LULEÅ UNIVERSITY OF TECHNOLOGY

2003:087 SHU

MASTER'S THESIS

Jamaican Deforestation and Bauxite Mining

Applying the Coase Theorem

TOMMY JOHANSSON

Social Science and Business Administration Programmes

ECONOMICS PROGRAMME

Department of Business Administration and Social Sciences
Division of Economics
Supervisor: Christer Berglund

2003:087 SHU • ISSN: 1404 – 5508 • ISRN: LTU - SHU - EX - - 03/87 - - SE

ABSTRACT

In Jamaica, bauxite mining is considered to be one of the most significant reasons behind deforestation. Within the last few decades, large areas of forest have been cleared on the island due to the open pit mining for bauxite. Because the bauxite land in many cases is owned by private landowners, the operating mining companies are forced to bargain with them to get access to the desired land. The purpose of this thesis is to analyze if the Coase theorem about optimal resource management through bargaining can be applied to the Jamaican deforestation problem caused by bauxite mining. The study was performed by interviews and observations and focus was turned to the hills of the Mocho Mountains in the parish of Clarendon. The conclusion is that there existed no practical obstacles for bargain to take place. However, since the market for bauxite mining is not characterized by perfect competition, an efficient allocation of the Jamaican forests is not achieved.

SAMMANFATTNING

Brytning av bauxit är av många ansedd som den största orsaken till Jamaicas avskogningsproblem. Under de senaste decennierna har stora skogsområden på ön skövlats till följd av de omfattande dagbrotten. Eftersom landområdena där bauxit existerar i många fall ägs av privatpersoner är de aktiva gruvföretagen tvingade att förhandla med dessa för att få tillgång till den eftertraktade marken. Syftet med denna uppsats är att analysera om Coase teoremet angående optimal resursanvändning kan appliceras på Jamaicas avskogningsproblem orsakat av brytningen av bauxit. Studien genomfördes genom intervjuer och observationer och fokuseras på Mocho bergen i territoriet Clarendon. Slutsatsen är att det inte existerar några praktiska hinder för denna förhandling. Emellertid karaktäriseras marknaden for bauxitbrytning inte av perfekt konkurrens och därför blir inte allokeringen av de Jamaicanska skogarna utsatta för bauxitbrytning optimal.

ACKNOWLEDGEMENTS

First of all I would like to thank my supervisor, Christer Berglund, at the division of economics at the Luleå University of Technology for his support and for always giving inspiration and assistance.

Second, I would like to thank Mr. Wilberne Persaud at the University of the West Indies at Mona, Jamaica, and Mr. Franklyn Brown at the Office of Utilities Regulation for helping me with all kinds of practical problems during my stay in Jamaica. I would also like to thank Ms. Mittoo at NEPA and Mr. Lyew-You at the JBI for their help with giving me information about the procedures and the ecological consequences of bauxite mining in Jamaica.

Third, I would like to thank the Swedish International Development Agency (SIDA) for financial support.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

The earth is fortunate to be blessed with a substantial amount of natural resources. With these resources, both renewable and exhaustible, it follows the responsibility of managing them in a sustainable manner. However, we experience environmental degradation in all parts of the world, regardless of prevailing economic systems or political ideologies. Moreover, in the very poorest countries, poverty leads to environmental stress and resource degradation (Pearce and Turner, 1990). The main underlying obstacle is that natural resources are scarce, whereas people's needs and wants are indefinite. The important question one should ask then is: how can we manage our resources in a sustainable way?

Over 60 percent of the earth's bio diversity contain of forests, which is one of our most important ecosystems. The world's forests provide a wide range of services and benefits including everything from preserving traditional ways of life to enhancing environmental stability and security (Forestry Department, 2001).

Jamaica is one of these developing countries with extensive forest cover. Unfortunately the island has suffered from heavy deforestation[1] rates during the last decades, and presently only 25 percent of its original forest cover is left.

---

[1] The term deforestation refers to removal of a forest where the land is put to a non-forest use (Forestry Department of Jamaica, 2001, p. 99).

This have lead to a number of negative effects, including the detoriation of more than a third of the county's watersheds as well as drying up rivers and streams (World Rainforest Movement, 2002b).

In conventional forestry debates, mining hardly is mentioned. However, it becomes increasingly obvious that the pressure on forests around the world now primarily stems from forces outside the forestry sector. This is a problem facing Jamaica as well. Among the various pressures that have lead to the high deforestation rates in Jamaica, bauxite mining is considered to be one of the more significant. Because of the fact that mining is a very lucrative business and often generate immense returns, it is often difficult to slow down (World Rainforest Movement, 2000).

The problem of sustainable resource management can be solved in a number of different ways. While some theorists advocate government intervention in terms of setting standards or taxes, others argue that, as long as property rights are well defined, the market itself will allocate the resources efficiently through bargaining[2]. The latter was developed by Coase (1960) and is better known as the Coase theorem (Pearce and Turner, 1990).

1.1 Purpose

The purpose of this thesis is to analyze if the Coase theorem about optimal resource management can be applied to the Jamaican deforestation problem caused by bauxite mining.

---

[2] In this thesis, only allocative efficiency is considered, i.e. a condition achieved when resources are allocated in a way that allows the maximum possible net benefit from their use. This is different from productive efficiency, i.e., when output is being produced at the lowest possible unit cost (Boutiaga, 2002).

1.2 Method

Using the Coase theorem, which states that as long as property rights are clearly defined the actors will allocate the resource efficiently, we analyze the Jamaican deforestation problem caused by bauxite mining. This is done through two steps. The first step is to look at the structure of the property rights to the forests in Jamaica and analyze whether or not they satisfy Tietenberg's (1996) required criteria for efficient resource allocation. These criteria include transferability, universality, exclusivity, and enforceability. The second step uses the five main deficits facing the Coase theorem, both in theory and practice. These deficits of the theorem are then compared with the design of resource allocation in the case of Mocho Mountains, Jamaica. The case study will be performed through interviews and observations in place in Jamaica.

1.3 Scope

The study is limited to the Mocho Mountains, Jamaica. The Mocho Mountains are located in the parish of Clarendon, which is only one of the seven parishes in Jamaica subjected to bauxite mining. There are two reasons why this particular parish was chosen to be studied in this thesis. First, representatives from the Jamaican Forestry Department recommended it due to the recent signing of a referendum of understanding concerning reclamation practices in the Mocho area. Second, the parish of Clarendon has been subjected to bauxite mining for over 40 years and therefore has a long history of bargains with private landowners.

1.4 Outline

The thesis proceeds as follows. Chapter two presents the necessary theories regarding the problem of sustainable natural resource management. In chapter three, a thorough background to the Jamaican forests as well as to bauxite mining is given, while chapter four presents the empirical result of the study. Finally, chapter five concludes the thesis.

Chapter 2
THEORY

This chapter discusses the theoretical foundation of natural resource management. We provide an explanation of the economics of renewable resource management and present theoretical solutions to this problem.

