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COPPER MINING AND ENVIRONMENTAL COSTS IN DOMINICA

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COPPER MINING AND ENVIRONMENTAL COSTS IN DOMINICA

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ABSTRACT

A proposal from an international mining company to establish a copper mining operation in the Caribbean island of Dominica could be highly favourable, given the potential for financial benefits associated with such a project. On the downside, such projects are often associated with environmental damage. The area targeted for this copper mine was a rainforest in the north-eastern portion of Dominica occupying around 12 percent of the island's total land area.

A critical question is therefore whether copper mining could be a viable alternative to agrarian uses of the targeted area, if both financial and environmental costs are taken into consideration.

A Contingent Valuation Survey of Dominicans and Visitors allowed for inclusion of non-market costs in the analysis. Cost-Benefit and sensitivity analyses were carried out to assess project feasibility. The results indicated that NPV was negative under conservative assumptions. NPV was sensitive to changes in the price of copper and the inclusion of environmental costs did affect the level of price increase required to make NPV positive.

Keywords: Copper mining, Dominica, environmental costs, sensitivity analysis, cost-benefit.

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INTRODUCTION

In 1997 the Caribbean island of Dominica was confronted with a major decision when an international mining company applied for a prospector's license to mine copper in the north-eastern portion of the island. Given the island's weak economic condition, the possibility of a mining industry in the heart of the rainforest of a tiny island raised the thorny question of the country's willingness to pay a possible environmental price for such development.

For its own reasons, the company later withdrew and the mining did not take place. Nevertheless, the question remains whether the welfare of Dominicans could have been improved with the mining of copper. Inquiry into this issue is of necessity concerned with accounting for the environmental costs of such a project.

This article first describes the Dominican scenario with respect to the status of its economy, its experience with the copper mining company and the potential environmental effects of such an operation. Against this background, the problem is defined and objectives of the research exercise are explained. This is followed by details of the empirical method utilised, the results of the analysis and conclusions, particularly with respect to whether the inclusion of environmental costs was of value to the analysis.

The Dominican Economy

The Dominican economy is at the crossroads. Globalisation is exerting external pressure to generate new competitive economic activities and internal pressure is also being brought to bear on the economy to satisfy growing expectations for higher living standards.

Agriculture continues to be the largest single contributor to total output in Dominica, though its relative contribution to the economy has been declining over the years, moving from 27.94% in 1985 to 20.46% in 1997, 17.96% in 2001 and 17.72% in 2003 (ECCB and CSO 2003).

The banana industry, which once enjoyed preferential treatment on the European market, achieved a peak in export value of EC$103.6 million in 1988. Since the early nineties, in the context of trade liberalization and the erosion of preferential market access to Europe for bananas, the island's banana industry has experienced steady decline, reaching a low in banana export value of EC$13.53 million in 2003 (DBPL 2005).

Overall economic performance has mirrored the decline in the banana industry. Real GDP growth, which averaged 4.4% per annum over the1980 to1990 decade declined to an average of

2.37% in the 1991 to 1998 period. In 2001 and 2002, there were two years of sharp contraction of –4.2% and -4.7% respectively, but the decline seems to have bottomed out in 2003 with the achievement of 0.0% growth rate.

Diversification has been the official policy of Dominica since the 1970s. While some diversification is taking place in the agricultural sector, diversification outside of the agricultural sector has been limited. There have been a few successes in agro-industry of which the most outstanding has been a soap manufacturing and cosmetics company. In 2003, this company earned EC$54.34 million in export revenue compared with EC$13.53 million earned from banana exports. (CSO 2003)

Eco-tourism Potential

Dominica's tall mountains, lush tropical rain forests, abundant rivers, lakes, waterfalls and wild life have been substantially preserved in their natural condition. Over 20% of Dominica's land area is protected by law and a Marine Park and one Marine Reserve have been established.

The island's topography is extremely rugged and there is little flat or gently sloping land. The island's mountains drop straight into the sea resulting in deep drop-offs. The leeward coast is one of the prime feed areas for sperm whales and consequently whale watching is a growing industry. The island has also been listed as one of the top diving destinations in the world.

