PAPER 16

CLIMATE CHANGE, BIODIVERSITY CONSERVATION, DEFORESTATION AND ITS POLICY RESPONSES IN BOLIVIA UNDER THE CURRENT POLITICAL CONTEXT: WHAT SCOPE FOR SYNERGIES AND INTERACTIONS?

BERNARDO PEREDO-VIDEA[1]

1 Environmental Change Institute, Oxford University Centre for the Environment

ABSTRACT: Biodiversity conservation is an economic, environmental and social process. It is also a political and cultural process in developing nations, characterised by being the richest regions in biodiversity but also the poorest economically. Paradoxically, while biodiversity and forest management provide substantial socio-economic and environmental benefits, local people have not often received benefits resulting from these processes. Thus ecosystem degradation and deforestation has increased. This would be the case of Bolivia, considered among the richest countries in biodiversity, especially within the Tropical Andes Hotspot, recognised as the global epicentre of biodiversity. However, the country is one of the poorest nations in Latin America with indigenous communities among the most vulnerable groups. Despite some progress and advances during the last decade in biodiversity conservation and climate change, these efforts have been mainly promoted by the international cooperation. Therefore, political arguments and economic policies are asking new questions on the effectiveness of these initiatives for conservation and sustainable development, including climate change and the discussion of emerging trade-offs as part of new development approaches to reduce poverty. Furthermore, new threats arise to the sustainability of these processes related to increasing deforestation rates. Hence, the current national agenda is recognising the need for improved roles and synergies in the management and ownership of renewable natural resources, including recent legal and policy frameworks that are integrated into national development plans.

Keywords: Climate change, deforestation, policy-making, biodiversity conservation, CO_2 emissions

1. Introduction

Evidence produced by several studies since the early 1990s suggested that large-scale conversion of tropical forests into pastures or annual crops could lead to changes in the climate (Nobre *et al.*, 1991). Hence, it has been documented that land-use change impacts regional and global climate through the surface-energy budget as well as through the carbon cycle (Pielke *et al.*, 2002). As well as influencing local long-term weather conditions, regional-scale land-cover change can impact on the global climate system (Avissar, 1995; Pielke, 2001; Claussen, 2002). These aspects of human influence on climate were not accounted for under the Kyoto Protocol. The neglect of land-use effects lead to inaccurate quantification of contributions to climate change. Thus the role of tropical forests may be significant in this process. Apart from their role as reservoirs, sinks and sources of carbon, tropical forests provide numerous additional ecosystem services. Many of the ecosystem services directly or indirectly influence climate, including the maintenance of elevated soil moisture and surface air humidity, reduced sunlight penetration, weaker near-surface

winds and the inhibition of anaerobic soil conditions. Such an environment maintains the productivity of tropical ecosystems (Betts, 1999). Nevertheless, deforestation is rapidly progressing in Amazonia, with estimates suggesting that if deforestation were to continue at the present rate, a significant reduction of Amazonian tropical forests would occur in less than 100 years (Nobre *et al.*, 1991, Killeen, 2007).

Academic and policy literature has directly linked deforestation rates with structural adjustment programmes (SAP) implemented in many South American countries, which promoted the expansion of timber and soy exports. In the case of Bolivia, deforestation has increased dramatically since the mid-1990s. A number of studies suggest that structural adjustment contributed to large-scale forest clearing for soybean production for export and, to a lesser extent, forest degradation by lumber companies particularly because Bolivia was amongst the first Latin American countries to initiate a far-reaching and relatively orthodox SAP, which did greatly contribute to forest clearing for soybean exports and to higher timber exports (Kaimowitz *et al,* 1999). Therefore, deforestation in tropical areas of South America and particularly in the Amazon is contributing to CO_2 emissions. Although, it has been considered that deforestation and tropical forests fires contribute globally with about 20 per cent of the total emissions, the major impact is related to the rapid loss of forest ecosystems and biodiversity. Accordingly, recent debates and positions are calling for action on the role of tropical forests and the role of deforestation in developing countries, including new visions and conceptions in developing countries based on current interest of policy-makers in considering schemes for income generation and responsibilities of developed countries.

This paper analyzes the opportunities to integrate climate change policies and biodiversity conservation into national development agendas, the impacts of climate change in Bolivia, the role of deforestation and the root causes for carbon emissions in the country. It also explores resulting policy connotations and approaches under a new administration, which present dissimilar conceptions of development, the role of the State and sustainable development, and the relationship between local and global impacts and responsibilities on climate change, deforestation and biodiversity conservation. Therefore, the research identifies the challenges of policy-making in the existing climate change and forest processes under the new administration of Evo Morales by providing up-to-date empirical evidence and conclusive analysis of the policy responses of the Bolivian government to climate change, forest management and biodiversity conservation.