2.1 Renewable resources

A renewable natural resource is a resource which stock is not fixed, which can therefore both be increased and decreased. However, the upper limit of the resource is limited which implies that there is a maximum stock. This comes from the fact that no natural resource can regenerate above its own ecosystem's carrying capacity. For example, if a forest would be left alone to grow, it would not grow forever. Instead it would stop growing when the ecosystem cannot support more trees. One positive thing about renewable natural resources is that they can be harvested continuously and still grow back to its original size. For renewable resources, this potential for stock increase depends crucially on human behavior. If for example forests are too heavily degraded, its rate of natural increase may be damaged and as a result the ecosystem's carrying capacity will be decreased. Having this in mind, it is easy to realize that over-harvesting of renewable resources will have dramatic consequences on their ability to regain its original stock size (Pearce & Turner, 1990).

2.2 The optimal use of renewable resources

In this subsection, we investigate some of the theories that have been put forward in the literature with respect to the optimal use of renewable resources.

In order to describe the problem of sustainable use of renewable resources, we make use of an illustrated example. Consider the case of a forest. Due to the limits of the ecosystem, the forest cannot regenerate itself any larger than what the carrying capacity of this ecosystem permits. *Figure 2.1* shows the growth curve through time for a forest. It is important to notice that this growth curve does not start at zero, but instead at $x_{\min}$. The reason behind this is that if the number of trees goes below the level of $x_{\min}$, the forest will not be able to regenerate. The level of $x_{\min}$ can therefore be referred to as the critical minimum level of the forest. By studying *figure 2.1*, it can also be seen that at low densities of trees the forest multiplies quickly. As the forest increases in size, the competition for land and water among trees becomes intensified until, finally, the carrying capacity, $x_{\max}$, for the ecosystem is reached and the growth ceases to take place (Pearce & Turner, 1990).

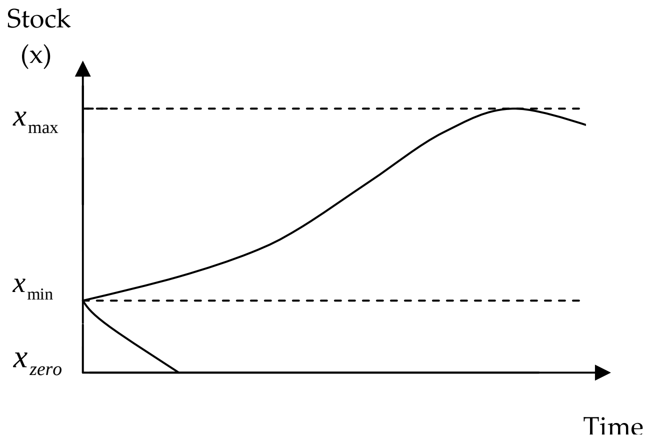

Figure 2.1 Growth curve for renewable resource
Source: Pearce & Turner (1990), p. 242.

However, the scenario described above only occurs as long as the forest is left alone. If the forest is utilized in other ways, e.g. for mining or timber extraction, the conditions for the resource to regenerate will change. In *figure 2.2*, the growth rate of the resource is shown. This rate of growth, $\dot{x}$, which illustrates the rate of change in *x* with respect to time, is shown on the vertical axis while the stock size is shown on the horizontal axis. As displayed in *figure 2.2*, the rate of growth of the forest is at first increasing before it declines and finally reaches its carrying capacity and thus the maximum level of the stock. The point in the figure where the growth rate of the forest reaches a maximum is called the maximum sustainable yield (MSY). If the renewable resource is employed in this way, it will not be depleted over time, instead the resource will regenerate itself and MSY can be yielded in the next period as well. This means that if it takes 5 years for the forest to regenerate, MSY can be harvested every 5 years on a sustainable basis. The duration of this time period depends on a number of factors, including the fertility of the soil, the type of trees growing, the weather, and how well the forests are managed (Pearce and Turner, 1990).

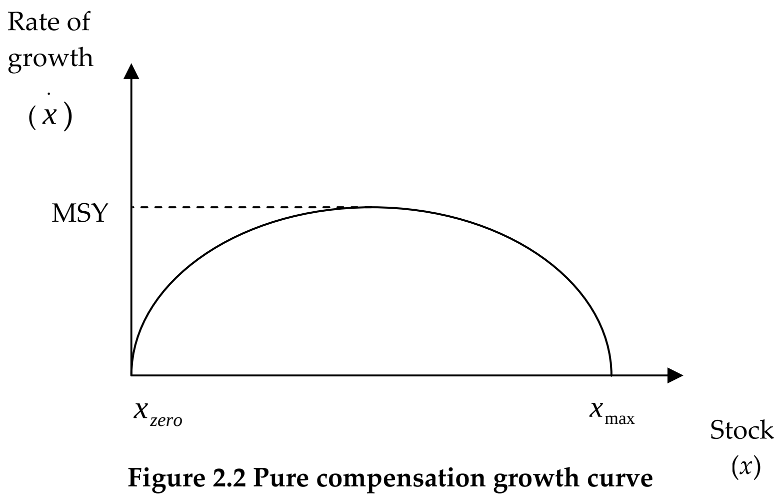

Figure 2.2 Pure compensation growth curve
Source: Pearce & Turner (1990), p. 243.

2.3 Proposed theoretical solutions

Several theories present solutions to the problem of sustainable resource use. However, considering the purpose of this thesis, only solutions within the so-called property rights paradigm are presented here. Other proposed solutions involve the intervention of government by setting taxes or standards.

2.3.1 Property rights solutions

Some economists argue that an economy with well-defined and transferable property rights will provide individuals and firms with sufficient incentives to use natural resources efficiently. This variant of environmental resource management is known as the property rights paradigm. To fully be able to grasp this approach, the concept of property rights must be understood. Property rights refer to the entitlement defining the owner's rights and limitations for the use of a specific resource. These rights can either be private or communal, whereas the latter is also known as common property. According to Tietenberg (1996), the structure of property rights should have four specific characteristics, illustrated in *Table 2.1*, in order to serve as a solid foundation for efficient resource allocation.

Table 2.1 Tietenberg´s property rights criteria

Universality	Private ownership of all resources as well as completely specified entitlements.
Exclusivity	All costs and benefits taking place as a result of owning and using the resource should be accrued only to the owner of the resource.
Transferability	All property rights, in a voluntary exchange, should be transferable from one owner to another.
Enforceability	Security from involuntary seizure or encroachment of the property rights by others.

Source: Tietenberg (1996), p. 41.

One important implication of the property rights paradigm is the undesirability of government intervention. It is also important to realize that even if one admits that markets are imperfect, it does not imply that collective action or government intervention is superior (Tisdell, 1993).

2.3.2 The Coase theorem

When discussing property rights solutions to sustainable resource management, the Coase theorem is clearly one of the most debated. The Coase theorem argues that as long as property rights are clearly defined, the market will allocate natural resources in an efficient way. Regardless of who owns the property rights, individuals will create markets in externality, and thus abolish the need for government interventions (Pearce and Warford, 1993).

