Behind the life cycle of coal: Socio-environmental liabilities of coal mining in Cesar, Colombia

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Abstract

Open-pit coal mining in Cesar, Colombia increased by 74% between 2000 and 2012, generating environmental and social damages unacknowledged by multinational mining companies and the state. This study aims to identify and value socio-environmental liabilities from coal mining at different stages of the coal life cycle. Environmental liabilities can be operationalized under three types of responsibilities: moral, legal, and economic. The identification of environmental liabilities allocates moral responsibility; the legal responsibility is needed for effective reparation; and the economic valuation provides arguments to claim compensation, seek remediation, and mitigation of damages. To identify socio-environmental liabilities, interviews were conducted and environmental mining conflicts were analyzed. To estimate monetary values, data were linked to existing literature on costs associated with damages. Results show that the economic values of socio-environmental liabilities per ton of extracted and exported coal are higher than the market price of coal. The main socio-environmental liabilities arise from pollution, public health deterioration, water table depletion, land and ecosystem services losses, damages from transportation and shipping, and coal reserve loss. A comparison with studies in China and the United States indicates that values increase when public health impacts and climate change on a global scale are included.

Keywords: Socio-environmental liabilities, coal mining, coal life cycle, economic valuation.

Highlights

- Every extracted ton of coal involves socio-environmental liabilities at each stage in the life cycle (extraction, transport and combustion) and at different scales (local, national, and global).
- The economic value of socio-environmental liabilities per ton of coal in Cesar from the mine to harbor for export exceeds the price of coal.
- Environmental liabilities value increases when public health impacts and climate change on a global scale are included.
- Environmental liabilities can be operationalized under three types of responsibilities: moral, legal and economic.

1. Introduction

Emerging global economies are provoking an expansion in global social metabolism.[1] There is an accelerated demand for primary resources generating pressure to exploit areas that were initially outside the scope of the market, such as Indigenous territories and pristine ecosystems (Muradian, *et al*. 2012). In Latin America, Gudynas (2013) describes this new economic and political order as “extractivism”. Svampa (2013) names this the "Commodity Consensus", including both post-neoliberal and neoliberal governments, substituting the "Washington Consensus" (imposed by the World Bank and International Monetary Fund). She describes two processes: first, reprimarization of economies through the expansion of large-scale extractive processes with limited added value; Second, the deepening of "accumulation by dispossession" (Harvey, 2003). These processes put pressure on the environment and local communities, causing strong social resistance (Gudynas, 2014). In Colombia, Pérez-Rincón (2014) has reported a relationship between the quantity and intensity of environmental conflicts and growing extractive industries. For instance, 42% of reported environmental conflicts in Colombia are related to mining activities and 19% to the exploration and extraction of fossil fuels. In particular, coal mining accounts for 15% of environmental conflicts.

Coal is one of the three main energy sources in the world and is used to generate 40.4% of the world’s electricity, while coal, peat and oil shale were responsible for 43.9% of global CO_2 emissions (IEA, 2014). Moreover, coal mining has a negative impact on the environment, human health, and climate change throughout the coal life cycle (Bell & York, 2012; Epstein *et al.*, 2011; Morrice & Colagiuri, 2013; Palmer *et al*., 2010; Yushi *et al*., 2008).

In 2013, Colombia was the fifth largest net exporter of coal, after Indonesia, Australia, Russia and the U.S. (IEA 2014). The coal exported by Colombia comes mainly from the Guajira and Cesar states. Coal production in Colombia increased by 57% in the last decade to 89.2 million tons in 2012. Cesar´s coal production increased by 74%, from 12

[1] It is defined as the physical process of the economic system, in terms of energy and materials associated with economic activities. It includes both direct and indirect inputs and waste. See Fischer-Kowalski and Haberl (2007).

million tons in 2000, to 46.6 million tons in 2012, overtaking the production in Guajira, traditionally the largest exporter, which in the same period increased its production by 37%, producing 35 million tons in 2012. All coal extracted in Guajira and Cesar is destined for export. In 2012, most of Colombian coal was exported to Europe (51.4%), in particular to the Netherlands (19.7%), while 7.8% was exported to Asia and 7.2% to the U.S. (SIMCO, 2015).

The expansion of large-scale mining in Colombia is driven by the metabolic change in the world economy, through a combination of commodity price increases and the governments' neoliberal policies that consider mining a "development locomotive". Through the Mining Code (Law 685 of 2001), governments promote mining as an activity of public utility and social interest, arguing that it advances industrialization, generates national and local development, increases exports, creates jobs, and produces royalties for the state. The Mining Code limits government participation to a regulatory role and leaves mining operations in the hands of the private sector (Fierro, 2012; Pardo, 2013). Indeed, foreign direct investment in the 1990s ranged from US$2-3 billion a year, increasing to more than US$10 billion in 2005, and topping more than US$16 billion in 2012 (Rudas & Espitia, 2013). Consequently, norms granted for Afro-descendant and Indigenous communities' rights and policies to protect ecosystems and biodiversity are violated in granting permits for exploration and mining (ABColombia 2012; Vargas 2013).[2]

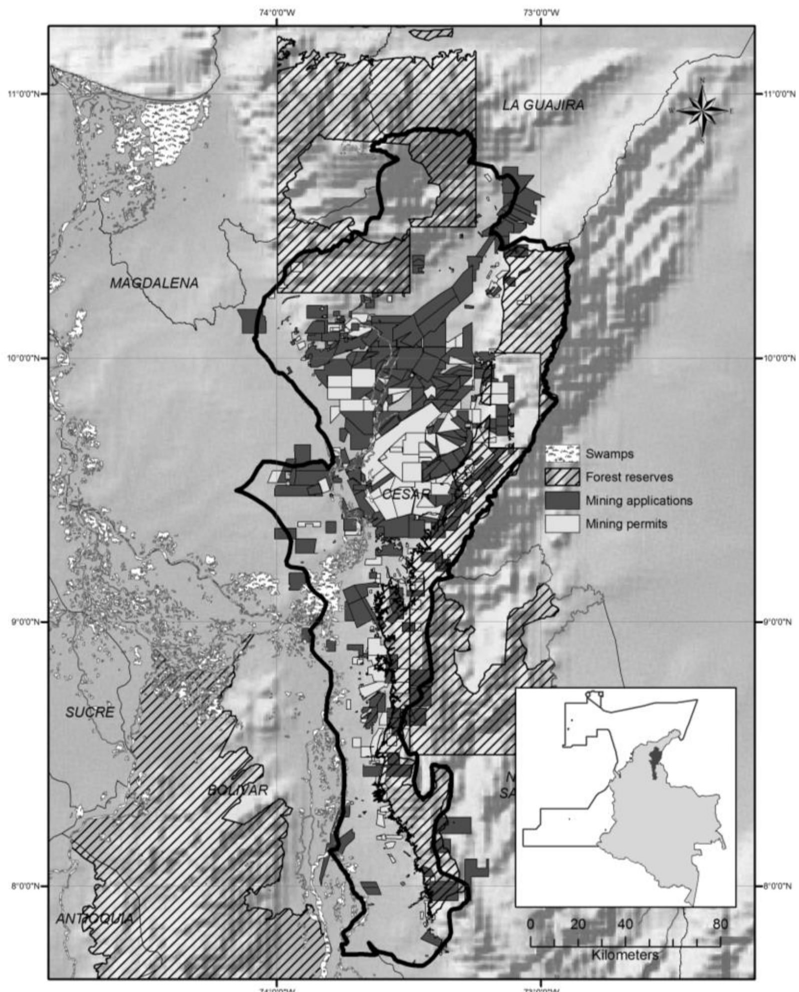
In Cesar, several multinational companies have been granted open-pit mining permits to extract and export coal in the past 10-20 years. The three main companies are: Drummond (U.S.-based), which exported 54% of the total coal production in Cesar in 2011; Prodeco (subsidiary of the Switzerland-based Glencore-Xstrata), which exported 16% in 2011; and Colombian Natural Resources (CNR; controlled by Goldman Sachs) responsible for 8% of exports (SIMCO, 2015).