2. Bolivia: Biodiversity, Forests and Protected Areas

Bolivia is a landlocked country comprising an area of 1,098,581 square kilometres, distributed in different eco-regions, containing more than fifty per cent of lowland areas (see Figure 1). In contrast to what is commonly assumed, a large portion of the country is covered by forest vegetation. The country's total forest area is 534,000 sq. km. which represents 48.60 per cent of the total surface. More than 80 per cent of the total forest area occurs in the Bolivian lowlands whereas the remaining 20 per cent is spread out in the highlands and the inter-Andean valleys.

FIGURE 1
Bolivia, its lowlands and its place in South America.

From the 80 per cent of forest area, four major zones have been identified: i) the humid and evergreen forest of the Amazonian lowland located in northern Bolivia; ii) the Beni plains, characterised by natural savannas and small patches of gallery forests, much of which are seasonally flooded; iii) the Chiquitania region, whose semi-deciduous forests are typical of slightly drier areas; and iv) the semi-arid Chaco region, with lower and less productive forests adapted to dry climates (MDSMA, 1995).

According to Pacheco (2006), the condition of Bolivia's lowland forests is the result, to a large extent, of the dynamics of occupation of forestlands and their intervention for timber extraction. Government plans and policies to develop the

lowland region in the mid-1950s included road construction, colonisation projects, saw-pits and low credit for agricultural production. Therefore, the most intervened forests have been those located in the department of Santa Cruz. Since the early stages of frontier occupation there were close interactions between agricultural frontier and forest frontier expansion, though the latter was focused on the extraction of the most valuable species, such as mahogany. The exhaustion of mahogany tress in the forest frontiers of Santa Cruz motivated a migration of the timber companies to the southwest of Beni and the north of La Paz in the early 1980s (Pacheco, 2006). In many cases, these contracts overlapped with private properties, indigenous territories or protected areas.

Nonetheless, protected areas in Bolivia play a role not only in conservation but in support of local livelihoods and social participation as well. The Bolivian government estimates that around 60,000 people live inside protected areas and some 200,000 people live in surrounding areas (see Figure 2 for protected areas

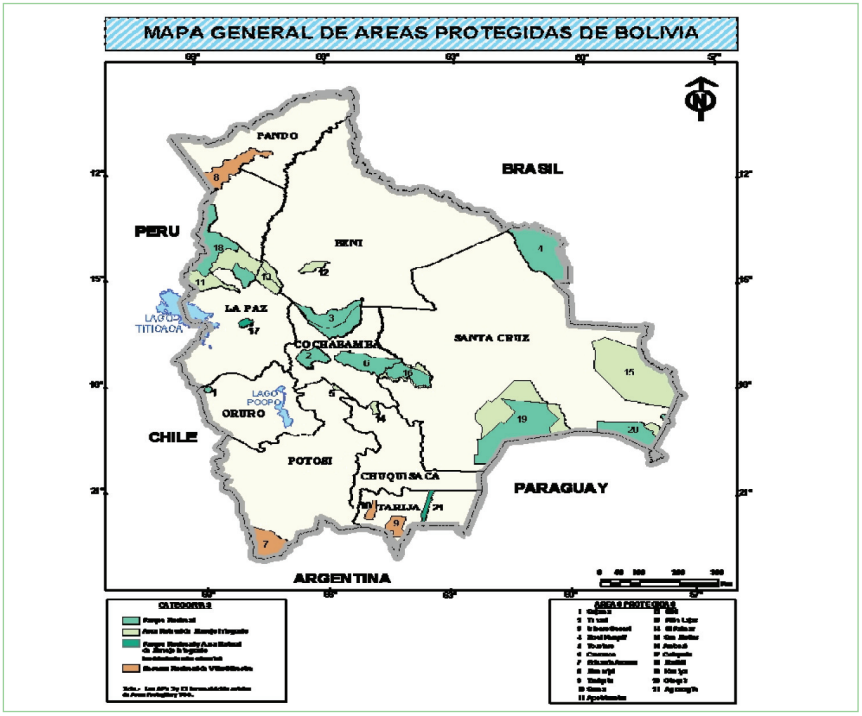

FIGURE 2
Official Protected Areas Map of Bolivia (in Spanish).

of Bolivia, and Figure 3 for how the percentage of land designated as protected areas has grown in Bolivia). Different management categories were created in order to adapt to local contexts. One of the most successful initiatives was the creation of Management Committees, composed by indigenous peoples authorities jointly with Park officials and government representatives, which are the main instruments used to obtain support for park protection. Through the committees, park administrators developed local agreements for a set of rules for resource use to make protection possible. In some parks, where local people have come to value the economic potential of wildlife and ecotourism, communities themselves identify and sanction violators.