There is a chain of peaks from south to north comprising at least seven volcanic centres in the interior of Dominica and a bubbling boiling lake (reputedly the largest in the world), which is testament to the smouldering active nature of the island (Evans and James 1997).

These are some of the reasons that the island has earned the title of being the "Nature Island" of the Caribbean. Despite its natural beauty, development of the tourism industry started late and the industry has performed poorly. In 2003, Hotels and restaurants contributed only EC$10.14 million or 2.45% to GDP (ECCB and CSO 2005). This industry has been identified as having great potential for diversifying the economy. However, the island is yet to find the right formula for product, price and place to permit serious growth in income generation.

A Proposal to Mine Copper in Deux Branches

The disappointing performance of the economy and weak prospects in the post banana-preferential-market era leave the island vulnerable to potential investors that promise a rapid boost to the island's fortunes.

In 1996 Broken Hill Proprietary Company Ltd. (BHP) [5], one of the world's leading natural resource companies, expressed interest in exploration of copper and gold ores in the Deux Branches area of Dominica. At the time, BHP was actively exploring for metallic mineral deposits throughout the Caribbean, and became interested in Dominica as a result of a 1960s survey, which indicated significant potential for mineral deposits in the Deux Branches area (Australian High Commissioner 1995).

Dominica is 750 square kilometres or 75,000 hectares in area and the proposed Prospecting Licence Area (PLA) shown in Figure 1, was 93 square kilometres or 23,000 acres (9,308 hectares), which is approximately 12% of Dominica's area (James 1996).

The initial exploration phase of the mining operation was to be concentrated in the Deux Branches area. However, in subsequent phases prospecting would have been carried out in other parts of the PLA.

The Forestry Division of the Government had provided to the authorities a comprehensive description of the PLA identified by BHP (Christian 1996). The PLA included several coastal and inland human settlements, a number of agricultural settlements. There was a substantial amount of private lands.

The area contained The headwaters of three of Dominica's largest river systems – Layou, Castle Bruce and Pagua, utilised by villagers in surrounding areas, including the Caribs, for drinking, washing, fishing, agriculture and bathing and by visitors for tyre tubing and other tourism related activities.

The Central Forest Reserve was completely within the PLA. The area also included an estimated 10% of the Northern Forest Reserve, all in tropical rain forest. The precipitation range of the PLA is 100" to 250", which had an altitudinal range from sea level to 2,750 ft above sea level.

Four major roads and several secondary and feeder roads ran through the area. South of the PLA area, in the south central part of the island, is the Morne Trois Piton National Park, which was nominated as a World Heritage Site by the UNESCO Environmental Program. This was the first such award in the Caribbean and it meant that the park is regarded as a unique global resource.

The island has a rich and diverse flora and fauna. The trees are the most impressive features of the rain forest. Nine species of wildlife are endemic to Dominica. They include a tree frog (eleutherodactylus amplinympha) that lives in the Northern Forest Reserve and

[5] The Company has since merged with another mining company and is now BHP Billiton Ltd., www.BHPBilliton.com.

the Morne Trois Piton National Park. The National Bird, the Sisserou or Imperial Parrot (*Amazona imperialis*) and the smaller Jaco or Red-necked Parrot (*Amazona arausiaca*) live nowhere else.

Dominica is a scientific and ecological treasure and the president of the Dominica Conservation Association at the time was quoted as saying that the proposed mine was "the greatest threat to Dominica since Columbus" (Horstman 1996).

Dr. Christian, the Director of the Division, speculated that royalties and other socio-economic benefits likely to be derived from the proposed project would be less than the value of the total watershed protection, aesthetics, eco-tourism potential, and timber value of the existing forests.

Despite caveats expressed by the Forestry Division, the Government of the day subsequently authorised the BHP to undertake some preliminary field investigation activities on State Lands (Christian 1996).

Local opposition to any exploration or mining for copper and gold in Dominica was expressed in a nationwide petition presented to the government (Van Leeuwen 1996). The coalition of groups included trade unions, indigenous groups, religious bodies and business organisations. They maintained that open pit mining was likely to create a major environmental disaster.