Consider the following example of mining in forest areas. In *figure 2.3*, deforestation, p, is measured along the horizontal axis, while the vertical axis refers to US dollars. MNPB stands for marginal net private benefit and illustrates the mining company's profits. The fact that MNPB slopes downward shows that the miner's profits vary positively with p, i.e. the higher profits, the more deforestation. In absence of any property rights, the mining company would naturally maximize its profits and choose the output level p_1. This is simply because MNPB is positive to the left of p_1 and negative to the right of p_1. MEC stands for marginal external cost. External costs are the costs imposed on the quality of the forest by the polluting firm, while marginal external cost is the effect on such costs for a small variation in p. MEC is upward sloping following the assumption that these incremental costs increase with the level of deforestation (Common, 1995).

Referring to *figure 2.3*, the Coase theorem goes like this. Suppose the persons who suffer from the deforestation do not own the property rights to the forest. These persons can then approach the mining company and ask them how much compensation they require to stop the mining activities. If the company begins producing at p_1, the sufferers can bargain with the firm to reduce the deforestation back to point p_0, where the MEC of the sufferer and the MNPB of the mining company are equal. This would be in the interest of both parties since the sufferers are willing to pay any amount smaller than $C + D$, while the mining company would accept any amount greater than C, the benefit it otherwise would gain. Thus, the bargaining result, p_0, is the optimum. If the property rights would be in the hands of the sufferers, the same result will follow. Beginning at point p_2, the sufferers would agree to bargain as long as MNPB is above MEC, and hence the bargain would take us to p_0. Thus, in the absence of barriers to negotiations, the forest will be efficiently allocated. This is because the very existence of inefficiently managed resources will lead to pressure for improvement (Pearce and Warford, 1993).

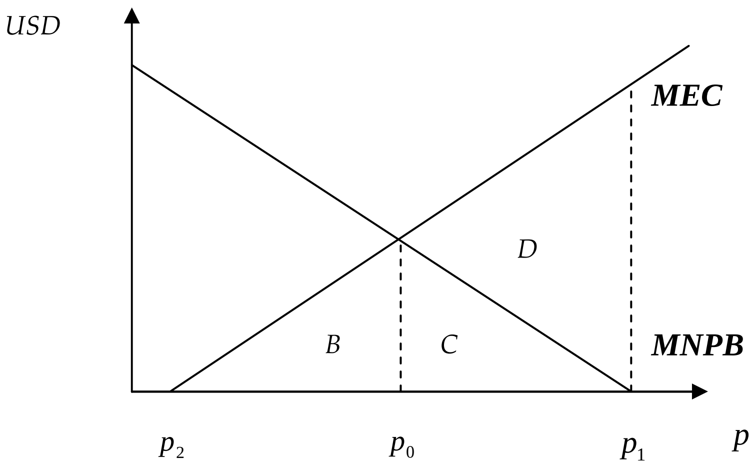

Figure 2.3 The Coase theorem
Source: Common (1995), p. 148.

2.3.3 Criticisms of the Coase theorem

The essential point of the Coase theorem is that clearly defined property rights triggers bargaining, which leads to an outcome consistent with efficient allocation of the resource. However, its importance should not be overstated. Several objections are raised, both theoretical and practical, to this bargaining method. The five main objections to this bargaining solution are presented below.

The existence of transaction costs and absence of bargains

The first criticism of the Coase theorem probably illustrates the most significant obstacle to bargaining actually taking place. This obstacle is the occurrence of transaction costs. If transaction costs, which includes the cost of bringing parties together, organizing the parties, and performing the bargaining itself, for any party is higher than the expected benefits of the bargain, that party will not participate in the negotiations. This obviously poses a problem when studying the Coase theorem since the aim of that theorem is to optimize the resource management with regards only to the environmental costs (Pearce and Turner, 1990).

Identifying the bargaining parties

Due to the fact that many pollutants stay in the environment for long periods of time, it is sometimes impossible for the two parties to come together and negotiate. Because of this, bargains may not take place even if transaction costs are less than the benefits of the bargain. Such pollutants include toxic chemicals, radioactive waste, and global carbon dioxide, among several others. One, although not so successful, attempt to solve this problem is to let individuals in the present generation negotiate on behalf of future generations of sufferers. Even in conventional pollution contexts, such as deforestation, it can be difficult to identify who the sufferers and polluters are. This mainly stems from the fact that even the sufferers themselves are unaware of the pollution and hence bargains are not likely to occur (Pearce and Turner, 1990).

Threat making

If the situation is so that the polluter has the property rights and the sufferer compensates him, there is a possibility that other polluters will try to enter the situation and demand compensation as well. The potential for making threats like this does certainly not contribute to an optimal use of scarce environmental resources. However, since this mainly occurs when the property rights are poorly defined, it can be avoided by a careful definition of who is entitled to the property rights of the resource. Another problem that might occur is that the company's pollution emission is deliberately increased in order to obtain extra compensation from the sufferers. What this means is simply that companies gets paid for adding to the social cost. In addition to this, threat making can occur even when the sufferers have the property rights. In the case of bauxite mining in Jamaica, the polluter may for example threaten the sufferer to increase the damages done to the lands while prospecting for the ore (Tisdell, 1993).

The free rider problem

Another difficulty with Coase's approach occurs when a large number of people are damaged. Not only will this cause the problem of costly organizing collective action, but it will also introduce the free rider problem. Some of the affected individuals may not wish to participate in such collective action in order to reduce pollution because they expect others to act. In this way, they obtain the benefits of the bargain without incurring any costs on themselves. Thus, the free rider problem makes it difficult for groups to act cohesively and effectively for the restoration of allocative efficiency (Tisdell, 1993).

The state of competition

Perfect competition is assumed in the analysis of optimal externality. Because of this, it can be seen in *figure 2.3* that MNPB=P-MC and hence (MNPB=MEC) where MNPB can be viewed as the polluter's bargaining curve in terms of the bargaining approach. It is MNPB that decides how much the polluter will accept, or pay, in compensation. But let us study the same situation when perfect competition no longer holds, i.e. when P-MC no longer represents the polluter's bargaining curve since it does not equals MNPB. Instead the polluter's bargaining curve will be his marginal profit curve which under imperfect competition is equal to MR-MC. Following that MR is not equal to P (because the demand curve is above the MR curve); the bargaining solution will not produce an optimal resource allocation under imperfect competition (Pearce and Turner, 1990).

2.4 Previous research

In this subsection we present in what way previous studies have employed the Coase theorem, and how this thesis complement and add to this research field. The Coase theorem has been employed in a wide range of research endeavors.

For instance, Donald J. Cymrot (2002) uses the Coase theorem in examining whether it is supported by migration patterns in professional baseball. Due to the major league baseball players´ highly developed skills, significant economic rents are generated. According to the Coase theorem, the allocation of these players should be independent of who owns the property rights to the gains from this migration. A dual system is established in American baseball where the market for senior players is competitive, allowing the players free agency, meaning that the players are allowed to attempt to contract with whatever team they choose, while the market for players with less professional years is monopsonic. Using player data from 1979 and 1980, Cymrot test whether baseball player movement is independent of the ownership of these economic rents. Over the years, the owners have argued that the competitive balance among teams has been threatened by the existence of free agents. Nevertheless, Cymrot demonstrates theoretically by using the Coase theorem, that free agency "is irrelevant to the question of competitive balance" (Cymrot, 2001, p.602). Similarly, Rosen and Sanderson (2000) use the Coase theorem in examining how property rights affect competition, supply, and player mobility in professional athletics.