As the World Bank (2002) reported, the ownership of the conservation ethic by some local communities is so strong that they are effectively functioning as *de facto* park wardens. Local people also use committees to address their needs, as communities, local organizations, and municipalities worked together to pool resources and undertake development activities that would not had been possible otherwise. Consequently, involving local communities in national park affairs and the parks promises of development benefits has helped increase their interest in conservation by adapting local and national realities towards a recognized acceptance of the importance of protected areas for sustainable livelihoods and biodiversity management and conservation.

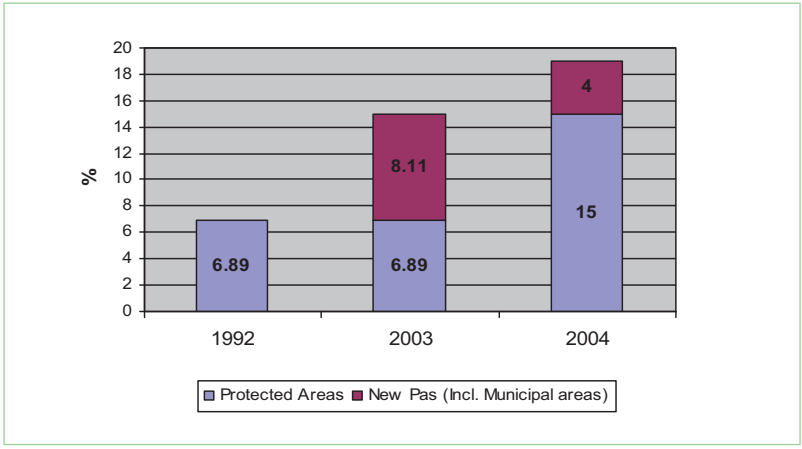

FIGURE 3
Percentage of Bolivia covered by Protected Areas.

In this sense, new protected areas were created in the last decade, which included different categories and a significant amount of natural areas for integrated management. This approach allows local and indigenous peoples to continue living in buffer zones and develop sustainable management practices of natural resources and biodiversity. Accordingly, the National Service of Protected Areas developed the framework of "Parks with People" in 2005, considering the importance and role of protected areas for sustainable livelihoods, poverty alleviation and sustainable development in rural areas, including a significant role on ecosystem services provision (Peredo, 2005). As part of this process, which is currently evolving into a national policy of "shared management" under the new government administration, not only national areas were represented in the national system of protected areas, but municipal protected areas and neighbouring declared indigenous territories are also areas for biodiversity conservation. Based on international support and funding, the percentage of national territory covered by protected areas in Bolivia increased in the last decade covering approximately 19 per cent of the total surface with representation throughout different ecosystems in the country (ABDES, 2005).

Several national parks are still having constraints in enforcing conservation measures and there is a persistence of conflicts for access to natural resources by several actors as the synthesis of rural conflicts. The root cause is related to the overlapping of territories containing vast natural resources, including minerals, hydrocarbons, timber, wildlife and land resources. The institution in charge to safeguard the biological diversity in Bolivia is living in permanent conflict. Although such conflicts remain widespread, the role of protected areas has been acknowledged and recognised under the new State Constitution, which defined them as part of the natural and cultural heritage of the country, undertaking environmental, cultural, social and economic functions (Republica de Bolivia, 2007). One of the reasons for this significant increase in conservation efforts is because Bolivia has been included within the 15 countries with the highest biodiversity rates in the world, due to its geographical location, the existence of several ecosystems and species richness and endemism, particularly in the so-called Tropical Andes Hotspot, which promoted a number of landscape initiatives regionally (see Table 1).

Extraordinarily high levels of species richness and endemism characterize the Bolivian portion of this hotspot, defined as the Madidi-Amboro Landscape. Few other areas in the world can compare with its biodiversity. For example, there are more than 5,000 plant species in Madidi National Park alone, which makes it the protected area with the highest plant diversity of the continent. Yungas

TABLE 1

Species richness in Bolivia (Source: Ibisch *et al.*, 2003)

Taxonomic Group	Number of Species	Number of endemic Species	Number of Threatened Species
Mammals	356	17	78
Birds	1.398	16	69
Fish	635	>10	76
Amphibians	204	41	3
Reptiles	267	27	24
Total	**2.730**	**80**	**250**

humid montane forests are a centre of diversity for Neotropical orchids, and 5% of all known orchids are found in the Amboro National Park and neighbouring areas (Conservation International, 2005). The Madidi-Amboro landscape plays an essential role in the regulation of ecosystem function at a regional level. In this context, this landscape includes upper Amazon Basin river systems, areas of heavy rainfall and watersheds that regulate seasonal flooding. Despite these impressive efforts and benefits arising from biodiversity and ecosystem services, threats to natural resources, biodiversity and sustainability still continue and have increased in the last ten years. Deforestation is greater than before affecting several regions in lowlands and the Bolivian Amazon, which worryingly resulted in high deforestation rates during the last decade.