The Dominica Conservation Association estimated that the earnings from the 25 years of BHP mining would be a maximum of 50% of the income from tourism in 1994 (Martin 1996).

Potential Environmental Problems for Dominica Associated with Copper Mining

The environmental problems experienced at the Ok Tedi mines in Papua, New Guinea are well documented and provide valuable information on the potential difficulties which could be experienced by an island such as Dominica.

In the Dominican case a worst-case scenario would have resulted in some of the following problems (Project Underground, 1996):

> "- Severe and ongoing erosion from road cuttings and drill holes and potential excavation in the area.
>
> - Pollution of rivers with sediments and chemicals. The exploration area includes the watersheds of three rivers – the Pagua, Castle Bruce Rivers and the Layou River.
> - Loss of forest cover. Comprising mountain rainforest of the Central and Northern Forest Reserves,

regarded as the most biodiverse on the island.
- Loss of wildlife habitat, including the habitat of endangered species.
- Disposal of overburden (earth covering the ore) and tailings (waste rock from which copper has been removed). Volumes of waste rock will be high as the average grade of copper is low (1 percent), so that the ratio of copper mineral to waste rock is roughly 1:99.
- Establishment of new town site for mine workers, leading to increased use of and encroachment on central forest areas.
- Establishment of a new port site on the East Coast for ore export, with possible slurry pipelines from mine to port.
- If in situ chemical extraction methods are used (e.g. sulphuric acid is injected into boreholes), then there is likely pollution to groundwater and river systems by extractive chemicals themselves and heavy metals in solution.

Finally, from the establishment of a mining town and the mining proposed upstream, the Carib people who depend particularly on the Pagua and Castle Bruce rivers, will find their waters polluted by sediment and chemicals. Their way of life, which depends upon Waitukubuli, will be forever altered by the mine. Ultimately it is these peoples, who have lived for generations on these lands, and until earlier this year had the legal title to it, who must decide its, and their fate."

With high rainfall, highly erodible soils, frequent hurricanes and seismic activity Dominica presents a major challenge to any mining engineer attempting to contain the consequences of open cut techniques and disposal of tailings.

NATURE OF THE PROBLEM

Whereas copper mining is potentially very attractive as an economic option for Dominica, the evidence regarding the negative environmental impacts of mining in Ok Tedi and elsewhere is also compelling.

With respect to the Dominican case local environmentalists were concerned both with the potential physical impact on the environmental assets as well as the effects such a mine would have on the island's ecotourism image. In 1994 Greenpeace instigated an ecotourism boycott of Dominica for one year because the Government of Dominica would not vote to ban whaling in the Pacific. That year, hoteliers complained

of cancelled reservations on account of this vote.

The establishment of a copper mining operation in Dominica would undoubtedly result in some financial benefits some of which would inevitably accrue to the local economy. However, there is a potential conflict between the mine and the island's tourism sector and other uses of the environmental resources in question.

Scientific curiosity therefore leads to the examination of whether in fact the net benefits of the mining operation would have been positive or negative. This question cannot be answered without counting the environmental costs of mining and therefore involves the issue of valuing environmental resources. That is, to determine whether copper mining is a viable alternative to agrarian uses of the area in Deux Branches, both financial and environmental costs and benefits have to be taken into consideration.

The problem of the study concerns the absence of knowledge of the economic feasibility of mining copper on the island of Dominica.

It is hypothesised that the cost-benefit analysis of copper mining in Dominica will yield a negative NPV. Given the small size of Dominica and the magnitude of potential damage to the island's environmental resources, its reputation as an eco-tourism destination and its economic future, there is a fair level of confidence that the weight of non-market costs will tip the scales in favour of the environmentalists' negative position on copper mining in Dominica.

The objectives of the study are therefore:

1. To assess whether in the Dominican context, the costs outweigh the benefits for copper mining.
2. To determine whether inclusion of the value of non-marketed costs associated with the mining project would influence the results of the cost/benefit analysis.