Previous empirical research focusing on the application of the Coase theorem also includes the analysis of horizontal property by Coloma (2001). Horizontal property refers to bundle of property rights assigned on a certain building where parts of it are individually owned and other parts collectively owned by possessors of the building. Coloma uses the Coase theorem as an economic tool to explain the rationale of horizontal property. By treating the Coase theorem as a solution to set up rights on assets that jointly produce benefits subject to joint and individual consumption, Coloma demonstrates that horizontal property can be preferred when governance costs, as well as the number of economic agents involved, are high. However, when governance costs and economic agents are smaller, solutions involving individual ownership may be a preferred system of property rights.

As far as we know, the Coase theorem has in the past not been applied to the area of mining. This is where the research in this thesis differs from these earlier studies.

Chapter 3

THE JAMAICAN FORESTS AND BAUXITE MINING

In order to fully appreciate this case study, it is important to understand the historical as well as present contexts surrounding the Jamaican forests and bauxite mining.

3.1 The forests of Jamaica

Jamaica, which is often referred to as the "land of wood and water", is a Caribbean island covered with heavy vegetation. The large forest areas contain a large number of different tree types including bamboo, mangrove, broadleaf and palm trees. The rainfall determines the distribution of these tree types, but due to the country's sad deforestation rates, 75 percent of its original forest cover has been lost (Morris, 2002).

3.1.1 Forest values in Jamaica

Forests provide a long list of goods and services to humans all over the world. Unfortunately, the various values of forests are difficult to measure and therefore the role of the forest easy to overlook. However, in order for governments, companies, and societies in general to take forest conservation seriously, these values need to be known. The Jamaican Forestry Department focuses on eight different values that forests contribute to the Jamaican society. These eight categories are presented below in *table 3.1*.

Table 3.1 Forest values in Jamaica

Forest value	
Water production	Primarily, the forests in Jamaica play a crucial role in maintaining a reliable supply of high quality water.
Biological diversity	Conservation of forests in Jamaica is a matter of survival for an extraordinary biodiversity of plants and animals, including 3200 known species of flowering plants, 600 species of ferns, and 256 known species of birds.
Carbon Dioxide Sequestration	Carbon Dioxide (CO2) is the major factor behind global warming. The forests in Jamaica can be sources, sinks or reservoirs of this carbon dioxide. When destroyed forests are restored, they remove (sequester) the dangerous carbon dioxide from the atmosphere.
Timber and Non-Timber products	Aside from the formal economy, including timber products such as hardwood lumber, yam sticks, and fence posts, there is a significant market for minor forest products such as furniture construction and handcrafts.
Employment	Many jobs are provided by timber production, especially in rural areas.
Energy	Fuel wood consumed through burning is widely used in industrial processing as well as in household cooking.
Tourism and recreation	Jamaica is internationally known as the "land of wood and water" and the country's scenic beauty is a fundamental component of its attraction. Forests play an important role in maintaining this image of a green and beautiful paradise like island. Therefore a destruction of Jamaica's visual amities represents a serious threat to the country's tourism industry.

Source: National Forest Management Conservation Plan (2000), pp. 37-40.

3.1.2 Forest cover change over time

Forest depletion in Jamaica is relatively well documented. The most recent, and probably one of the most accurate, study was presented in March 2000 by the Jamaican Forestry Department and covered the island's total forest cover change between the years 1989 and 1998. The results from the study are presented in *table 3.2* and indicate that the loss of forestland over this ten-year period amounts to 3,063.62 hectares, which implicates an annual deforestation rate of almost one per cent. Bauxite mining, which is argued to be the largest threat to the island's forests, has the largest increase of land use over this period, 3,728.66 hectares. This figure include where open pit mining has taken place and not been rehabilitated. Two of the other main agents of deforestation in the country, infrastructure and buildings had a combined increase in land use of only 350.19 hectares during the same period (National Forest Management Conservation Plan, 2000).

Table 3.2 Land use/cover change in Jamaica, 1980 to 1998

LAND USE	1989 (hectares)	1998 (hectares)	Difference (hectares)	Loss/gain (hectares)
Forest land use/cover				
Broadleaf	269,870.64	266,855.18	-3,015.46	-1.12
Bamboo	2,791.20	2,979.41	188.21	6.74
Mangrove	9,751.46	9,731.37	20.09	-0,21
Sub-total	338,979.17	335,915.55	-3,063.62	-0.90
Non-forest land use/cover				
Buildings/Infrastructure	51,909.59	52,259.78	350.19	0.67
Fields	273,176.05	274,478.64	1,302.59	0.48
Plantations	83,145.25	82,341.34	-803.91	-0.97
Bare rock	866.98	933.88	66.90	7.72
Bauxite	1,193.29	4,921.94	3,728.66	312.47
Sub-total	423,025.41	427,599.70	4,574.29	1.08

Source: National Forest Management Conservation Plan (2000), p. 27.

Approximately 335,900 hectares, or over 30 percent, of Jamaica are classified as forest[3]. 39 percent, or 427,600 hectares, is classified as non-forest. Non-forest areas consist of water, bare rock, cultivated areas, bauxite mining, and buildings/other infrastructure.

[3] Ecosystem characterized by a dense and extensive tree cover, usually consisting of stands varying in characteristics such as species, composition, structure, age classes, and associated processes. Forests may include meadows, streams, fish, and wild life (Forestry Department of Jamaica, 2001).

3.2 Bauxite mining

Along with copper and iron, aluminum is regarded to be one of the most significant metals with respect to industrial processes and its value on world markets. Although it is possible to manufacture aluminum from several different ores, bauxite is by far the most important one (Banks, 1979). Bauxite occurs in massive quantities in the earth, dominantly in tropical and semi tropical regions, while seldom in colder and temperate zones. While grades of bauxite and chemical composition are principal, other important factors when determining the economic value of bauxite reserves are their access, their size, the transportation costs, and mining infrastructure cost. The aluminum oxides or "alumina" in bauxite, which typically is about 35-50 percent, are refined from the non-alumina by the so-called Bayer process. The alumina is then transported to aluminum plants, which most often is located in Canada or the US, where it is converted to aluminum by an electrolytic process. To yield one tonne of aluminum, two tonnes of alumina (Al2O3) is required (Campbell, 1985).

3.2.1 Bauxite mining in Jamaica

Bauxite is the most important mineral in Jamaica, and is currently the second largest industry in the country. Jamaica's over 1.8 billion tonnes of located reserves mainly occurs in pockets of limestone (Mines and Geology Division, 2002). Estimations show that at least one billion tonnes of the total amount of reserves are easy accessible, enough to last more than 100 years at current production rates. According to the Jamaican Bauxite Institute (JBI), the government agency responsible for monitoring the bauxite/alumina industry in Jamaica, approximately 85 percent of the countries' bauxite reserves are believed to be located (Interview JBI, 2002). The main deposits occur in the highlands, about 1.200 ft above the sea, in the parishes of Manchester, St

Elizabeth, St Ann, Trelawny, St Catherine, St James, and Clarendon. The bauxite in Jamaica is of the terra rosa type and contains 45-55 percent alumina. Its color varies from dark red to reddish brown, a peculiarity that indicates the occurrence of iron metal in the ore. No overburden covers the bauxite in Jamaica, which makes the ore easy and cheap to mine. The size of the deposits can be as large as 125 hectares (Mines and Geology Division, 2002).