Open-pit coal mining in Cesar takes place in tropical dry forests, weakly protected ecosystems, involving a high probability of loss to biodiversity and ecosystem services.

[2] Law 70 of 1993 and ILO Convention 169

Coal deposits are located within valuable ecosystems including: Santa Marta *Sierra Nevada* in the northwest; *Perijá* mountains in the east; and the *Zapatosa* wetland in the south. These ecosystems are essential for regional agriculture. Figure 1 depicts the overlap between forest reserve areas, mining titles and applications for July 2013.

Figure. 1. Forest reserves, mining titles and applications in Cesar, Colombia



Source: Colombian Mining land registry (July 2013).

As in other regions of Colombia, mining areas in Cesar are historically affected by guerrilla and paramilitary violence (PAX, 2014). Moreover, coal mining operates under weak environmental institutional frameworks reflected in inadequate control instruments and sometimes coopted authorities (Fierro, 2014). The livelihoods of local communities are negatively affected. They face significant social, environmental and human rights damages that are not compensated by mining companies. These economic, ecological and social liabilities may increase if Colombia doubles its coal exports. Under these conditions, two critical points stand out. First, the coal mining multinationals do not take moral and legal responsibility for environmental damages nor for the health problems of the local population. Second, the communities do not have decision-making rights regarding distribution of mining revenues.

The objective of this study is to identify, characterize, and value the socio-environmental liabilities of mining in Cesar to evaluate the monetary and/or non-monetary compensation for the damages.

Section 2 will explore the meaning of environmental liability. Section 3 explains why economic valuation is sometimes appropriate to assess such socio-environmental liabilities. Section 4 presents the methodology. Section 5 identifies several socio-environmental liabilities from coal mining in Cesar and gives the economic valuation. Section 6 compares the results with studies conducted in China and the U.S. Section 7 draws conclusions and explores limitations of the study.

2. Environmental liability

Liabilities and assets are the two main items on a balance sheet in accounting terminology. Liability accounts include the current debts of the company; i.e. the monetary value of all debts to banks and suppliers, among others. In double-entry accounting, liabilities are claims on assets. Normally, all monetary debts are included in the balance sheet but environmental and social debts are not. They are considered externalities.

The concept of environmental liability has been operationalized as three different responsibilities: moral, legal and economic (Zografos *et al.*, 2014). Identifying “uncompensated damage” allocates moral responsibility due to unfair distribution of the damage. Environmental Justice Organizations (EJOs) acknowledge that moral responsibility generates an obligation to repair damage, to compensate (in monetary and non-monetary terms), and to stop further damages. However, moral responsibility is not sufficient for reparations. Legal responsibility is needed for the effective reparation of environmental damage and compensation to the victims (Fierro & López, 2014).

The degree of the legal responsibility depends on each countries´ legislative system, and the strategies to compensate for remediate damages. In Europe, the Environmental Liability Directive (OJEU, 2004) regulates payment for remedying damage once it is possible to prove a causal link between a damage and the activity of a company. In the U.S., the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) determines liabilities as retrospective obligations to pay for cleanup costs of pollution.

Some EJOs and activists have claimed that the environmental liabilities of exporting extractive industries are part of an ecological debt from the global North to the South, that would also include "climate debt" because of "loss and damages" (in the vocabulary of the international negotiations). Conceptualizing environmental damage as environmental liabilities and ecological debt is a language deployed not only for claiming compensation but more importantly to stop and prevent further damages (Martinez-Alier *et al.*, 2014).

2.1 Environmental Liabilities from Mining

In the case of mining activities in Latin America, the concept of environmental liability ("*pasivo ambiental*") has been used in the public sector for the management of abandoned mines (Yupari, 2004). In Peru, the term is used not as a concept of obligation or debt, but to name the elements present in abandoned mining infrastructure and effluents, such as acid drainage.[3] In Chile, the National Commission for the Environment (CONAMA) acknowledges *pasivo ambiental* as "abandoned mining workplaces which constitute a significant risk to human health and the environment." In contrast, Bolivia´s Environmental Law 1333 adopts a general definition of *pasivo ambiental*: "A group of negative impacts dangerous to health and/or the environment, caused by activities which existed for a determined period of time and generated unresolved environmental problems."

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[3] This definition was included in the Law 28271 of 2004, Perú.

In 2010, the firm Econometría undertook a study for the Colombian Ministry of Mines and Energy, which established a characterization, prioritization and valuation methodology for environmental liabilities in order to formulate policy guidelines.[4] They defined two types: those derived from uncompensated damage of inactive or abandoned mines; and those resulting from damage caused by current mining activities. The study suggested that liability should not be limited to impacts associated with inactive mining because active mining also generates environmental damage that requires management, for instance toxic water spills or accidental tailing dam failure. The responsible agent is the mining company, but there are also co-responsibilities of the environmental authorities who have allowed (by acting or by omitting any action) the "configuration of environmental liabilities" (Econometría, 2010).

This paper approaches environmental liabilities in Cesar as the uncompensated damages caused by companies that currently mine coal.

3. Is economic valuation (EV) appropriate for environmental liability accounting?

In an ecological context, EV is a process that assigns monetary value to natural resources. The methodology includes both the estimated monetary value of goods and services provided by environmental resources and the quantification, in economic terms, of environmental damages. Economic valuation is widely used and accepted, but for Ecological Economics the term "valuation" implies other ways of valuing besides the monetary approach (Kallis *et al.*, 2013). Non-economic languages such as ecological and sacred values of Indigenous and Afro-descendant communities are becoming stronger at a global scale, and they have a considerable meaning in multicultural countries (Rodriguez Labajos & Martinez-Alier, 2013). Therefore, when dealing with the EV of environmental liabilities it is important to consider that values are expressed in different languages and scales (Martinez-Alier *et al.*, 1998), because of the diversity of actors involved that have different perspectives and different degrees of dependence on the use of natural resources.

[4] The methodology proposed has not been adopted by Colombian regulations.

Previous studies have used EV as a framework to highlight the environmental costs of coal mining damages. For instance, Yushi *et al.* (2008); Epstein *et al.* (2011); and Li *et al.* (2011) have estimated a wide range of costs derived from air, water and soil pollution associated with mining; the impacts of transport and combustion of coal; and effects on communities, ecological integrity, and climate change. They used different EV methods – including market values, opportunity costs, and restoration costs – to assess socio-environmental costs of the coal life cycle.

This paper intends to advance the understanding of environmental liabilities accounting. Although not all liabilities can be measured and economically valued, some of them can be evaluated through other quantitative or qualitative indicators.

4. Methodology

To identify environmental liabilities, we conducted 23 semi-structured interviews in the Cesar coal mining area, Valledupar and Bogota in June 2013. The purpose was to understand the impacts of mining activity, investigate the local perception of environmental liabilities, and explore reparation options. We selected leaders of the representative organizations and governmental institutions working in the coal mining sector including: miners with work-related illnesses; union representatives from the multinational companies Drummond and CNR; community leaders from the villages of El Hatillo, Plan Bonito and Boquerón; Non-Governmental Organizations; the Secretary of Agriculture; and a panel of experts in different areas working in the coal mining sector (a medical doctor, a toxicologist, a geologist, two engineers, and two lawyers).

The semi-structured interview focused on the following questions: What are the impacts of coal mining in the community? How many people have been affected and what are the consequences? How can we estimate the cost of damages? How can mining companies compensate or remediate these damages? The duration of the interviews ranged between 1-3 hours.

Next, we listed the environmental liabilities, and compared the qualitative findings from interviews with quantitative secondary data from national and local governmental institutions and linked them to the analysis of environmental mining conflicts. The secondary data included press releases from trade unions and various organizations related to coal mining; court sentences and legal documents from Cesar; and news reports.