3. Deforestation in Bolivia: Persistence of Threats and Underlying Causes

Most of the academic literature on deforestation suggests the importance of understanding its underlying causes and their relation to political and economic policies in developing countries, especially under structural adjustment programmes (SAPs), which rarely include considerations of long-term environmental consequences in tropical forests in particular. Structural adjustment policy had tended to liberalise the internal markets of labour, capital and goods, and to open them to international markets in order to adjust macroeconomic variables. It reduced fiscal expenses by reducing public employment and eliminating subsidised programmes. It aimed at restructuring the productive sectors by favouring tradable sectors through devaluing national currencies, established export incentives and removed agricultural import restrictions. Therefore, governmental policies have a decisive role in deforestation, as they can influence directly the land-use decisions (Reed, 1996).

Deforestation intensifies when agents make a profit from forest-competing land-uses and, therefore, when the profit that agents obtain from an economic activity is higher than the costs that such activity demands (Pacheco, 2006). The goal of SAP in Bolivia was to transform the state-dominated economy to a market-based production based on exports and foreign direct investment. The implementation of SAP based on fiscal and commercial policies stimulated the expansion of the agricultural frontier at rates of growth never before experienced.

Up until the late 1980s, deforestation rates in Bolivia were among the lowest in Latin America, based on key determinants which included a weak domestic demand for agricultural products and lack of infrastructure (Kaimowitz, 1997). Two national inventories of forest resources concluded that deforestation increased dramatically during the 1990s (Steiniger *et al.,* 2000; Camacho *et al,* 2001), especially after the implementation of the structural reforms during the same decade (Kaimowitz *et al.,* 1999). In this context, Camacho (2001) estimated that more than 3 million hectares of lowland forests in Bolivia have been cleared, with 1.4 million hectares (46.7 per cent) deforested in the department of Santa Cruz between 1993 and 2000. Consequently, deforestation rates have quadrupled during this time after the structural reforms and policies introduced in 1993, as Table 2 shows.

TABLE 2

Estimates of deforestation in the department of Santa Cruz

Dept.	Total Area	Forest Cover 1986 (ha)	Forest Cover 1993 (ha)	Forest Cover 2000 (ha)	Deforestation (ha)	
					1986-1992	1993-2000
Santa Cruz	35,643,850	34,465,013	33,890,513	32,431,848	574,500	1,458,665

These estimates led to several proposals and studies suggesting that structural adjustment have contributed to increase deforestation rates for soy and timber exports, by applying economic instruments and policies that removed price controls on soybeans, devalued the Bolivian currency, promoted investments in physical infrastructure such as roads and telecommunications, and introduced tax breaks and fiscal incentives for exporters (Kaimowitz *et al.,* 1998). These studies argue that the increasing deforestation rates in Bolivia as a whole are indicative of the general weakness of the government in the forestry and environmental sectors. Moreover, municipal governments have been largely ineffective in preventing deforestation (Hecht, 2001; Davies *et al.,* 2000; Camacho *et al.,* 2001;

Contreras and Vargas, 2001). These reasons are also encapsulated in the notion that structural adjustment reduced the role and capacities of government.

Following on Pacheco (2006), the estimates of deforestation (Table 3 and Table 4) that are available for the country as a whole are based on four datasets from the following institutions: i) The department of Geography from the University of Maryland (UMD), which shows the annual deforestation rates from 1984-87 to 1992-94. According to Steininger *et al.* (2000), it is the most serious estimate of forest-cover change because it is based in a wall-to-wall analysis of digital satellite data MSS and TM; ii) The estimates of the former Ministry of Sustainable Development and the Environment (MDSMA) for the period 1979-1993; iii) FAO's deforestation assessment for the decade of 1990 published in 2001, and iv) estimates for the period 1993-2000 of the Bolivian Forestry Project (BOLFOR), which promotes sustainable forestry in Bolivia.

The amount of deforestation that has taken place in Bolivia has been relatively low compared to other countries with tropical forests, but this trend has been reversed dramatically in the last years. The deforestation rate during the last decade, according to most of the estimates, is becoming closer to one of the Amazonian countries as a whole, but it is undoubtedly higher when considered on a per-capita basis.

TABLE 3

Estimates of deforestation in Bolivia (thousand hectares)

Sources	Years	Forest Cover	Deforestation in the period	Annual deforestation	Deforestation rate (%)
ERTS (1)	1975	56,400			
MDSMA (2)	1993	53,400	3,024	168	0.29
ERTS (1)	1978	56,468			
Agrarian Superint. (3)	2001	53,960	2,508	109	0.19
UMD (4)	1987	44,707			
UMD (4)	1993	43,790	2,470	153	0.34
FAO (5)	1990	54,678			
FAO (5)	2000	53,068	1,610	161	0.29
MDSMA (6)	1993	53,400			
BOLFOR (6)	2000	51,383	2,017	270	0.50

Notes: 1) GEOBOL, 1987; 2) MDSMA, 1995; 3) Agrarian Superintendence, 2001; 4) Steininger *et al*, 2000; 5) FAO, 2001; 6) Rojas *et al*, 2003. Based on Pacheco (2006) and ABDES (2006).