Since the early 1950s, bauxite mining has been a vital part of the Jamaican economy. In the middle of the 1970s, the government enlarged its interest in the industry by purchasing a large portion of the island's bauxite operations as well as the majority of the company owned reserves. In return, 40-year leases were granted to the companies (JBI, 1996d). In 2002, only Australia and Guinea produced more bauxite than Jamaica. At present, there are four operators in the Jamaican bauxite industry. These are Kaiser Aluminum, Alpart (Alumina partners of Jamaica), Jamalco, and Windalco which all are assigned reserves by the government. According to the JBI, the industry serves as a leader in its contribution to the national economy, contributing 60 per cent of the island's foreign earnings. It also contributes to labor productivity, occupational safety, and the development of science and technology on the island (Interview JBI, 2002).

3.2.2 Environmental impact of bauxite mining

Bauxite mining, which is performed by open pit mining, is land extensive, dusty, and noisy. The mining process begins with a careful removal of the topsoil, which is then stored and replaced following the depletion of the mine. The problem with this is that the mining itself can reduce the soil's water retention capability. When the topsoil is replaced, it is thus less capable of retaining water, resulting in that mined lands are sometimes difficult to restore to its original state (American University, 2002). However, what by many are considered as the most significant cause of deforestation linked to the mining of bauxite are the access roads. Not only are forests cleared in order to make way for the access roads, but also once they exist, loggers move in and illegally remove trees in and around the mining areas. According to JBI, which has been mandated by the Natural Resource Conservation Authority (NRCA) to monitor all environmental activities in the industry, the access roads present bauxite mining's most serious threat to the forest cover on the island (Interview JBI, 2002).

Additional consequences that bauxite mining may have for the long-term survival of the country include abnormal rainfall patterns as well as prolonged droughts. These consequences are in themselves an effect of the large scale clearing of the island's vegetation (Neufville, 2001). The environmental affects facing the industry have long been a matter of public attention and possibly this is the main reason why Jamaica is considered to have one of the best records of restored mined lands in the world (American University, 2002). According to the JBI, all four operating mining companies are demonstrating moral as well as legislative compliance with the existing laws regulating environmental protection. More specifically, each company has an environmental management team that plays an integral role in its organization and is responsible for everything from environmental control and land restoration to education programs and public awareness (JBI, 1996e).

3.2.3 Mining legislation in Jamaica

In the late 19th century, when bauxite first was discovered on the island of Jamaica, no mining legislation existed. However, in 1943 the Commissioner of Lands underscored the need for mining legislation to control the future mining activities on the island. Four years later, following long and intense discussions about the content of this law, the Mining Act was signed on September 7, 1947 (Davis, 1989). At this point in time, the bauxite industry was at its initial stage of establishment in Jamaica and few people were aware of the potential effects the industry posed to the environment. However, the Mining Act heavily regulates the bauxite industry in Jamaica. In this section, a short presentation to some of the environmental aspects of the law is given.

When bauxite exists in Jamaica, it is owned by the government and not by the owner of the land. This signifies that all naturally occurring minerals in Jamaica are for the common benefit of the Jamaican people. The private landowner only has the surface rights while everything below the ground belongs to the Government. Since bauxite mining is performed through open pit mining, it is obvious that a problem arises. The case when bauxite occurs on private land is however heavily regulated in the Mining Act (Interview JBI, 2002).

The Government may issue licenses to anyone to explore the land, or mining leases to exploit it. Both local and foreign persons and companies are eligible for these licenses and leases. The Mining Act gives the lessee or the licensee the right to enter government land or privately owned land to search for minerals or to mine minerals after giving 14 days notice to the landowner or to the person occupying the land. Of course, fair and reasonable compensation is payable for all damages and for disturbance of the landowners surface rights, or for any damages done to his livestock, crops, trees, buildings, or works (JBI, 1996a). According to the Act, the companies holding the mining license, must, as soon as mining activities are finished, restore every mined area of land to the level of productivity that existed prior to the mining. This restoration must take place within six months after the activity has ended and failure to do so will result in a penalty of US$ 4,500 per acre. Since the average cost of restoration for mined-out bauxite lands is US$ 4,000 per acre, the companies are encouraged to restore rather than pay the fine. According to the JBI, failure of restoration is very unusual (JBI, 1996b).

Another important piece of legislation regulating the mining operations on the island is the Natural Resource Conservation Authority (NRCA) Act from 1991. Under this Act, before any physical development or construction can take place in the industry, a permit must first be obtained from NRCA. NRCA then reserves the right to grant or refuse this permit, as it sees fit. When any activity is likely to result in the discharge of industrial influents into the environment, the application for a permit must be accompanied by application for a license to discharge influents. NRCA reserves the right to refuse a permit if it is satisfied that the operation is likely to be harmful to public health or to any natural resources. NRCA can enforce these controls by ordering immediate cessation of the offending activity, or even closure of the plant (NEPA and Statistical Institute of Jamaica, 2001).

3.2.4 Land acquisition practices

A central issue of the bauxite mining in Jamaica is land acquisition, whether by outright purchase or by other means. However, this process often tends to be both a costly and difficult one involving the interests of the bauxite companies, government, and the landowners. The land acquisition process has shown in the past to sometimes be a lengthy one, where landowners and companies bargain for most favorable terms. It is important to recognize that, in order to prospect and search for minerals, the companies do not need to purchase the land. When a company decides to begin mining operations, they have a number of different alternatives to acquire the desired land. These include: (a) outright purchase of the property; (b) resettlement of landowners; (c) temporary relocation; and (d) cash compensation (JBI, 1996a).

Outright purchase of the property

As companies and landowners negotiate for most attractive terms, the process of property purchase can sometimes be a difficult and demanding one. The landowners naturally seek to maximize the returns for their land while the purchasers (bauxite mining companies) want to minimize their costs. Problems arise when landowners try to increase the value of their property by for example quickly begin construction of large buildings or hastily planned seedlings at unrealistically high density in order to get a higher compensation per acre. Due to problems of this kind, companies tend to prefer land resettlement programs over cash purchases (JBI, 1996a).