In order to evaluate the socio-environmental liabilities we examined the stages of the coal life cycle, using the framework proposed by Epstein *et al.* (2011) which tabulated and derived monetary values for a wide range of environmental costs. They monetized and tabulated those that are monetizable, quantified those that are quantifiable but difficult to monetize, and described the qualitative impacts. We replicated this classification.

The compiled data were linked according to the specific mining conditions in Cesar with existing literature on the costs associated with these types of environmental damages using market prices, remediation treatment, and mitigation costs. The estimates are presented in minimum and maximum ranges to address uncertainty regarding environmental damages accumulated over time. All the values are presented in US dollars based on 2012 prices.

5. Valuing socio-environmental liabilities of coal mining

Table 1 shows the socio-environmental liabilities identified on local, national, and global scales. Sections 5.1 to 5.9 explain the values given in Table 1.

Table 1. Economic valuation of socio-environmental liabilities of coal mining in Cesar

	Environmental and social liabilities		Indicators: Qualitative and quantitative	US$ per ton of coal 2012: Min.	US$ per ton of coal 2012: Max.	Economic Valuation Method used in the literature	Limitations of the economic valuation
Local	**Pollution**						
	Air	Gas emissions and coal dust	Reported levels of TSP and PM10 surpassed permitted limits	0.23	7.31	Hedonic prices and contingent valuation method (Mendieta *et al.*, 2010). Treatment cost (Li et al, 2011)	overestimated
	Soil	Mining waste	Ratio coal/mining waste = 1/18	39.78	59.61	Avoided treatment cost	underestimated
	Water	Water quality loss	Risk of water quality index > 35%. unfit for human consumption	0.38	0.50	Avoided treatment cost	underestimated
	Territory loss by open pit mining						
	Water resources committed: diversions of rivers and groundwater affected		10-14 m level of abatement				Irreversible non-monetizable loss
	Loss of agricultural land and livestock		36% decrease in temporary crops	1.82	6.50		overestimated
	Relocation: El Hatillo, Plan Bonito y Boquerón		912 families	0.58	1.02	Compensation agreement in Plan Bonito	underestimated
	Ecosystem services loss - Protected Areas		10% of protected areas have mining titles and 11% in mining request				Non-monetizable
	Public health loss		21 Drummond miners dead, 60% of doctor visits are respiratory illnesses	42.72	52.09	Dose-response method (Morales *et al.* 2012)	underestimated
National	**Loss by transportation and shipment of coal**		The distance travelled by the coal train is 240 km. It passes through 10 municipalities. It operates 24 hours a day	18.84	18.84	Hedonic prices, travel cost and contingent valuation (Coronado and Jaime, 2010), External cost rail freight (Forkenbronck,2001)	underestimated
	Lives lost in coal transportation accidents		In 2008-2011 there has been 25 deaths and 280 injured	0.20	0.48	Value of statistical life-VSL (Miller, 2000; Viscusi & Aldy, 2003; Viscusi, 2008)	underestimated
	Coal reserve loss (non-renewable resource)		About 1,933 Mton of coal reserve	5.44	13.09	"User cost" method (El Serafy, 1989)	It depends on the duration of the reserves and interest rate
	Subtotal	**Colombia**		**109.99**	**159.44**		
Global	**Pollutant emissions from power plants and climate damage from combustions emissions**		1 ton of coal would produce 2.5 tons of CO_2 and others pollutants (methane, oxides of nitrogen, oxides of sulfur, mercury and others)	376.99	1,900.73	Epstein, *et al.* 2011	underestimated
	Total			**486.98**	**2,060.17**		

5.1. Air Pollution

Several gases and pollutants are released when explosives strip rock covering the coal, and when mining wastes are exposed to air and water. Morales and Carmona (2007) indicate that the trace elements presented in Cesar open-pit coal mines are arsenic, mercury, selenium, cadmium, and lead.[5]

Along with coal extraction, storage and transport, dust is released. The coal dust causes: visibility reduction; material damages to buildings due to corrosive properties; alteration of local climate; and harm to respiratory systems. Total Suspended Particles (TSP), with the mass concentration of PM10 and PM2.5 have easy access to lung alveoli, which can cause severe respiratory diseases and irritation of mucus membranes (CorpoCesar, 2013).[6]

Each mining company includes air pollution control measurements in its environmental management plans. However, the pollution control is insufficient and the accumulated emissions of the mining companies in the coal zone area exceed the limits established by Colombian regulations.

In 2007, strong protests arose in La Jagua de Ibirico provoked by high levels of air pollution and the presence of respiratory disease in the community. As a result, the government declared Cesar´s mining district as a "pollution site" and imposed a remediation program on the mining companies. Nevertheless, the 2012 air quality monitoring system reported levels of TSP and PM10 that surpassed permitted limits.[7] In Plan Bonito, the TSP level was reported at 162.43µg/m³, while the maximum allowed level is 100µg/m³ per year. Along the road that leads to La Jagua, pollution levels reached 122.71µg/m³. PM10 levels in Plan Bonito and La Jagua were 74.05µg/m³ and

[5] Morales and Carmona (2007) investigated the coal from Cesar, particularly in the area La Jagua de Ibirico. They observed that coal has "(…) relative low percentages of ashes and high sulfur percentages," in comparison to those of the Guajira (Cerrejón area). The analysis of trace elements in the samples of Cesar reveals the following concentrations: mercury, 0.017 ppm – 0.336 ppm; arsenic, 0.32 ppm – 11.67 ppm; selenium, 0.92 ppm – 6.63 ppm; cadmium, 0.13 ppm – 0.91 ppm; and lead, 0.56 ppm – 1.97 ppm.

[6] It includes all the aerodynamic diameter particles of 100µm or less. The breathable particles PM10 which have an aerodynamic diameter of 10µm or less; and PM2.5, which measures particulate material and has an aerodynamic diameter of 2.5µm.

[7] Online system and monitoring: http://sevca-zcc.dyndns.info/ambiensQ/ambiensqamt/corpocesar/

61.52µg/m³ respectively, while the maximum limit should be no more than 50µg/m³ per year (CorpoCesar, 2013).

Mendieta *et al.* (2010) estimated the cost of the externalities caused by the reported PM10 levels at US$7.31/ton of coal using hedonic price and contingent valuation method. This estimate can be considered the value of the environmental liability or debt since coal companies are not paying an environmental tax. We estimated US$0.23/ton for the minimum losses caused by the coal dust treatment based on the estimation in Li *et al.* (2011).[8] Therefore, the socio-environmental liability caused by air pollution is estimated in the range between US$0.23/ton - US$7.31/ton. This range is overestimated because it may involve double counting over other estimated liabilities, such as health effects.

5.2 Soil – Mining waste

Mining waste is a by-product of open-pit coal mining. Fierro and López (2014) calculated a ratio of coal to waste (stripping ratio) in the Colombian Caribbean region of 1:18 based on reports made by Drummond and Cerrejón. Coal production from Cesar reached 420.7 million tons in the period of 1990-2012 resulting in 7.57 billion tons of mining waste.

The mining companies are responsible for the treatment of mining waste dumps. However, the National Audit office (*Contraloria General de la República de Colombia* – CGC, 2014), found irregularities regarding the treatment, soil remediation and stability of the dumps with further evidence that the mining companies have only performed 42% of the rehabilitation.

The rehabilitation process involves covering the ground with an organic material of at least 15 cm; reforestation with manually planted, native species with a density of 1,111 trees per hectare; and maintenance for three years following the year of planting. According to the interviews conducted with three engineers working in the mining sector, the treatment costs range between US$3.81 - US$5.71 per ton of mining waste, resulting in US$68.58 - US$102.78 per ton of coal (based on the ratio of coal:waste, 1:18). Since

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[8] Li et al (2011) estimated the loss of US$31.6 million caused by the treatment costs of the coal dust from 1949 to 1959, in Mentougou District of Beijing, China, with extraction of 150 million tons.

mining companies must still complete 58% of the rehabilitation of the dumps, the liability is estimated between US$39.78/ton – US$59.61/ton.