THE STRUCTURE OF COST BENEFIT ANALYSIS

Cost Benefit Analysis (CBA) and contingent valuation are techniques, which are utilised in meeting the objectives of the paper. CBA permits the computation of whether the net present value of the project is positive. Contingent Valuation allows for inclusion of non-market costs in the analysis.

As described by Hanley and Spash (1993), there are several essential stages in Cost Benefit Analysis (CBA). These are, defining the project, identifying impacts which are economically

relevant, physically quantifying impacts, calculating a monetary valuation, discounting, weighting, and sensitivity analysis.

The first stage of defining the project is essential in order to determine the reallocation of resources being proposed and the population of persons who may be affected. This step therefore establishes the boundaries of the analysis.

Once the limits of the project have been defined, it is necessary to identify the specific impacts that will result from the implementation of this project. Positive impacts are referred to as benefits and these may result from increases in the quantity or quality of goods and services that generate positive utility or a reduction in the price at which they are supplied (Hanley and Spash, 1993). On the other hand, any decreases in the quantity or quality of goods and services or increases in their prices would count as costs.

In deciding which impacts are economically relevant, where environmental goods are concerned the important criterion is that an impact on production or utility can be recorded, not whether a market exists. Transfer payments such as taxes and subsidy payment, are generally excluded from a CBA since, they do not involve the utilisation of real resources, but are simply a redistribution of money by the Government.

The fourth stage involves the physical quantification of relevant impacts and determining the timing of these impacts.

Stage five determines the monetary values of project impacts. This includes projections of value flows in the future, so that costs are entered in the years in which they are incurred and benefits in the years that they are realized.

CBA is conducted with real values. Where there is no market, a variety of techniques can be used to obtain monetary values such as contingent valuation (CV), the travel cost method, hedonic pricing and others.

Given the time value of money, once relevant project impacts have been expressed as monetary values of cost and benefit flows in stage six, they must be discounted to obtain their present values. The present value of a cost or benefit (x) is calculated as:

$$PV\ (x_t) = x_t[(1 + i)^{-t}]$$

Where i is the discount rate, which may be assumed to be the (real) rate of interest and the expression in square brackets is the discount factor. The discount factor is always between 0 and +1. A higher discount rate is associated with a greater preference for money in the present time rather than later. As a result of the time value of money, the greater is time t the smaller are the discount factor and the present value.

As stated previously one of the criteria used to select projects and policies is the Net Present Value Test (NPV). The test is simply whether the sum of the discounted benefits exceed the sum of the discounted losses, that is:

$NPV = SB_t (1 + i)^{-t} - S\ C_t\ (1 + i)^{-t}$

The project is considered as being an efficient shift in resource allocation if the NPV is zero or greater, when discounted at the opportunity cost of capital. The opportunity cost of capital is the rate which will result in utilization of all capital in the economy if all possible investments are undertaken that yield that much or more return (Gittinger, 1982). If the discount rate is set perfectly it will represent the choice made by the society as a whole between present and future returns. However, the true opportunity cost of capital is not known. One problem of using the NPV criterion, therefore, is that this criterion cannot be applied if a satisfactory estimate of the opportunity cost of capital is not available. While there it no certainty to this rate, however, in developing countries, where capital is relatively scarce, it is assumed to be between 8 and 15 percent and a common choice is 12 percent.

At stage eight, a sensitivity analysis is prudent, given the uncertainty of the future and the potential for parameters to vary from the assumed projections. In sensitivity analysis changes are made in key parameters and the NPV criterion is recalculated in order to determine how vulnerable the project performance may be to changes in these parameters.

EMPIRICAL PROCEDURES

This study attempted to determine whether establishment of a copper mining operation would have improved the economic well-being of Dominicans.

The project, which has already been defined, is the proposed copper mining project. The initial sampling area was in the Deux Branches area, but future exploration was to be extended to an area shown on the map in Figure 1. With respect to the relevant population, the CBA was carried out from a global viewpoint. Given the high proportion of land area targeted, it was expected that the entire population of Dominica would be affected. Visitors to the island would also be affected, and they were also taken as representative of the global population.