Resettlement

The most widely used practice for land acquisition for mining in Jamaica involves the resettlement of landowners. This practice has taken place in Jamaica ever since the Jamaican bauxite industry emerged in the early 1950s. In the bauxite industry, resettlement means relocating persons or communities from their former homes as well as replacing their assets and livelihood. Although the four companies currently operating in Jamaica have different resettlement policies, there are a few standard procedures that are followed by them all. One of these procedures is that once it has been decided that a certain area of land is to be mined, an offer is presented to the landowner by a representative of the company. When approached by this company representative, the landowner is faced with a number of offers, among them resettlement. This means that the landowner and the company agree on the basis of the purchase of the land, and the resettlement of the landowner to another location. A compensation package for crops and structures on the land is also worked out. The Mining Act sets out the basis for calculating this compensation. In some cases, the resettlement involves moving whole communities and thus providing water, electricity and associated infrastructure. However, in most cases resettlement involves relocating only one family to a lot near the land that was given up. Trough the development of resettlement lands, the companies try to ensure that affected persons improve, or at least regain, their former standard of living and earning capacity after a reasonable transition period. Connection fees for electricity and water are paid for by the companies and a tank of approximately 7000 gallon capacity is constructed (JBI, 1999b).

Although companies usually put in a great deal of effort to ensure the satisfaction of resettled families, the process is far from always smooth. Some of the factors that may create problems and delays in the resettlement process are presented below (JBI, 1999b):

- The resettlement sites often contain bauxite deposits and will eventually be required for bauxite. Resettled households then have to settle for alternative locations.
- It is often difficult to arrive at a mutually agreeable price. The asking price for land and other assets is often more than what the company's policy will allow it to pay. It therefore requires the use of private valuators and an agreement on a final valuation.
- Absence of legal documents, disputed land ownership, and absentee owners.
- Delays in transfer even in the cases where required legal documents are available.

- Resistance to severing family, friendship and cultural ties and the adjustment to new location.

Temporary relocation

The option of temporary relocation is exercised when the bauxite company is given access to the property to mine, but does not acquire the title to it. Usually, temporary relocation takes place when: (a) the owner cannot be located; (b) legal documents are unavailable; (c) the property is needed urgently; or (d) the property owner is ill and located too close to the mining area.

When this option is undertaken, the company restores the property after the mine is depleted to a level where it meets the standards set by the Ministry of Agriculture and Mining (JBI, 1997b). Standard procedures for all companies are that compensation, including full payment, is entitled to the landowner for:

- Disturbance of surface rights (loss of use of loss if income from the land).
- Damage done to the surface of the land.
- Damage of crops, trees, buildings or works.
- Rental of property during mining or reclamation operations.

Depending on the speed of the negotiations, this process can take between six months and two years. Although this option may seem very complicated and demanding, the JBI assure that a settlement is usually arrived at with the landowner emerging with a favorable deal (JBI, 1997b).

Cash compensation

In some cases, the landowner is content to allow the mining company to mine his land and to pay him compensation for damages. These damages include disturbance of surface rights, damages to crops, trees, buildings and other valuables. This is hardly ever done and when it is, the landowner is also entitled to 5 percent of whatever royalties that are payable to the government (JBI, 1996b).

3.2.5 Land reclamation practices

According to the Mining Regulations Act from 1947, it is a requirement that all mined-out lands must be restored as nearly as practicable to the level which existed prior to the mining. Usually, these mined-out lands are restored to pastures, root crops, tree orchids, or housing. If the restored lands are deemed unsatisfactorily restored by the Commissioner of Mines, fines to the companies are issued (JBI, 1996b). According to the JBI, all four companies operating in Jamaica have satisfactorily reclamation programs where hundreds of acres of land have been re-forested or put into agricultural production (JBI, 1996c).

Chapter 4

THE CASE OF MOCHO MOUNTAINS, CLARENDON

This chapter presents the empirical findings from the Jamaican minor field study. Using Tietenberg's (1996) criteria for property rights structures that support efficient resource allocations, information was gathered regarding whether or not a good basis for bargaining did occur in the Mocho area. Subsequently, we examined whether or not the five main criticisms of the Coase theorem (discussed in chapter two) were valid in the case of the Mocho area, Clarendon. This was mainly done by interviews with a number of government agencies monitoring the industry, but also with representatives from the operating bauxite company, Jamalco[4]. A possible source of interview bias may spring from the fact that the Jamaican government is co-owner of Jamalco and therefore less willing to reveal information that may hurt the company's image. However, interviews with local private landowners were not possible to perform. This naturally gave birth to some weakness in reliability of the study. Considering that much insightful information from other agents with environmental concerns was acquired, it was still possible to make a valid analysis whether or not the Coase theorem can be applied to the case of the Mocho area, Clarendon.

4.1 Background

Clarendon is a parish in the southern side of Jamaica, about halfway between the eastern and the western ends of the island. It has an area of approximately 1.167sq km and a population of just over 200.000 citizens. Clarendon boasts a

[4] Transcripts of the performed interviews will be handed out by the author upon request.

number of mountain ranges. The Mocho Mountains rise over 600 meters above sea level and are situated to the west of Chapleton, an important area for bauxite exploitation. Like most other parts of the island, the Mocho Mountains are covered with dense forest. Clarendon is also one of the major bauxite producing parishes on the island. For over forty years, the industry has been operating in the parish through the bauxite/alumina company Jamalco. Jamalco is an enterprise owned by the Jamaican Government and the Aluminum Company of America (ALCOA). ALCOA is the world's leading producer of primary aluminum, fabricated aluminum and alumina, and was the last bauxite/alumina company to come to Jamaica. The mining operations primarily take place in the Breadnut Valley mines in the Mocho Mountains. The bauxite is then transported by rail to the refinery, where the ore is made into alumina (Morris, 2002). Due to a coming removal of a 28-year-old Government levy on Bauxite in the year of 2003, Jamalco will lower its costs by approximately 30% and thus be expanding its operations in the future (Interview JBI, 2002).

4.2 The Case of Mocho Mountains, Clarendon

To acquire the desired land to mine in the Mocho Mountains, Jamalco almost exclusively exercises the practice of resettlement. The other three alternatives, cash compensation, outright purchase, and temporary relocation are hardly ever undertaken. According to JBI, this choice is almost entirely based upon the will of the landowners (Interview JBI, 2002).

Cash compensation is in most cases an impossible alternative because of the fact that the actual property is needed for the mining operation. However, in the cases when it is possible, landowners tend to prefer it over resettlement (Interview JBI, 2002). Because of the long duration of the mining operations in the area, temporary relocation is also not a suitable alternative. If for example a family has been relocated to another lot and lived there for as long as five years, it is very likely that the family have adjusted to the new community and therefore wishes to not move back to their old property. Why most individuals prefer resettlement over outright purchase is a question of risk and safety. With the resettlement property, the landowners know for sure what they get and this represent the sort of safety most of these relatively poor people need. This safety is not provided in the case of outright purchase.

Regarding land reclamation, Jamalco has performed well. The mined-out lands on the hills of the Mocho Mountains are now restored to productive use. Jamalco has never been fined for unsatisfactorily reclaimed mined-out lands in the Mocho area (Interview JBI, 2002).

4.3 Application of the Coase theorem

So, can the Coase theorem about optimal resource use be applied to the case of Jamalco and the Mocho Mountain forests? To be able to answer this question, the property rights arrangements to these forest areas must be studied. Are the property rights clearly defined and do they satisfy the four conditions required for efficient resource allocation set up by Tietenberg? The fulfillment of these four characteristics in the Mocho area case is discussed below.