According to Kaimowitz *et al.* (1999), Pacheco (2006) and the sources of deforestation analysed, there is a clear relationship of deforestation caused by medium and large companies and producers in the soy and timber production for exports, as the following data shows based on data from the Department of Agricultural Statistics, Ministry of Agriculture and compiled by Pacheco (2006).

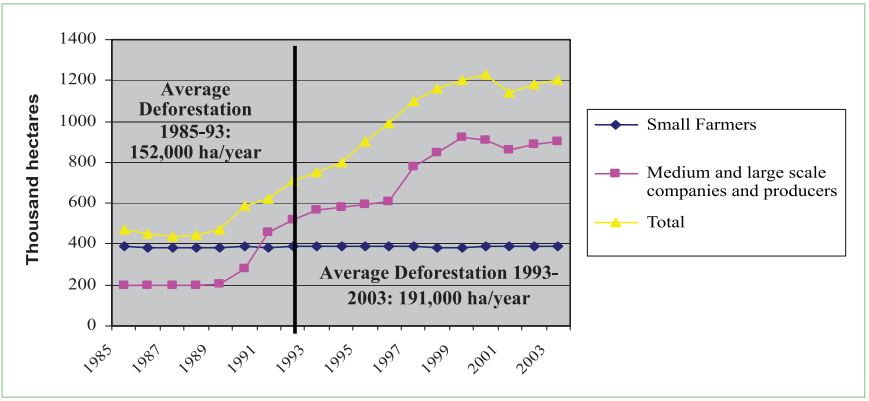

FIGURE 4
Deforestation in the Bolivian lowlands since the structural adjustment programme.

The extensive deforestation resulting from the implementation of SAP policies was not an unexpected side effect but would be more accurately described as a calculated cost that had been taken into account when the policy instruments were designed (Anderson, 2002).

The type of model adopted for soy exports, based on medium and large companies and producers, was the problem. It was thought that big producers were more efficient and they could provide more economic benefits. This model only included small producers in the productive chain in a marginal perspective. Therefore, the model promoted larger rates of deforestation (Pacheco, Pers. Comm., 2007).

In national terms, deforestation increased from an average of 152,000 hectares per year in the period 1985-1993 to an average of 191,000 in the following ten-year period of 1993-2003. Deforestation continued the following years from

TABLE 4

Estimates of Deforestation by Type of Factors

Type	Annual deforestation (thousand ha/year)		Deforestation Rate (%)		Participation with respect to total (%)	
	Mid 1980s to mid 1990s	Mid 1990s to 2000	Mid 1980s to mid 1990s	Mid 1990s to 2000	Mid 1980s to mid 1990s	Mid 1990s to 2000
Medium to large-scale	54.0	105.2	2.28	–	35.6	55.1
Predominantly colonists	62.4	41.7	1.19	0.86	41.1	21.8
Cattle ranching	6.8	13.6	0.33	0.67	4.5	7.1
No identified	28.6	30.4	0.08	0.09	18.8	15.9
Total	**151.9**	**190.9**	**0.34**	**0.43**	**100.0**	**100.0**

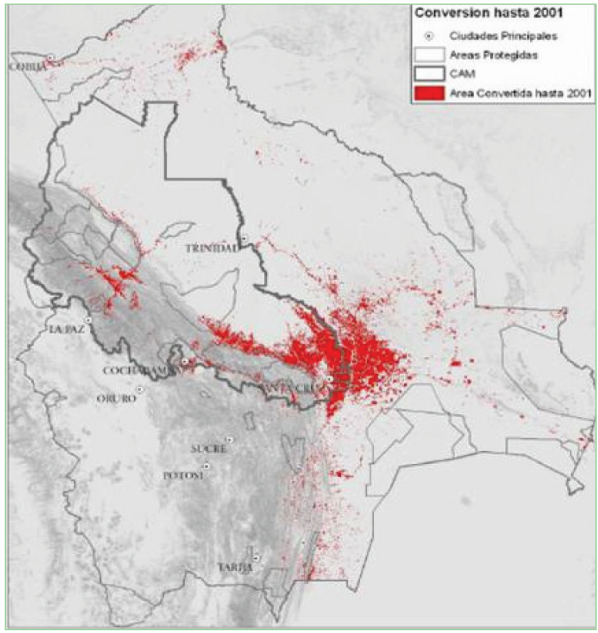

FIGURE 5

Land conversion until 2001 (Source: PNUD (2005) based on Ledezma and Painter (2005) and Killeen *et al.* (2005).