There were therefore two main sets of relevant project impacts identified. These were the financial costs and benefits associated with the copper mining operation as well as the non-market costs associated with the loss or destruction of environmental resources for the copper mining operation. The value of the non-market costs related to this project was arrived at from a

contingent valuation survey and analysis (Harris-Charles, 2005).

With respect to quantities and prices for the financial analysis, one of the main sources of information was a draft license submitted by BHP to the Government of Dominica (BHP Minerals International Exploration Inc., 1996). The Work Plan of the draft license stated that:

> "Initial Exploration Phase, Year one, Minimum US$250,000: BHP intends to follow up on work conducted by the Geological Survey of Guyana in 1968-1969 in the Deux Branches area of northeastern Dominica. The initial work will consist of geochemical sampling of stream sediments, rock, and solid, in the immediate area of Deux Branches to confirm the anomalies indicated in the previous work… The work will be performed by 1-3 BHP geologists with assistance from 3-5 local laborers for clearing and sampling.
>
> Second Exploration Phase, Year 2-3, Minimum Annual Investment $US500,000: Drilling is expected to continue pending favorable results in the immediate Deux Branches area with an anticipated program of 10-20 holes at depths up to 1000 feet and spacings approximately 300 feet between each hole…
>
> Phase Three, Years 3-4, Investment $US1Million per year: Assuming favorable results from the previous work, detailed closely spaced drilling will be undertaken in areas where mineralization has been identified… These procedures will be conducted in advance of a feasibility study which will be the final process before a decision for mining can take place.
>
> The Type of mine expected to be encountered is a porphyry copper-gold deposit minable by open pit. The deposit size we hope to encounter is in excess of 400 Million tons at a grade of 1% copper with gold values ranging up to 1 g/ton. These types of deposits typically have a mine life in excess of 25 years, require capital investments in excess of US$500 Million and employ 300-1000 workers. BHP operates similar mines in Canada, the U.S., Peru, Chile, and Papua New Guinea and is the second largest producer of copper in the world."

Use of BHP's estimates regarding size of deposit and grade of deposit had to take into account their preliminary

nature as well as a probable promotional element. More conservative figures were therefore utilized. Additional information for the financial analysis was obtained through a benchmarking process based on financial statements of similar mining companies and other information regarding copper-gold mining found on the internet.

Assumptions regarding the market costs and benefits were therefore as follows:

1. Deposit size:- 200,000,000 tonnes.
2. Investment period 5 years commencing in 1997
3. Project Life:- 25 years
4. Total Capital Investment – US500 million
5. Copper prices:- annual averages of US$0.71 per pound in 2002 and US$0.81 in 2003 and US$1.25 up to June 2004 (World Bank, 2004). Prices remain the same from 2005 onwards.
6. Gold prices:- annual averages of US$310 per troy ounce in 2002, US$364 in 2003 and $400 up to June 2004 (World Bank 2004). Prices remain the same from 2005 onwards.
7. Grade of copper:- 0.5 percent (MBendi 2002). Hence the mine is projected to yield 1 million tons over its life. With the conversion factor of 2,204.62 pounds in a metric ton, total copper production is therefore estimated at 2,204.62 million pounds or 88,184,800 pounds annually over a 25 year period.
8. Grade of gold:- 0.8 grams per ton. As a result total production over the life of the project is 160 million grams, which converts to an estimate of 5.144 million ounces or 206,000 ounces annually.
9. Cash Operating costs:-

   Copper

   Cash operating costs of US$0.67 per pound. Given production of 88,184,800 pounds, annual cash operating costs amount to US$59,083,816.

   The global cost of production is said to vary, but is roughly considered to be US$0.65 to US$0.70 per pound (Barron's 2002). Information from mines in Zambia indicated cash operating costs varying from US$0.27 cents (one of the lowest in the world) to US$0.75 cents per pound (First Quantum Minerals Ltd. 2003).