As displayed in *table 4.1*, the property rights characteristics completely fulfill the requirements of universality, exclusivity, and transferability. The requirement of enforceability is only partly fulfilled due to the legal right of the miners to, with of without the approval of the landowner, enter private land within 14 days of notice. However, since this right is not exercised in the Mocho area, it can still be argued that the private property is secure from involuntary seizure and encroachment.

Table 4.1 Property rights characteristics in Mocho Mountains

Criterion	Grade of Achievement	Authors´ comments
Universality	Yes	According to the JBI, the forest and woodland areas on the hills of Mocho Mountains, Clarendon, are almost entirely privately owned. The entitlements are completely specified. This has been the case ever since Jamalco started their mining activities in the area in the early 1960s.
Exclusivity	Yes	Following that the property rights to the forests and woodland areas are clearly defined and privately held, all benefits and costs accrued as a result of owning and using them is accrued to the owner. Common use of the forest areas does not exist.
Transferability	Yes	All property rights are transferable from one owner to another. These transfers are completely voluntary.
Enforceability	Partly	Even though the mining company has the legal right to enter and mine the property of a private landowner within 14 days of notice, this legal right is not exercised at Jamalco. By acting in this way, Jamalco sustains the positive company-community relationships, which have proven to be invaluable for their profitability and success on the market. Hence, it can be argued that the property rights are secure from involuntary seizure of encroachment by others.

Thus, a good foundation for an efficient allocation of the forests exists on the bauxite land in the Mocho area, Clarendon. Due to the fact that the property rights structures of the forests fulfill these four characteristics, the landowners on the hills of the Mocho Mountains are provided with a strong incentive to use their land optimally. This is because a decline of its value would represent a personal loss to them. Therefore, we can move on to the Coase theorem. As outlined in chapter two, knowledge about the mining company's MNPB curve and the private landowner's MEC curve, must be known in order to be able to say anything about the optimal amount of externality. In order to gain information of the MNPB and the MEC, knowledge about the household preference system as well as the production technologies are required. Of course, this is very difficult. However, this is where the attraction of markets and bargains enter the analysis. Bargains reveal this information, which in turn identifies the efficient allocation of the resource.

By studying how well each of the five main criticisms of the theorem, outlined in subsection 2.3.3, fit in the case of Mocho area, conclusions regarding the Coase theorem can be drawn. We will therefore discuss each critique in turn, and present its impact of the outcome of the theorem.

The existence of transaction costs and the absence of bargaining

In the case of Jamalco and the Mocho area, Clarendon, the presence of transaction costs is negligible and does not pose and obstacle for bargaining taking place. Since Jamalco has been active in Clarendon for over 40 years, the company has established headquarters in the parish and because of this, the cost of transportation can be disregarded. In order to set the compensation sum for households, Jamalco performs property assessments where they study the value of the property, including the trees. According to the JBI, these surveys are done within a few hours or a day at most, and the cost of performing them is budgeted for as part of acquisition cost. These surveys are sometimes, but not always, performed by a qualified valuator. The process usually begins with Jamalco sending out a company representative to valuate the property, but if the landowner is not satisfied with this, a private valuator is engaged. By performing land and household surveys, Jamalco determines whether or not it is profitable to resettle a household or community. The factors that are studied include the location of the property, land classification, quality of nearby roads, details of water supply and the distance from main town.

When this is done, Jamalco sends out a company representative to meet with the individual who owns the land with the offer. Since this is a relatively short trip, the transportation cost is close to zero. Regarding the private landowner's transaction costs, these are also negligible. Aside from the possible opportunity cost of time, the initial transaction cost is in fact zero since these individuals are approached in their own homes with the ready offer. In cases when the company's first offer is rejected, negotiations follow which will increase transaction costs (Interview JBI and Jamalco, 2002).

The major factor why transaction costs are so low in this case is that Jamalco, like all other three bauxite/alumina companies in Jamaica, deals with the private landowners individually. If this would not be the case, the landowners would be forced to organize collectively and that would lead to increased transaction costs.

Even though no interviews with resettled landowners were performed during this field study, several examples tell us that Jamalco´s resettlement programs are received well by concerned inhabitants of the Mocho area. Ms. Dorothy Simpson was relocated from her farm on Mocho road to her present location in Pusey, Mocho Land Settlement, in 1992. Ms. Simpson was relocated to a house of equal size and a lot that is twice the size of the old one. In addition, Jamalco planted citrus trees on her lot and, for five years after the resettlement, sent a representative to weed her farm and fertilize her crops (JBI, 1999c). Mr. Murrel Osbourne is another Mocho inhabitant who has experienced a successful Jamalco resettlement. Mr. Osbourne was one of the first to be relocated on reclaimed land by Jamalco and says that he is much better off on his new land than he was on the old land. Like Ms. Simpson, Mr. Osbourne appreciates the regular visits from Jamalco´s agricultural specialists where they both get valuable advice and help (JBI, 1996f).

Identifying the bargaining parties

In the case of deforestation due to Jamalco's mining operations in the Mocho area, Clarendon, there is no problem of identifying the bargaining parties. This is entirely due to two factors. First, each bargain made by Jamalco includes only two parties, Jamalco itself and one single private landowner. Since Jamalco deals with every private landowner separately, there never exists any problem of identifying who this is. Second, in the Mocho area, almost all property rights are legally documented with clearly defined entitlements. In the cases where legal documents are missing, exchange agreements are entered into while the landowner is required to obtain a legal title for exchange for a resettlement lot. However, these cases are very rare, and are therefore not representative in this analysis. Since legal documents stating the owner of the land exists, Jamalco has no problem of identifying whom to bargain with in order to access the land they desire (Interview JBI, 2002).

Threat making

No evidence was found to support that the private landowners have threatened Jamalco to receive higher amounts of compensation in the past. Concerning the issue of possible threats made by Jamalco aimed at private landowners, no complaints have been conveyed over the years. Ms. Dorothy Simpson, resettled by Jamalco in 1992, said this about Jamalco´s behavior: "If I ever say Jamalco has treated me bad, I would be a wicked person" (JBI, 1999c).

The free-rider problem

The free-rider problem is avoided in the case of Jamalco and the Mocho Mountains, Clarendon, simply because of the fact that the bargain only includes one sufferer and one polluter. Thus, there is no space for any of the parties to act as a free rider and draw benefits from this, regardless of who owns the property rights to the forest.

State of competition

As has been shown in the previous chapter, perfect competition does not prevail on the Jamaican bauxite/alumina market. First of all, there are only four companies currently operating on the market. Second, the Jamaican Government assigns each company long-term licenses to mine certain areas, which imply that no competition at all exists on the market. In the case of Mocho Mountains, Jamalco is the only operating bauxite/alumina company performing mining activities. In terms of the Coase theorem and the bargaining approach, this means that the MNPB can no longer be said representing the Jamalco's bargaining curve. This in turn implies that the solution reached in the bargain will not be an optimal solution.

Chapter 5

CONCLUSIONS

It is now time to summarize the findings of this case study and draw conclusions about the forest and woodland management in the Mocho area, Clarendon, Jamaica. The hypothesis that the forest and woodland areas in bauxite mining areas in Jamaica are optimally allocated according to the Coase theorem must be rejected. This field study shows that the conditions surrounding the forest management in the Mocho Mountain are not sufficient to apply the Coase theorem.