5.3 Loss of water quality

In November 2013, the CGR (2014) conducted a multidisciplinary audit of the coal mining companies in Cesar, including a water quality analysis in the mining zone. The results of the audit show alterations caused by sulfur lixiviation and oxidation due to high levels of sulfate, manganese, and iron, increasing water acidity. The concentration of the chemical pollutants exceed Colombian and international standards for drinking water.

In 2011, the Ombudsman office (*Defensoría del Pueblo)* had requested Cesar´s Health Office to analyze the drinking water in El Haltillo due to complaints. Samples from underground water and the El Haltillo´s community aqueduct were analyzed. The laboratory results revealed a risk index for water quality (IRCA) of 37.5%, whereby values over 35% are classified as high risk and undrinkable. Likewise, reports from the Health Office of El Paso municipality, showed an IRCA of 36% in 2011 and for La Jagua de Ibirico, an IRCA of 47.33% in 2009.

One of the reasons for low water quality is the deficient wastewater treatment in the mines despite licensing requirements. The mining companies do not report their water usage. Prodeco, was obliged to report their water use due to plans to deviate the Calenturitas River.[9] The MAVDT (2009) reported that the total water consumption of the Predeco mine was 85.36 liters (L) per ton of extracted coal. This data is comparable to the figures reported by Cerrejón (2011) in a planned expansion project in Guajira (55-60 million tons per year), which would demand 17,000 m^3 of water per day or 103.4 -112.8 L/ton. In comparison, the water consumption in rural areas in Colombia accounts from 83

[9] Water use at this particular mine was used for the following activities (MAVDT 2009): Water-pumping from mining pits used to control coal dust; Water-pumping from wells used for fabricating explosive elements, washing vehicles and moistening coal. The excess is pumped into the Calenturitas River without treatment; Water run-off from treated mining waste dumps is directly pumped into Calenturitas River; Water run-off from untreated mining waste dumps with high levels of chloride, sulfur, calcium, sodium and other metals is pumped into sedimentation ponds.

to 120 L/day per person (Ojeda, 2000). In Guajira and Cesar during dry seasons or “El Niño”, consumption levels can drop to 7 L/day (Cabrera & Fierro, 2013).

To calculate the environmental liability of water pollution, we consider the lack of water treatment as a debt, with an avoided treatment cost of US$4.44/$m^3$.[10] This value is multiplied by the minimum and maximum values of the mines' water consumption. This value ranges from US$0.38/ton to US$0.50/ton. This range is underestimated because the water treatment is not sufficient to remediate the damages in flora, fauna, and humans for water pollution.

5.4 Loss of territory due to open-pit mining

Environmental liabilities include territorial loss at large mining sites. This includes the local population´s lost livelihoods due to loss of land and ecosystem services, given the fact that open-pit mining does not share land-use with any other activity.

5.4.1 Water resources loss: river deviation and groundwater damage

Large quantities of groundwater deposits are pumped from coal mines and several rivers of high importance to the local populations´ food security have been deviated. For example, the extension of the Calenturitas mine (Prodeco) altered the course of the Calenturitas River for 5.1km; Maracas River for 1.41km; and Tucuy River for 1.39km (MAVDT, 2009). These alterations changed the geography, the riverbeds, the availability and diversity of aquatic species.

Prodeco and SIG Ltda (2008) made a hydro-geological model to predict how mining will affect the points where drinkable water is captured. For instance, the lowering of the water table in Plan Bonito would reach 14.8m by 2020, probably caused by mining operations by the three companies. The model also evidences that Calenturitas River will face a flow reduction of 0,86 L/s. This study concludes that, given the limited availability of water in the coal zone, a deficit is foreseen, increasing the need for imported water from other distant sources such as the Perijá mountain range and the Magdalena River.

[10] We calculate the treatment cost based on personal interviews with engineers from Cerrejón and Coquecol SA and the author, August 2013.

The mining sector audit in Cesar conducted by CGR (2014) included water level measurements in wells close to those reported in the study by Brown (1983). The CGR compared the data and found a minimum of a 10m reduction to the water table. In addition, they found that Drummond deviated a stream without authorization, consequently there is a pending law suit.

The depletion of the water tables is an irreversible non-monetizable loss, because of the complexity of the water system and consequences on ecosystems and local livelihoods.

5.4.2 Loss of agricultural and grazing land

Cesar was a model in Colombia for its cattle, rice, and cotton farming. Between 1990 to 2010, temporary crops decreased by 36% from 531,890 to 338,585 tons, while for all of Colombia the decline was 7% from 8,770,590 to 8,190,616 tons (URPA 2010).[11] Between 1990 and 2012, the municipalities of Codazzi and El Paso lost approximately 9,300 ha of arable land. However, other towns such as Becerril, Chiriguana, and La Jagua reported increases in arable land by 14.161 ha, despite the constant and growing presence of mining in the last five years (Poveda, 2012). This could be explained by the presence of new monocultures of oil palm. In economic terms, between 2000 and 2011 the share of Cesar´s agricultural production within the national agricultural sector decrease between 11.13% and 3.1%.[12] This loss is assumed as a liability from coal mining and is estimated between US$1.82/ton – US$6.50/ton. This value is possibly overestimated because the agricultural sector could be affected by other impacts such as “El Niño” and agricultural national policies, among others.

5.4.3 Population relocation

In 2010, El Hatillo, Boquerón and Plan Bonito were given relocation orders by the Ministry of Environment to avoid further damage from air pollution that exceeded allowed limits. This was the first time in Colombian history that the environmental authority ordered a relocation. The Ministry imposed responsibility on Drummond,

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[11] Crops that mature within one or more rain seasons and are destroyed after harvesting, e.g. rice, maize and cotton

[12] Estimation based of the Colombia National Statistical System http://www.dane.gov.co/index.php/estadisticas-por-tema/agropecuario

Glencore-Prodeco, and CNR, for the resettlement of 912 families.[13] Plan Bonito was given one year to relocate, and El Haltillo and Boquerón were given two years. However, they are all pending resettlement.

Plan Bonito residents have been negotiating monetary and non-monetary compensation since 2007 for damage and loss. Table 2 lists the compensations according to agreements made in monthly meetings between November 2012 and December 2013. This process will be finalized when the companies give the families the agreed compensation.

Table 2. Monetary and non-monetary compensation for Plan Bonito relocation

Items to compensate	Compensation
House Replacement	105 m^2
Home furniture	Living room, TV, bed
Terrain	180m^2 of productive gardens
Crops	The productive life of a fruit tree and crop value.
Profits loss- commercial establishments	Earnings Loss during the last 6 years
Profits loss – Farmers	Minimum wage for the last 6 years
Emerging damage	The cost of moving and the rising cost of living
Dismantling the housing	Mining companies compensate to remove reusable material
Bonus for damages	Depends on the time lived in the town
Livelihood restoration program	Psychological support during and after the relocation. Youth education fund. Micro-enterprises fund. Grant to elderly.
Health	Medical examination and residents will be affiliated to private health care

Source: Personal Interview with lawyer representing Plan Bonito community

The relocation process of El Haltillo and Boquerón has advanced at different stages. In El Hatillo the mining companies are constructing a “transition plan” to overcome the food crisis decreed in February 2013 due to general unemployment and lack of cultivatable land. The plan includes food subsidies and creation of productive projects.

In Boquerón, more than half of the population is Afro-descendant and they are demanding the recognition of their ethnic rights as a *palenque*. However, the government does not acknowledge this and the relocation agreement is pending.[14]

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[13] According to the census made by the operator RE PLAN, Plan Bonito has 176 families; El Haltillo, 279; and Boquerón, 457.

[14] Ministry of Interior Certification 957 of May 30th 2012

The liability derived from not relocating these populations (in the period of time stipulated by the law 2011-2012) is valued based on the assumption that the monetary compensation negotiated by Plan Bonito would be replicated for the families in Haltillo and Boquerón. In Table 3, the liability due to non-relocation is estimated between US$0.58/ton to US$1.02/ton. This value is underestimated because the compensation plan in Plan Bonito (Table 2) does not include damages from air pollution and low water quality.