   Main individual components of cash costs are estimated at the following percentages of total cash costs:-

   - Production costs 50 percent
   - Treatment charges 45 percent
   - Exploration 1.7 percent
   - Administration 1 percent

- Provision for site closure and reclamation 2.3 percent

With respect to projections, mineral prices vary according to general world economic conditions as well as market conditions in specific industries that utilize these minerals. In conditions where it is difficult to predict the movement of prices in the future, the best approach is to assume that future prices will retain the average relationships they have held over the recent past years.

Gold

The cash cost of US$246 per ounce is used. With the annual production of 206,000 pounds, cash cost is estimated at US$50,617 million annually.

The cost of production in South Africa in 2001 was US$246 (MBendi 2002). The cost of production in the United States of America was US$189 per ounce and in Canada was US$169 per ounce. In Niolam Island, Papua New Guinea, total cash costs were US$283 per ounce in March 2003 (Lihir Gold Limited 2003).

10. Royalties and other taxes, which are transfer costs, were excluded from the analysis.

The information for the non-market valuation was obtained from the CV analysis, which yielded estimates of WTP for each social group. This WTP was an estimate of the cost in terms of the loss of the environmental goods and services. The WTP was estimated for two main groups – Dominicans and Visitors. The total non-market cost of the copper mining operation was estimated from the WTP for each group times its total population size. In the case of the visitors, the figure for total annual stay-over visitor and cruise passenger arrivals in 2001 was used for population size. Since the referendum question was for a one-time contribution, this amount was included as a cost in project year zero.

The Net Present Value was calculated using a discount rate of 12%. This is a figure which is often used to estimate the opportunity cost of capital in developing countries.

A sensitivity analysis was conducted to test the effect on NPV of changes in copper prices, copper production costs, the deposit size, the exclusion of all environmental costs, exclusion of environmental costs for all visitors and different discount rates.

RESULTS

The market and non-market costs and benefits included in the CBA are summarized in Table 1.

As indicated in the BHP workplan, the first four years were included in the exploratory phase, which was taken as the period between 1997 and 2001. Actual mining would have commenced in 2002.

Actual market prices of the minerals were used in the first three years of operation, 2002 to 2004 and prices in 2004 were projected for the remaining 23 years of the life of the mine. Estimated annual production of copper was 88,184,800 pounds, compared to only 206,000 ounces of gold. However, as a result of the higher price of gold, the value of gold produced was US$ 62.79 million, compared to US$62.61 million for copper in project year one.

The total estimated benefits amounted to US$126.40 million in the first year of operations, US$146.22 million in the second year and US$192.54 million thereafter. Total market costs in project year one were projected throughout the 25 years of the life of the project.

From the Contingent Valuation Survey and analysis the total environmental costs were estimated at US$56,443,000. The resulting net benefit stream, discounted at 12%, yielded a negative NPV of (US$2,441,000) million, which indicated that the project should not be undertaken.

The sensitivity analysis results are presented in Tables 2 to 6 below. Table 2 indicates the original position, the effect of the exclusion of environmental costs and use of BHP's original deposit size estimate. The figures showed that removal of environmental costs was enough to make NPV positive. The use of BHP's deposit size also made NPV positive even with the environmental costs included.

The results in Table 3 indicated that a doubling of prices from 2005 would result in a positive NPV, which would make the project viable even with environmental costs included. Conversely a 50% price decline would make the project non-viable. The Table also indicated that a price increase of 0.46% would change the negative NPV of (2,441,000) in the original position to zero or just positive.

The results in Table 4 show the effects of changes in copper production costs from 2005 onwards.

With respect to cost of production changes table 4 shows that an increase in copper production costs by 25% would make the project non-viable. The exclusion of environmental costs does not result in a positive NPV.

A sensitivity analysis was also carried out to find out the effect of

excluding all visitors in the calculation of the environmental costs. The results are presented in Table 5.

The exclusion of the all visitors in the calculation of environmental costs leads to a positive NPV. This means that the inclusion of environmental costs for Dominicans alone was inadequate to make the project non-viable.