First of all, Tietenberg's four characteristics of property rights structures were studied. By doing this, it was clear that the property rights structures in the Mocho area laid a solid foundation for a bargaining solution to the problem of deforestation due to bauxite mining. However, when focus was turned to the Coase theorem to analyze if it could be applied to the deforestation problem in the case of Mocho Mountains caused by bauxite mining, we find that, much due to Jamalco´s practice to bargain separately with all private landowners, none of the four practical obstacles to the bargaining approach could be applied to this case. Nevertheless, the theorem is assuming perfect competition and since this does not prevail on the Jamaican bauxite/alumina market, my hypothesis must be rejected. Thus, an optimal allocation of the forests in the Mocho area is not taking place.

However, we should not dismiss the forest management in this area as a total failure. Several positive aspects of the property rights approach is presented in the forest and woodland management in the parish of Clarendon and even if the solution is not optimal, we believe that bargaining solutions like these frequently can prevent the worst excesses of environmental degradation from taking place. Among these positive aspects are the low transaction costs, the absence of free riders, as well as the simplicity of identifying the bargaining parties.

Implications for the future

Even though no further research was done, it seems as similar kind of bargaining solutions take place in Jamaica as a whole. So the question to be asked should be; can this type forest management through bargaining take place in other parts of the world in similar situations? However, it does not necessarily need to involve the mining for bauxite. Other land extensive operations like timber extraction may also have potential to apply the same practices. At a first glance, it seems so. But it is important to remember that Jamalco have been established in the parish of Clarendon for more than 40 years, which have lead to a genuine knowledge of the community as well as transaction costs that are negligible. However, the forest management in Mocho Mountains, Clarendon, sets a good example for sustainable resource use for other parts of the world where similar conditions prevail.

LIST OF REFERENCES

American University, USA [2002] *Jamaica Bauxite Case (BAUXITE)* Website (http://www.american.edu/ted/bauxite.htm), 2002-11-05.

Banks, F.E. [1979] *Bauxite and Aluminum: An introduction to the Economics of Natural, Minerals.* Lexington Books.

Boutiaga, V. [2002] *Introduction to Economics.* Website (http://www.eco.nm.ru), 2003-01-10.

Campbell, D.C. [1985] *Global Mission – The Story of Alcan*. Ontario Publishing Company.

Coase, R. [1960] The problem of Social Cost. *Journal of Law and Economics,* October, 1960. pp 1-44.

Coloma, G. [2001] An Economic Analysis of Horizontal Property. *International Review of Law and Economics*. September 2001, Vol. 21, Issue. 3, pp. 343-54.

Common, M. [1995] *Sustainability and Policy – Limits to Economics*. Cambridge University Press.

Cymrot, D. J. [2001] 'Who's on first': an empirical test of the Coase Theorem in baseball, *Applied Economics*, Apr2001, Vol. 33, Issue 5, pp. 593-603.

Davis, E. C. [1989] *Jamaica in the World Alumina Industry 1938-1973.* JBI Publications Ltd, London.

Forestry Department of Jamaica [2001] *National Forest Management and Conservation Plan*. Website (http://www.forestry.gov.jm/PDF_files/-ForestPlan.pdf), 2002-10-05.

Forestry Department of Jamaica [2001] *Forest Policy 2001*. Website (http://www.forestry.gov.jm/legis.htm#), 2002-10-05.

JBI [1996a] Land acquisition practices in the bauxite/alumina industry, *Bauxite/Alumina Industry Review, March-December 1996*. p. 21.

JBI [1996b] The role of the Ministry of Agriculture and Mining in the bauxite/alumina industry, *Bauxite/Alumina Industry Review, March-December 1996*. pp. 5-6

JBI [1996c] Bauxite Land Reclamation practices yield benefits to farmers, *Bauxite/Alumina Industry Review, March-December 1996*. pp. 22-23.

JBI [1996d] Bauxite and Alumina: The making of an industry, *Bauxite/Alumina Industry Review, March-December 1996*. p. 2.

JBI [1996e] Environmental monitoring and control systems in the bauxite/alumina industry, *Bauxite/Alumina Industry Review, March-December 1996*. pp. 17-18.

JBI [1996f] My experience on Jamalco reclaimed land, *Bauxite/Alumina Industry Review, March-December 1996*. p. 23.

JBI [1997a] Bauxite Mining and Environmental Regulation, *Bauxite/Alumina Industry Review, January-December 1997*. pp. 8-9.

JBI [1997b] Resettlement programmes in the bauxite/alumina industry, *Bauxite/Alumina Industry Review, January-December 1997*. p. 6.

JBI [1999a] Industry concerns for the industry, *Bauxite/Alumina Industry Review, January 1998-December 1999*. p. 3.

JBI [1999b] Resettlement practices in the bauxite/alumina industry, *Bauxite/Alumina Industry Review, January 1998-December 1999*. p. 11.

JBI [1999c] My Jamalco resettlement… good experience – Dorothy Simpson, *Bauxite/Alumina Industry Review, January 1998-December 1999.* p. 11.

JBI, Kaiser Aluminum, Alcan, Alpart & Jamalco [1992] *The Bauxite/Alumina Industry and the Environment*. JBI, Kingston.

Mines and Geology Division [2002] *Jamaica's Mineral Resources*. Website (http://www.minesandgeologyjamaica.com/resources/resources.htm), 2002-12-10.

Morris, M. [2002] *Discover Mandeville.* Website (http://www.discoverjamaica.com/gleaner/discover/tour_ja/tour7.htm), 2002-12-10.

NEPA & Statistical Institute of Jamaica [2001] *Jamaica's Environment 2001*. Statistical Institute of Jamaica, Kingston.

Neufville, Z. [2001] *Environment – Jamaica: Bauxite Mining Blamed for Deforestation,* Website (http://www.forests.org/archive/samerica/bauxitemini. htm), 2002-10-20.

Pearce, D. & Turner, K. [1990] *Economics of Natural Resources and the Environment*. Harvester Wheatsheaf, Hemel Hempstead.

Pearce, D. & Warford, J. [1993] *World Without End – Economics, Environment, and Sustainable Development*. Oxford University Press.

Tietenberg, T. [1996] *Environmental and Natural Resource Economics, Fourth edition*. HarperCollins College Publishers, New York.

Tisdell, C. A. [1993] *Environmental Economics: policies for environmental management and sustainable development*. Aldershot, England.

World Rainforest Movement [2002a] *What are the underlying causes of deforestation?* Website (http://www.wrm.org.uy/deforestation/indirect.html), 2002-11-15

World Rainforest Movement [2002b] *Deforestation linked to mining, agriculture and tourism.* Website (http://www.wrm.org.uy/bulletin/50/jamaica.html), 2002- 11-15.

World Rainforest Movement [2000] *Undermining the Forests. The need to control transnational mining companies: a Canadian case study*. Forest Peoples Programme, Philippine Indigenous Peoples Links and WRM, January 2000.