Table 3 Socio-environmental liability for not relocating the Hatillo, Bonito Plan and Boquerón

Relocation cost by family	Families	Minimum	Maximum
Families with commercial establishments (5%)	46	6,754,471.91	13,899,166.48
Farmers	866	45,444,046.71	78,250,341.10
Total	912	52,198,518.61	92,149,507.59
Cesar tons of coal production 2011-2012	90,366,460		
Social liability per extracted ton of coal (US$/ton)		0.58	1.02

Source: Author, based on data provided in the interview with the lawyer of Plan Bonito residents (June 2013)

5.4.4 Loss of forests and ecosystem

Nearly 27% of Cesar consists of national and regional protected areas while 10% of these protected areas have mining titles and 11.4% have mining requests pending. There is an overlap between mining development and protected zones. The land use change of forestry reserves and other protected areas has been regulated as 1:1 environmental compensation.[15] However, the loss of ecosystem and compensation for environmental impacts, are not considered.

Nature Serve (2010) conducted an ecosystems evaluation for 1,278,600 ha, which corresponds to 56% of the Cesar area. Only 30% of this area is covered by natural ecosystems and secondary vegetation. The remaining dry and riparian forests are in critical danger. The recommendation is to protect from 76% to 100% of these forests although they are located in areas with mining titles. The projections made by this study

[15] 1 ha of subtraction of forest reserves: 1 ha of reforestation. The species type for the reforestation is not regulated.

argued that coal mining causes loss of water, biodiversity, and ecosystems. Even when there is a 1:1 compensation for deforestation, the biodiversity loss is non-compensable (Yunis, 2010).

The coal mining activities affect the health of ecosystems. Cabarcas-Montalvo *et al.*, (2012), Coronado-Posada *et al.*, (2013) and Guerrero-Castilla *et al.* (2014) showed that the flora and fauna living around the Cesar coal mining areas have a greater chance of DNA damage and metal toxicity having implication on ecosystem services and human health.

The liability from loss of forest could be considered equal to the cost of "reforestation". However, ecosystem loss is considered as non-monetizable. Future investigations should approach an integral valuation that includes other valuation language such as ecological and cultural values.

5.5 Loss of public health

Section 5.1 and 5.2 estimates how much money companies save by not complying with environmental quality norms. These savings appear as extra profits. Here we give monetary estimates for the increased morbidity from coal mining. Failure to compensate for such damages also increases profits.

There is widespread frustration among the local community and miners due to the lack of government responsibility and mining corporations to address community health, and this has a powerful influence on the overall well-being of the locals. According to the Association of Sick and Injured Workers of Drummond (Asotred, 2012), 133 associates have had work accidents; 347 present several pathologies such as disc herniation and spinal diseases (53%); 4% have respiratory disorders; and 2% have been diagnosed with mining pneumoconiosis. After experiencing negative health effects and receiving the above mentioned diagnoses, mining workers began a legal process to pressure the Professional Risks Insurance (PRI) company to acknowledge their sicknesses as "professional" and allow them to be relocated, indemnified, or to retire. However, union members and sick workers reported that mining companies manipulated the PRI with the intention of cataloging their pathologies as “common disease” and thus, denying any right to compensation.

Asotred (2012) reported that during the years 2000 to 2011 have been died 21 miners, 16 in work accidents, two have died from respiratory diseases and three union leaders have been killed. There is a lawsuit against Drummond for collaborating with paramilitaries responsible for murdering these union leaders (PAX, 2014).

Hendryx & Ahern (2009) estimated the economic value of the mortality in Appalachian coal mining regions trough the Value of Statistical Life (VSL) Lost. The VSL concept is based on the amount that a group of people is willing to pay for fatal risk reduction (Miller, 2000; Viscusi & Aldy, 2003; Viscusi, 2008). The VSL have increasingly used in environmental analysis to value the benefits of pollution control policies or other public benefit programs (Miller, 2000), or to value the lost lives due to pollution (Hendryx & Ahern, 2009). Miller (2000) showed that VSL may vary between countries due to differences in cultural norms or income levels. He estimated that for developing countries (Peru and Venezuela) the VSL is about 120 – 300 times the annual GDP per capita. Table 4 shows the liability due to miners lost lives.

Table 4 Liability estimation due to miners’ deaths

Liability – miners deaths	Min	Max
VSL Miller (2000)* Colombia GDP per capita 2012 (US$7,763)	931.560	2.328.900
21 mining mortalities (Drummond)	19.562.760	48.906.900
Drummond production 2000-2011	172.487.454	
$VSL loss /ton	0,11	0,28

The Departmental of Health (Secretaria de Salud de la Gobernación del Cesar 2011) reported that 51.3% of the El Haltillo population presented diseases related to environmental pollution such as respiratory disease (30.08%), skin rashes (11.59%), and eye disease (1%). In La Jagua de Ibirico in 2012, 7,575 cases of illnesses related to environmental pollution were reported, out of which 68% corresponded to respiratory damages. Children are most affected. Agudelo, *et. al*, (2012) evaluated 1627 children from the Cesar coal mining zone and found that the frequency of respiratory diseases is higher in the population living in towns near mining waste deposits and with heavy coal traffic.

To economically value damages to health we used results proposed by Morales *et al*., (2012). The authors applied the dose-response method and concluded that for each 1μg/m^3 of annual exposure to MP10, 1,974 cases of Acute Respiratory Infection (ARI) are produced per year. They also estimated that in Colombia the average cost for ARI treatment is US$2,258 per person, including consultation, hospitalization, and treatment.

Liability due to ARI generation in the entire coal production area is calculated based on the annual emissions of PM10 between the years 2007 and 2012 which range between 382.7 μg/m^3 – 464.81μg/m^3 with an average annual coal production of 40Mtons.[16] The value estimated ranged between US$42.61/ton to US$51.81/ton. This is underestimated because it does not include other diseases caused by environmental pollution.

5.6 Losses due to coal transportation and loading

Mining companies transport extracted coal by train and trucks. The Atlantic railway is 240 km and in 1999 the private enterprise Fenoco received an authorization for its use. Two mining multinationals are the main owners of Fenoco: Drummond and Glencore-Prodeco. The train operates 24 hours a day with a 20 minute frequency and goes through 10 municipalities of Cesar and Magdalena.

Coal dust is dispersed from the mine to the port of Santa Marta. Coronado and Haider (2010) used three EV methods (hedonic prices, travel cost, and contingent valuation) to calculate a total annual loss of US$30.52 million in the real estate market in Santa Marta, a port city in the northwest of Colombia. The houses next to the coal transportation systems are impacted by noise and coal dust, deteriorating their value. This study also estimated a loss of US$67.3 million per year related to diminished travel frequency of national and foreign tourists (because of damage to landscapes, beaches, water and mobility). As a consequence, there is less income related to lodging, restaurants, and

[16] In 2007, the environmental authority in Cesar began air pollution measurements in response to the social movements in La Jagua.

leisure. The sum of these losses is considered to be the liability due to coal transportation in the area of Santa Marta, which is estimated to be US$2.44/ton.

To estimate the liability in other towns where coal is transported and shipped we consider external costs from train freight transportation (air pollution, greenhouse gases and noise) estimated by Forkenbrock (2001) as US$0.08 ton/mile (1994 prices). Table 1 shows the value converted into 2012 prices and multiplied for the equivalent of 240km miles with a total value of US$18.84 ton (including the liability in Santa Marta above). This value is underestimated because it does not include the regional effects due to coal transportation by truck freight.