A sensitivity test was also carried out in order to see the effects on NPV of using different discount rates. All the parameters were kept at the original positions as indicated in Table 2, with the exception of the discount rate, which was 12% in Table 2. Table 6 below shows the NPV calculated at interest rates 9%, 13% and 15%. For each discount rate two NPVs are calculated one with and one without environmental costs.

The results showed that with a discount rate of 13%, the NPV was positive without and negative with environmental costs. However, at a discount rate of 9%, the NPV was positive with or without environmental costs. With a discount rate of 15%, the NPV was negative with or without environmental costs.

CONCLUSION

The sensitivity analysis shows clearly that given historical prices and reasonable assumptions about production levels and costs, without environmental costs, the copper project would have been viable. This implies that the copper mine would have been an efficient use of resources, despite prospects of environmental damage.

This result is reversed with the assumption of a copper price decline to 50% of its 2004 levels from 2005 onwards. A 25% increase in copper production costs also results in a negative NPV even when environmental costs are excluded. If the discount rate is less than 12% the NPV becomes positive even with environmental costs. Whereas with higher discount rates of 15% and over the NPV is negative even without environmental costs.

The most significant result is that without estimation and inclusion of environmental costs in the analysis the policy implication would be to proceed with the copper mining operation regardless of the potential negative welfare impacts of the mine. These negative impacts would include losses in the well-being of locals as well as potential reductions in visitors as a result of the degradation of the island environmental assets.

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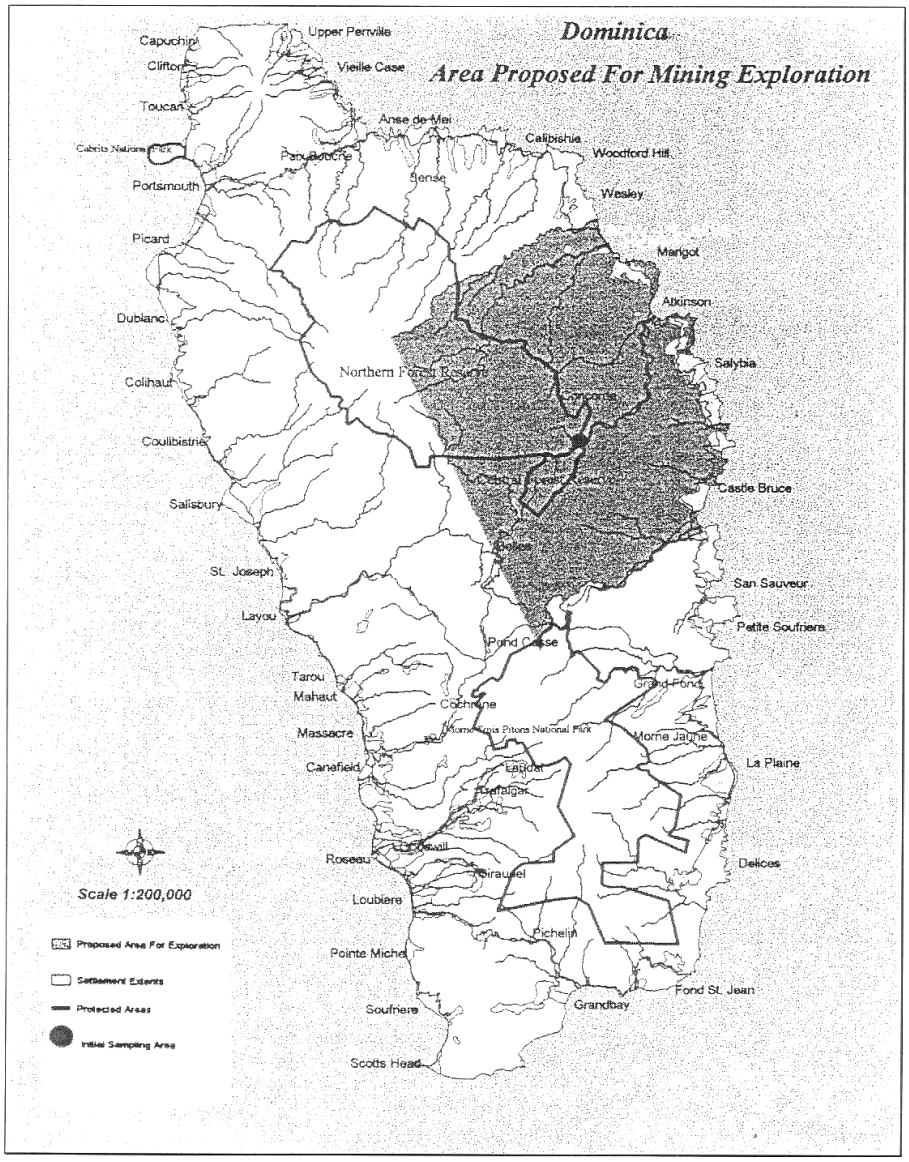
Figure 1 Map of Dominica and PLA