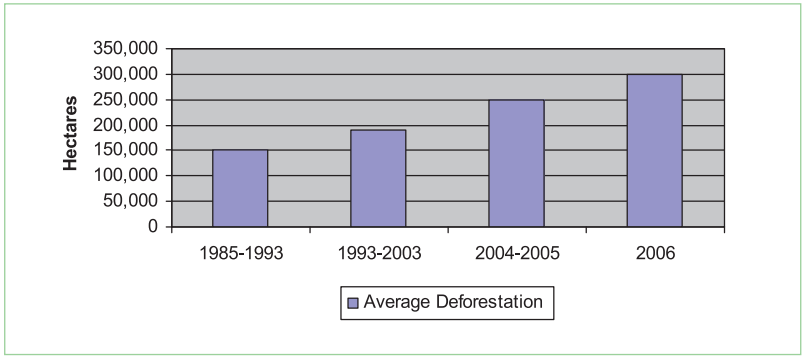

FIGURE 6
Evolution of Deforestation Rates in Bolivia 1985 to 2006.

250,000 hectares/year in 2005-2006 and reached approximately 300,000 hectares per year in 2006, according to the Forestry Superintendence (2007).

From 2005 and onwards, the presence of forest fires has increased to almost 90 thousand fires throughout the country but particularly in tropical regions, which represent almost double than in the period 2001-2006. Most of these fires have been attributed by the Ministry of Rural Development to large land-owners related to soy, cattle and timber economic activities. However, there may also be an increasing contribution of colonists in land conversion, which jointly causes an expansion of the agricultural frontier.

These fires reached the peak value in September 2007, which represented almost 50 per cent of the total fires of that year. This caused disruption and airports closure in capital cities in the eastern part of Bolivia, as well as health problems by producing and affecting respiratory issues both in rural and urban areas, predominantly in the department of Santa Cruz. An underlying factor for the increase of forest fires is the interest in accomplishing the social and economic function of the land, promoted and legally enacted by the new administration under the Land and Agrarian Reform Law of 2006. The main goal is to achieve social redistribution of land for productive purposes and social and political issues as well.

This legal framework may bring further impacts on deforestation, in order to comply with this legal requirement, particularly by large and medium land-owners, but by colonists groups and landless movements as well. Accordingly, it

is estimated that conversion and land-use change will increase. The government is also promoting the development of infrastructure projects in the Bolivian lowlands, which are thought to increase environmental degradation. These mega-projects are particularly related to extensive road construction and improvement in the northern Amazon, known as the "March to the North". Other national and regional projects also include dams and sugar factories and oil exploitation in the north of La Paz.

4. CO_2 Emissions in Bolivia: The Role of Deforestation

The second national report of sustainability for the accomplishment of the Millennium Development Goals in Bolivia estimated that national emissions of CO_2 were likely 63K Gg. for 2002 (ABDES, 2005). The official inventories indicate that the dominant cause of CO_2 emissions is land-use change (NPCC, 2003). The widespread practice of slash-and-burn and the conversion of land for agro-industry and cattle-stock eliminate vegetation and burn biomass, which

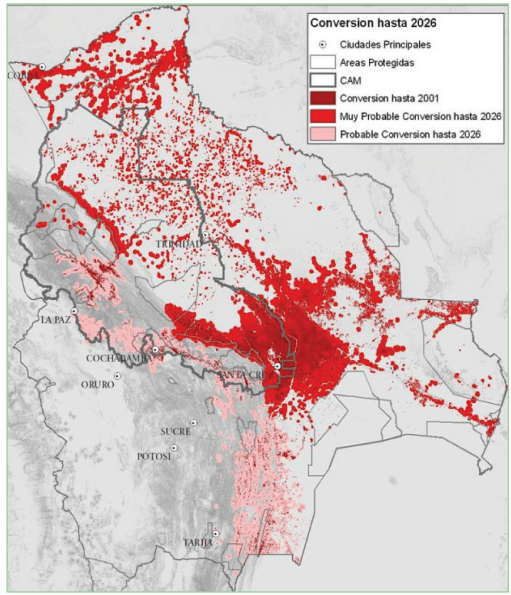

FIGURE 7
Land conversion until 2026 (Source: Ledezma (2005) ; Andersen (2005)).

represent the major cause for deforestation, biodiversity loss and CO_2 emissions. These emissions are distributed in three main sectors. Around 89 per cent of emissions are based on land-use change, followed by 10.5 per cent of emissions related to the energy sector and only 0.46 per cent to the industrial process produced by cement factories (ABDES, 2005).