5.7 Loss of human life due to accidents related to coal transportation

Coal transportation by train results in frequent accidents. Between 2008 and 2011 there were 25 deaths and 280 injuries reported. Fenoco denies responsibility, whereas the families of the victims argue that those situations could have been avoided if the coal mining companies had prevention mechanisms such as safety signs, alarms, and traffic lights that announce the trail´s arrival.[17]

To economically value the liability due to loss of human life we used the VSL lost (Miller, 2000; Viscusi & Aldy, 2003; Viscusi, 2008) used in section 5.5. To estimate the liability for those injured in coal transportation accidents the Colombian statutory accident insurance (SOAT), establishes a maximum of 500 times the legal minimum wage per day (SMDLV) for medical expenses and 180 times the SMDLV for permanent disability compensation.[18] Additionally, permanently disabled persons can access disability pensions through social security. With these costs we estimate the minimum at US$22,270.12 per person. To estimate the maximum we used the comprehensive injury cost estimated by Miller, *et al.* (1994), which includes medical and ancillary care, ambulance services, vocational rehabilitation, lost quality of life, lost wages, and legal defence cost. They estimated a cost of US$46,570.55 per person (converted to 2012

[17] This documentary informs about the accidents occurring in the railway: http://www.noticiascaracol.com/informativos/septimodia/video-301528-nadie-responde-victimas-del-tren-de-la-muerte

[18] The current legal minimum daily wage –SMDLV- in 2012 was US$10.5 and the legal minimum monthly wage-SMMLV was US$315.14

prices). Table 5 shows the total liability due to coal transport accidents is US$0.20/ton-US$0.48/ton. This value is underestimated because there are no reports of accidents before 2008 (the train began to operate in 1999).

Table 5 Estimation of the Liability due to coal Transport Accidents

Social Liability - coal transport mortalities		
	Minimum	Maximum
VSL US$	931,560.00	2,328,900
Total Value (25 victims) US$	23,289,000.00	58,222,500
Cesar tons of coal production 2008-2011	147,429,380	
US$/ton	0.16	0.39
Social Liability - injured in coal transport accidents		
	Minimum	Maximum
Cost per person injured in train accident	22,270.12	46,570.55
Total Value (280 injured)	6,235,633.93	13,039,754.00
US$/ton	0.04	0.09
Total Social Liability - Coal Transport Accidents US$/ton	0.20	0.48

5.8 The "user cost" – loss valuation of the coal reserve in Cesar

The "user cost" method (El Serafy, 1989) refers to the disinvestment made when consuming a nation´s non-renewable resources, since the country would be spending its potential of generating future income. In the case of coal extraction, Colombia is losing non-renewable resources and decapitalizing. According to El Serafy (1989) the irreversible loss of natural resources should be deducted from the generated income. For instance, the coal reserves in Cesar are 1,933Mton, if the annual coal extraction is 48Mton, the duration of the coal reserves will be 40 years. At an interest rate of 5%, the companies should deduct a 14% user cost from the revenue produced by coal extraction and deposit it in an account that will compensate for the depletion. In Colombia coal mining companies must pay 10% royalty (different from tax on profits) for a production larger than 3Mton per year. If the annual coal extraction increases to 65Mton (as predicted), El Serafy´s rule (always at 5% interest rate) would indicate a 22% "user cost".

Thus, they could be obliged to put this quantity into a fund that would be managed by the state on a concept of depreciation of this "natural capital". The state should be able to receive the interests of this fund once the coal is depleted. If the mentioned fund had started in 2012 (year 0) and assuming that the revenue of this sector corresponds to the whole market price of coal per ton, the mining companies would have to contribute US$13.04/ton if the annual coal extraction is 48Mton, or US$21.02/ton if 65Mton. In fact, in Colombia coal royalties of 10% is applied over the coal price without transport cost (US$79.35/ton) regardless of extracted tons and the length of reservations, the royalty is US$7.94/ ton.[19] Based on the values of the "user cost" (estimated above), the liability for the loss of coal reserves is US$5.44/ton - US$13.09/ton.

5.9 Global cost of coal combustion

Epstein *et al.* (2011) estimated the full cost accounting for the Appalachian coal life cycle ranged between $US818.7/ton to US$2,352.1/ton.[20] To estimate the cost associated to coal combustion in electric power stations they considered the local loss of public health, pollution, and damage to climate change. This loss could reach $US376.99/ton to US$1,900.73/ton and according to them, this values still undervalues the total effects. This estimation is used to value the socio-environmental liability due to Cesar coal combustion outside Colombia.

6. Comparison: Socio-environmental liabilities of the coal life cycle in Cesar and other studies

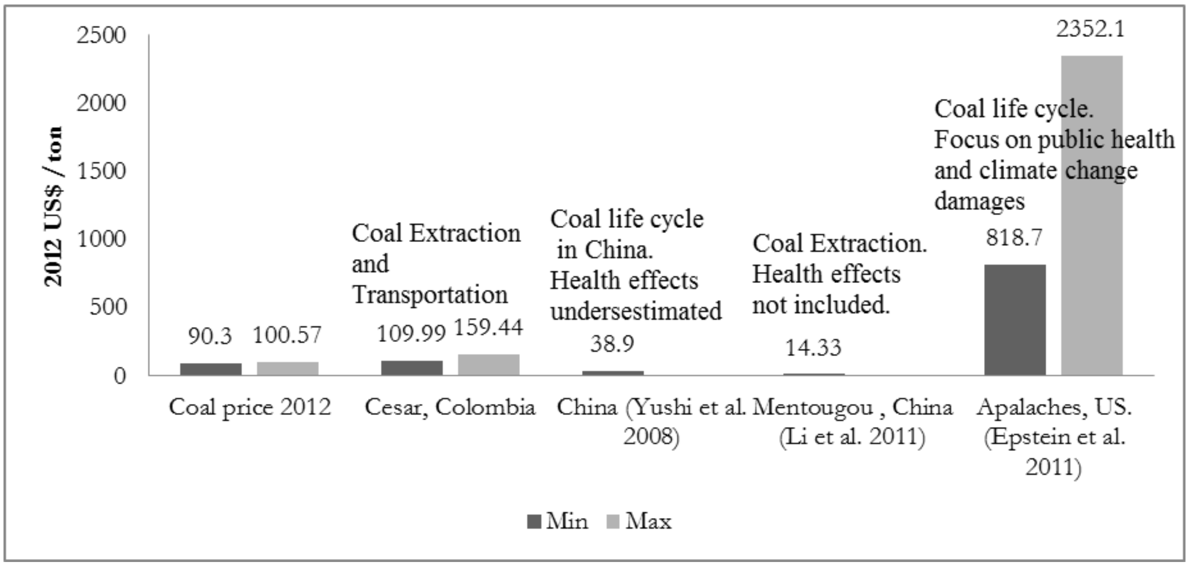
The aggregation of estimated values determines that each ton of extracted coal in Cesar produces socio-environmental liabilities valued between US$109.99/ton – US$159.44/ton during the extraction and transportation process. These results exceed the market price of one ton of coal, which in 2012 fluctuated between US$90.3/ton - US$100.57/ton. When including the value of socio-environmental liabilities of combustion (based on Epstein *et al.* 2011) those values increase to between US$486,98/ton – US$2,060.17/ton.

[19] price average of Ministry of Mines and Energy´s Resolutions (0141 March 29 of 2012, 0309 June 27 of 2012, 0429 September 27 of 2012, 0577 December 31 of 2012)

[20] Epstein *et al*. (2011) presents the costs in terms of ¢/kWh. A conversion to tons of coal equivalent was made: 1 ton coal equivalent = 8141 kWh.

In comparing the estimated values in Cesar with similar studies conducted in China and the U.S., the results show that values increase greatly when public health and climate change caused by combustion of coal on a global scale are included (Figure 2). For instance, Epstein *et al*. (2011) reported the largest socio-environmental cost associated to the coal´s life cycle at the national and global scales; and Li *et al*. (2011) reported the lower values because they only included damage estimations of coal extraction in a small district in Beijing, China. In turn, Yushi *et al*. (2008) estimated the value of the damages for the whole coal life cycle, but only at the national scale in China.