Source: GIS Unit, Physical Planning Division, Government of Dominica.

Table 1 Cost Benefit Analysis (US$'000)

Items	*1997-2001*	*2002*	*2003*	…	*2026*
BENEFITS					
Copper - Cu	0	88,185	88,185	…	88,185
Production in '000 pounds					
Price per pound	0	0.71	0.81	…	1.25
Sub-Total	0	62,611	71,430	…	110,231
Gold – Au					
Production in '000 ounces	0	206	206	…	206
Price per ounce	0	310	364	…	400
Sub-Total	0	62,786	74,794	…	82,304
Total Benefits	0	126,397	146,223	…	192,535
COSTS					
Capital	500,000				
Copper – Cu					
Production	0	29,542	29,542	…	29,542
Treatment charges	0	26,588	26,588	…	26,588
Exploration	0	1,004	1,004	…	1,004
Administration	0	591	591	…	591
Provision for site closure	0	1,359	1,359	…	1,359
Gold – Au					
Total Production	0	50,617	50,617	…	50,617
Total Market Costs	500,000	109,701	109,701	…	109,701
Non-Market Costs	56,443	-	-	…	-
Total Costs	556,443	109,701	109,701	…	109,701
NET BENEFITS	(556,443)	16,696	36,523	…	82,834

TABLE 2. Sensitivity analysis for changes in environmental costs and deposit *size*

Item	*Original Position*	*Zero Environment Costs (0EC)*	*BHP Estimate of Deposit Size*
Price in 2005	$1.25	$1.25	$1.25
Deposit Size	200,000,000	200,000,000	400,000,000
Environment Costs	$56,443,000	$0	$56,443,000
NPV	($2,441,000)	$47,955,000	$491,942,000

TABLE 3. Sensitivity analysis for copper price, and environmental costs

Item	*Price increase from 2005*	*Price decrease from 2005*	*Price change from 2005 for NPV=0*
Price in 2005	$2.50	$0.625	$1.26
Price Change	x 2	x 0.5	X 1.0046
Copper Revenue	$220,462,000	$55,116,000	$110,734,000
Environmental Costs	$56,443,000	$56,443,000	$56,443,000
NPV	$533,095,000	($270,209,000)	0

TABLE 4. Sensitivity analysis for changes in copper production cost and environmental costs

Item	*Cost of Production increase from 2005*	*Cost of Production increase from 2005*
Cost in 2005	$73,854,770	$73,854,770
Cost Change	x 1.25	x 1.25
Environmental Costs	$56,443,000	$0
NPV	($105,879,000)	($55,484,000)

TABLE 5. Sensitivity analysis for exclusion of all Visitors

Item	*Original Position*	*Excluding all Visitors*
Price in 2005	$1.25	$1.25
Deposit Size	200,000,000	200,000,000
Environment Costs	$56,443,000	$11,001,000
NPV	($2,441,000)	$38,132,000

TABLE 6. Sensitivity analysis using different discount rates

Item	*Discount rate of 9%*	*Discount rate of 13%*	*Discount rate of 15%*
Environment Costs	$0	$0	$0
NPV	$196,320,000	$10,952,000	($49,632,000)
Environmental Costs	$56,443,000	$56,443,000	$56,443,000
NPV	$144,537,000	($38,998,000)	($98,713,000)