Available data on CO_2 emissions as a result of slash-and-burn practices shows a discrepancy between the official data provided by the National Programme of Climate change and those provided by San Andres University (UMSA). The official estimates by the NPCC were 0.044 GT of CO_2 for 1998 (NPCC, 2003), while the emissions estimated by the university shows 0.36 GT of CO_2 (Gutierrez and Palenque, 2000). These scenarios were based on the vulnerability assessment of ecosystems undertaken by the National Programme of Climate Change (NPCC, 2000b) and supported by different models accepted internationally, such as UKHI, HADCM2, GISSEQ, MAGICC, and the meteorological data available for the country. It is clear that the major source of CO_2 emissions is produced by land conversion and slash-and-burn practices accounting for more than 82 per cent of total emissions, and may be increasing as deforestation rates and forest fires are also increasing.

Such a high share of emissions from a land use changes and deforestation are second only to Indonesia and almost a similar value with Malaysia (Clabbers, 2004). Bolivia and many other Latin American countries are currently undergoing an economic and development transformation, including a steep upward trend of its greenhouse gas emissions primarily as a result of deforestation and energy (Silva-Chavez, 2005).

TABLE 5

LULUCF Emissions as share of total GHG emission (Source: in Silva (2005))

Argentina	19%
Bolivia	82%
Brazil	69%
Indonesia	86%
Malaysia	82%
Mexico	16%

In terms of the energy sector that represents the second largest source of Bolivia CO_2 emissions, the Clean Development Office has been developing a project portfolio aimed at achieving emission reductions of 5.8 million tons of CO_2, in seven years under a CDM framework.

TABLE 6

CDM Project Portfolio in the energy sector (Source: Trujillo, R 2006 in NPCC Informative Bulletin No. 3)

PROJECTS	MW	CO_2 emissions reduction (annual tons)	CO_2 emissions reduction (7 years/ tons)
ENERGY INDUSTRY			
Hydroelectricity projects	204,3	0.39	2,72
Wind energy projects	20,6	0.0011	0.0077
Geothermal projects	1,5	0.0044	0.031
Biomass Projects	18,7	0.095	0.66
Energy efficiency and generation projects	80	0.34	2,38
Industrial projects	0	0	--
Fuel substitution	5,3	0.0018	0.0013
TOTAL	**330,4**	**0.83**	**5,81 MT**
WASTE MANAGEMENT			
Capture of landfill methane emissions	0	0.422	2,9 MT

It is clear that the highest CO_2 emissions in Bolivia are related directly to deforestation and slash-and-burn practices both in forests and savannas in the lowlands region, which are annually undertaken in order to expand the agricultural frontier for cultivation and cattle ranching. Nevertheless, these CO_2 emissions in the country are relatively low compared to other regions in a per capita basis. In Bolivia, they reach only 1.4 mT capita, while in Latin-American and the Caribbean as a whole these carbon emissions reached 2.5 t per capita. In contrast, emissions in the United States are about 19.7 mT per capita (World Bank, 2003). According to several interviews with former and current policy-makers, there is the perception that climate change has been produced by developed economies, and these countries should be responsible for adopting mitigation, adaptation and compensation measures.

These perceptions were enhanced after the unfortunate flooding of January and February 2008 in which more than 47 municipalities were affected, particularly at

the Amazonian department of Beni. These floodings caused the death of more than 50 people and left more than 45,000 people affected. Although this event is not directly linked to climate change, there is the perception that there is an increasing role which provokes traditional events to have more severe impacts. It is also considered that developing countries shall not reduce their economic growth because of climate change as this is generally a clear responsibility of developed economies in the first instance. The following graph based on data from the World Bank clearly shows such economic and emission inequalities.

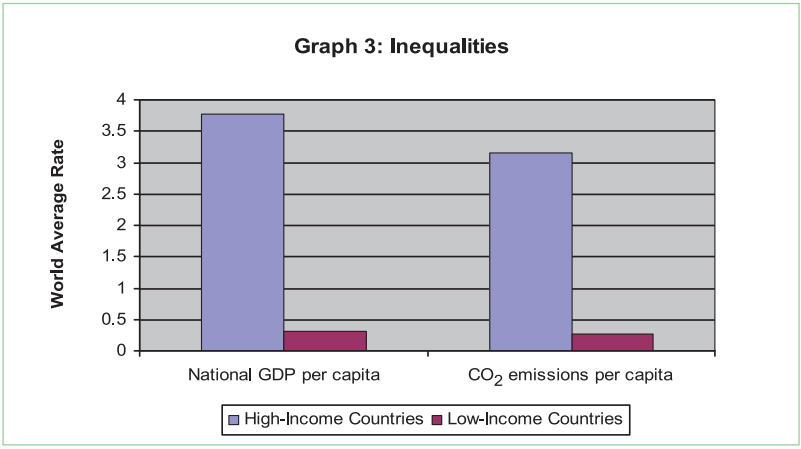

FIGURE 8
Inequalities of income and CO_2 emissions between high and low income countries.

