of those employed in the sector through a provision of an increased income. However, this stands in contrast to the externalities (e.g. pollution, deforestation, land use change and siltation) associated with mining, which can pose significant challenges for both the community and the environment, potentially leading to serious problems in the future.

In this study, the total economic value of the resources roughly around PhP 4.5 billion per year is relatively too huge to be compromised by mining activities besides the economic benefits that were translated into socio-economic services. While this was only based on estimated total economic values as perceived by the participants, it is still imperative to revisit the implementation of mining operation to be sustainable for the present and future generations. Further, relevant comprehensive study is recommended to fully capture the values of other resources that are not considered in this research; and to strengthen the initial findings of this study, for instance, the conduct of Cost-Benefit Analysis (CBA). Likewise, it is important to revisit the impacts of mining to the socio-economic aspects (i.e. quality of life and standard of living) and socio-ecological systems within the watershed and nearby localities.

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