Figure 2. Socio-environmental liabilities of coal life cycle in Cesar vs. other studies



7. Discussion and conclusions

The economic valuation of socio-environmental liabilities per ton of coal depends on the life cycle that is being assessed, the scale, and the environmental damages included. Calculations of environmental liabilities in Cesar are based on the best available data produced and used by a wide range of institutions. This EV is limited by the difficulty to quantify the loss of water resources and damage to ecosystems. In addition, the study does not include other socio-environmental damages, such as mental health of the population and miners, others diseases and coal transportation damages in the whole region. Externalities for transportation from the Colombian coast to the importing countries are not included. Another limitation is “pricing” damages that are ethically difficult to monetize, such as the life value (or death value). Moreover, we have included data from different studies in this field, which have their own assumptions and uncertainties.

Regardless of the precise economic values, each ton of extracted coal in Cesar produces socio-environmental liabilities at each stage of the coal´s life cycle at the local, national, and global scales. When a ton of coal from Cesar is exported to Europe, the U.S., or Asia, it carries uncompensated socio-environmental liabilities values between US$109.99/ton – US$159.44/ton, which are considerably higher than the market price of coal. It also carries (in other valuation language) displacement of local communities, infringement of territorial rights, health problems, frustration in the communities, irreversible depletion to the water table, biodiversity and ecosystem loss, and human lives, among others.

In the relocation plan for Plan Bonito, El Hatillo and Boquerón, environmental liabilities such as cultural loss of territory should be included. The monetary compensation is an end-point intervention that does not fully resolve the distribution of benefits-damages. Further, these compensations may increase inequalities inside the communities, and can generate new conflicts and corruption.[21]

Throughout the whole coal life cycle who bear the social and environmental cost of coal extraction are the locals at all scales: the most impoverished communities and Afro-Colombian communities in Cesar; Colombia is losing coal reserves, water tables, forest and biodiversity; the combustion of coal affect the communities at the surrounding areas of the power plants but also contribute to the global climate change.

[21] Norwich declaration on environmental justice: "Money can´t buy justice". Available at: http://www.uea.ac.uk/documents/439774/0/Norwich+Declaration/ea31d880-ca9d-4176-9289-35e017a58350

The identification of environmental liabilities should start from a collective reflection that allocates moral responsibility of the damages, where the people can express their own concepts of reparation and compensation of damage. The EV of the damage provides arguments to claim compensations and the communities could explore different legal mechanism for effective reparation. Governments must include environmental liabilities in national macroeconomic accounting and the inclusion of the socio-environmental liabilities in the mining companies´ balance sheet must be a requirement for granting mining concessions. Other non-monetary valuation languages such as social and ecological values of damages should be considered.

References

ABColombia: CAFOD, C. A. U., Oxfam GB, S. and T. (2012). Regalándolo Todo: Las Consecuencias de una Política Minera No Sostenible en Colombia. UK.

Agudelo, C., Robledo, R., Quiroz, L., Medina, E., & Hernández, L. (2012). Prevelancia de enfermedad respiratoria en niños menores de 10 años residentes en seis municipios mineros del Cesar, Colombia. Universidad Nacional de Colombia. Instituto de Salud Pública.

Asotred-Asociación de Trabajadores enfermos de la Drummond. (2012). *Relación Patologías*. Valledupar, Cesar. Colombia.

Bell, S., & York, R. (2012). Coal, Injustice, and Environmental Destruction Introduction to the Special Issue on Coal and the Environment. *Organization & Environment*.

Brown, P. E. (1983). *Preliminary Evaluation of the Groundwater Regime of the La Loma Coal Licenses, Cesar Department, Colombia, S.A.* Bogotá D.C., Colombia.

Cabarcas-Montalvo, M., Olivero-Verbel, J., & Corrales-Aldana, H. (2012). Genotoxic effects in blood cells of Mus musculus and Iguana iguana living near coal mining areas in Colombia. *The Science of the Total Environment*, *416*, 208–14. doi:10.1016/j.scitotenv.2011.11.080

Cabrera, M., & Fierro, J. (2013). Implicaciones ambientales y socialesdel modelo extractivista en Colombia. In L. J. Garay (Ed.), *Minería en Colombia I: Fundamentos para superar el Modelo extractivista*. Bogotá: Contraloria General de la República de Colombia.

Cerrejón. (2011). Resumen del Proyecto de Expansión Iiwo´uyaa para Grupos de Interés.

CGR - Contraloría General de la República de Colombia. (2014). *Actuación Especial a la explotación minera de Carbón en el Departamento del Cesar*. Bogotá D.C., Colombia.

Congreso de Colombia. Código de Minas. Ley 685 de 15 de agosto de 2001.

Coronado, J., & Haider, J. (2010). *Valoración de Costos Ambientales Asociados al Transporte y Embarque del Carbón en Santa Marta*.

Coronado-Posada, N., Cabarcas-Montalvo, M., & Olivero-Verbel, J. (2013). Phytotoxicity assessment of a methanolic coal dust extract in Lemna minor. *Ecotoxicology and Environmental Safety*, *95*, 27–32. doi:10.1016/j.ecoenv.2013.05.001

CorpoCesar. (2013). *Informe anual de operación del sistema especial de vigilancia de calidad de aire en la zona carbonífera del Departamento del Cesar*. Valledupar, Cesar. Colombia.

Econometría, C. (2010). Diseño y validación del marco conceptual y metodológico para caracterizar, priorizar y valorar económicamente los pasivos ambientales mineros en Colombia. Ministerio de Minas y Energía. República de Colombia.

Epstein, P. R., Buonocore, J. J., Eckerle, K., Hendryx, M., Stout Iii, B. M., Heinberg, R., … Glustrom, L. (2011). Full cost accounting for the life cycle of coal. *Ann N Y Acad Sci*, *1219*, 73–98. doi:10.1111/j.1749-6632.2010.05890.x

Fierro, J. (2012). *Políticas Mineras en Colombia*. ILSA Instituto Latinoamericano para una Sociedad y un Derecho Alternativo.

Fierro, J. (2014). Análisis intersectorial sobre la minería de carbón en el departamento del Cesar.Un enfoque desde la perspectiva del riesgo. In L. J. Garay (Ed.), *Mineria en Colombia IV: Control público, memoria y justicia socio-ecológica, movimientos sociales y posconflicto* (pp. 43–161). Contraloría General de la República de Colombia.

Fierro, J., & López, R. (2014). Aportes a la conceptualización del daño ambiental y del pasivo ambiental por minería. In L. J. Garay (Ed.), *Mineria en Colombia III: Daños ecológicos y socio-económicos y consideraciones sobre un modelo minero alternativo* (pp. 79–187). Bogotá D.C., Colombia: Contraloria General de la República de Colombia.

Fischer-kowalski, M., & Haberl, H. (2007). *Socioecological Transitions and Global Change: Trajectories of Social Metabolism and Land Use . Advances in Ecological Economics Series*. Cheltenham: Edward Elgar Pub.

Forkenbrock, D. J. (2001). Comparison of external costs of rail and truck freight transportation. *Transportation Research Part A: Policy and Practice*, *35*(4), 321–337. doi:10.1016/S0965-8564(99)00061-0

Gudynas, E. (2013). *Extracciones, extractivismos y extrahecciones un marco conceptual sobre la apropiación de recursos naturales*. *Observatorio del Desarrollo*.

Gudynas, E. (2014). *Extractivismos. Ecología, economía y política de un modelo de entender el desarrollo y la Naturaleza*. *RedGE*. Lima, Perú.

Guerrero-Castilla, A., Olivero-Verbel, J., & Marrugo-Negrete, J. (2014). Heavy metals in feral mice from coal-mining areas of Colombia and expression of genes related to oxidative stress, DNA damage and exposure to metals. *Mutation Research*, *762*, 24–29. doi:10.1016/j.mrgentox.2013.12.005

Harvey, D. (2003). *The New Imperialism*. OUP Oxford.

Hendryx, M., & Ahern, M. M. (2009). Mortality in Appalachian coal mining regions: the value of statistical life lost. *Public Health Reports (Washington, D.C. : 1974)*, *124*(4), 541–550.

Kallis, G., Gómez-Baggethun, E., & Zografos, C. (2013). To value or not to value? That is not the question. *Ecological Economics*, *94*, 97–105.

Li, F., Liu, X., Zhao, D., Wang, B., Jin, J., & Hu, D. (2011). Evaluating and modeling ecosystem service loss of coal mining: A case study of Mentougou district of Beijing, China. *Ecological Complexity*, *8*(2), 139–143. doi:10.1016/j.ecocom.2011.01.002

Martinez-Alier, J., Anguelovski, I., Bond, P., Del Bene, D., Demaria, F., Gerber, J. F., … Yánez, I. (2014). Between activism and science: Grassroots concepts for sustainability coined by environmental justice organizations. *Journal of Political Ecology*, *21*(1 A), 19–60.

Martinez-Alier, J., Munda, G., & O'Neill, J. (1998). Weak comparability of values as a foundation for ecological Economics . *Ecological Economics*, *26*, 277–286.

MAVDT-Ministerio de Ambiente Vivienda y Desarrollo Territorial. (2009). *"Por la cual se modifica un Plan De Manejo Ambiental y se toman otras determinaciones." 6 De Marzo De 2009*. Dirección De Licencias, Permisos Y Trámites Ambientales.

Mendieta, J. C., Perdomo, J. A., Rodriguez, M., Garcia, L., Rodriguez, O., Cardona, D., … Correa, J. V. (2010). *Valoración económica de externalidades en la zona carbonífera del DCesar que comprende los municipios de Agustín Codazzi, Jagua de Ibirico, el Paso, Becerril y Chiriguaná*. Universidad de los Andes.

Miller, T. R. (2000). Variations between countries in values of statistical life. *Journal of Transport Economics and Policy*, *34*(2), 169–188.

Miller, T. R., Douglass, J. B., & Pindus, N. M. (1994). Railroad injury: Causes, costs, and comparisons with other transport modes. *Journal of Safety Research*, *25*(4), 183–195. doi:10.1016/0022-4375(94)90043-4

Morales, T., Martínez, A., & Varela, M. (2012). Valoración económica del efecto sobre la salud dela contaminación atmosférica por fuentes móviles en Pereira. *Scientia et Technica. Universidad Tecnológica de Pereira, Pereira, Colombia Scientia et Technica*, *XVII*(52).

Morales, W., & Carmona, I. (2007). Estudio de algunos elementos traza en carbones de la cuenca Cesar-Rancheria, colombia. *Boletín de Ciencias de La Tierra, N. 20*.

Morrice, E., & Colagiuri, R. (2013). Coal mining, social injustice and health: a universal conflict of power and priorities. *Health & Place*, *19*, 74–9. doi:10.1016/j.healthplace.2012.10.006

Muradian, R., Walter, M., & Martinez-Alier, J. (2012). Hegemonic transitions and global shifts in social metabolism: Implications for resource-rich countries. Introduction to the special section. *Global Environmental Change*, *22*(3), 559–567. doi:10.1016/j.gloenvcha.2012.03.004

Nature Serve, T. N. C. (2010). Aplicación de la herramienta NatureServe Vista en la prevención, mitigación y compensación por impactos sobre la biodiversidad. Caso del área minera del Departamento del Cesar, Colombia.

Ojeda, E. (2000). Informe Nacional sobre la Gestión del Agua en Colombia, Recursos Hídricos. Agua Potable y Saneamiento. Colombia.

OJEU-Official Journal of the European Union. DIRECTIVE 2004/35/CE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, 2003 Regulation 56–75 (2004).

Palmer, M. A., Bernhardt, E. S., Schlesinger, W. H., Eshleman, K. N., Foufoula-Georgiou, E., Hendryx, M. S., … Wilcock, P. R. (2010). Mountaintop mining consequences. *Science*.

Pardo, A. (2013). La conflictividad por el territorio, el control de los RNNR y la renta minera. El choque de las locomotoras mineras en Colombia. In L. J. Garay (Ed.), *Mineria en Colombia II: Institucionalidad y territorio, paradojas y conflicto* (pp. 143–191). Contraloría General de la República de Colombia.

PAX. (2014). *The Dark Side of Coal. Paramilitary Violence in the Mining Region of Cesar, Colombia*. The Netherlands: PAX for Peace.

Pérez-Rincón, M. A. (2014). Conflictos ambientales en Colombia: inventario, caracterización y análisis. In L. J. Garay (Ed.), *Minería en Colombia IV: Control público, memoria y justicia socioeconómica, movimientos sociales y posconflicto* (Vol. 4, p. 492). Bogotá, Colombia: Contraloría General de la República.

Poveda, D. (2012). Impacto sobre frontera agropecuaria por explotación de carbón en 5 municipios del departamento del Cesar. In *Secretaria de Agricultura y Desarrollo Empresarial del Departamento del Cesar.* Valledupar, Cesar. Colombia.

Prodeco, & SIG. (2008). Actualización del modelo hidrogeológico matemático para el área de influencia del proyecto de explotación minera calenturitas, dando cumplimiento a los requerimientos establecidos en el auto 1805 del 6 de junio de 2008 emitido por el MAVDT.

Rodriguez Labajos, B., & Martinez-Alier, J. (2013). The Economics of Ecosystem and Biodiversity. When is money valuation appropiate? In H. Healy, J. Martinez-Alier, L. Temper, M. Walter, & J. Gerber (Eds.), *Ecological Economics from the Ground up* (pp. 488–512). London and New York: Routledge.

Rudas, G., & Espitia, J. (2013). La paradoja de la minería y el desarrollo. Análisis departamental y municipal para el caso de Colombia. In L. J. Garay (Ed.), *Mineria en Colombia II: Institucionalidad y territorio, paradojas y conflicto* (pp. 27–84). Bogotá D.C., Colombia: Contraloria General de la República de Colombia.

Secretaria de Salud de la Gobernación del Cesar. (2011). *Informe de estudio poblacional sobre prevalencia de enfermedades relacionadas con la contaminación ambiental en la vereda El Hatillo – Corregimiento La Loma- Municipio del Paso*.

SIMCO. (2015). Sistema de Información Minero Colombiano. Retrieved April 3, 2015, from http://www.upme.gov.co/generadorconsultas/Consulta_Exportaciones.aspx?idModulo=4

Svampa, M. (2013). « Consenso de los Commodities » y lenguajes de valoración en América Latina. *Nueva Sociedad No. 244*, 30–46.

URPA-Unidad Regional de Planificación Agropecuaria departamental. (2010). *Diagnóstico y Estadísticas Agropecuarias del Cesar*.

Vargas, F. (2013). Minería, conflicto armado y despojo de tierras: Impactos, desafíos y posibles soluciones jurídicas. In L. J. Garay (Ed.), *Mineria en Colombia I: Fundamentos para superar el modelo extractivista*. Contraloria General de la República de Colombia.

Viscusi, W. K. (2008). How to value a life. *Journal of Economics and Finance*, *32*(4), 311–323. doi:10.1007/s12197-008-9030-x

Viscusi, W. K., & Aldy, J. E. (2003). The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World. *Journal of Risk and Uncertainty*. doi:10.1023/A:1025598106257

Yunis, J. (2010). A comer Carbón. Retrieved January 3, 2015, from http://www.colombiapuntomedio.com/Visualizar/tabid/79/ArticleId/47/A-comer-carbon-por-jose-Yunis-Mebarak.aspx

Yupari, A. (2004). *Informe Pasivos Ambientales Mineros en Sudamérica. Informe elaborado para la CEPAL, el Instituto Federal De Geociencias y Recursos Naturales, y el Servicio Nacional de Geología y Mínería*.

Yushi, M., Hong, S., & Fuqiang, Y. (2008). *The True Cost of Coal*. China: Greenpeace, The Energy Foundation, WWF.