Greenhouse emissions in terms of CO_2 in Bolivia are only 0.097% of the total global emissions. However, climate change impacts may affect in different ways and have been increasing in the last decade in many regions of the developing world. In Bolivia these climate alterations brought droughts in the Andean region, including glaciers retraction such as Chacaltaya (Figure 9) and Tuni-Condoriri (Figure 10) in the Bolivian highlands and flooding in lowlands and the Amazon. Hence, vulnerability to climate impacts are high in the country affecting natural ecosystems, water resources, food security, health and loss of infrastructure (NPCC, 2006). Based on political, economic and policy perspectives, the role of Bolivia and South American countries, with the only exception of Brazil as part of the BRIC (Brazil, Russia, India and China), is almost insignificant in global carbon emissions as North American, European and Asian

nations are the primary sources of emissions. The graph in Figure 11 based on available data for 1999 presented by McKibbin and Wilcoxen (2002) clearly illustrates such differences.

Several political positions claim the need to tackle these inequalities and that South American developing countries have their own right to develop by using their natural resources. This position has been widely presented and supported

FIGURE 9
Chacaltaya Glacier Retraction in the Andean Region: Left shows the glacier in 1940 (Source: UMSA Archives – IHH – IRD) and right shows glacier in 2007 (Source: Ivy Beltran).

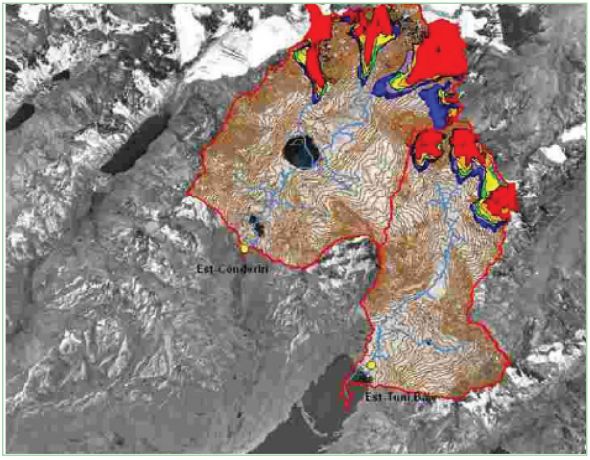

FIGURE 10
The Tuni Condoriri Glacier and water supply (Source: IPQ Project / LP /01037. NPCC – UMSA – IHH –IRD).

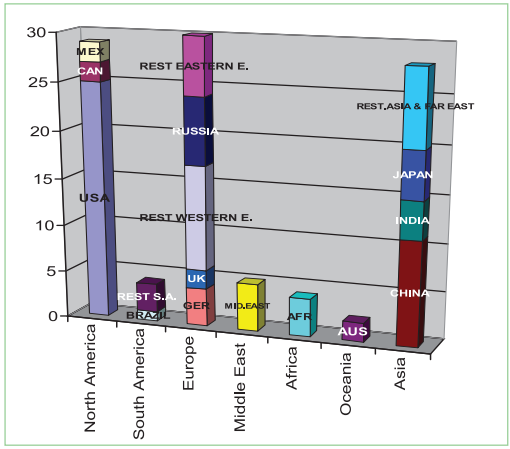

FIGURE 11
Global Carbon Emissions (% by region and country).

by Morales' administration, which have promoted the role of the State as a major political and economic change towards better redistribution of benefits, management of natural resources and participation of local and indigenous communities. In terms of climate change, there is the wide perception that although Bolivia is not a country producing carbon emissions, the impacts of climate change will be suffered throughout the country.

5. Bolivia and Climate Change: Potential Impacts

Maximum temperature increases are predicted to occur in the high mountains of Andean countries. If the models are correct, the changes will have important consequences for mountain glaciers and for communities that rely on glacier-fed water supplies (Bradley *et al.*, 2006). Bolivia is a country with a high vulnerability to climate change for several reasons: the population density in fragile mountain ecosystems, the expansion of arid zones, the existence of several regions exposed to periodic flooding, particularly in lowlands and the valleys, and the increasing deforestation rate and high poverty levels (Palenque, 2005).

These socioeconomic and environmental conditions mean the country is not very tolerant to climate change. Furthermore, the minimal infrastructure for natural disasters poses additional challenges. Based on that, the level of vulnerability for rural areas and poor people are severe, considering that these sectors will be

more exposed and impacted seriously from climate change. One of the most notorious impacts of global warming is the slow disappearance of Andean glaciers. The Andean Range in Bolivia is one of the examples of tropical glaciers that have been affected by an increase in temperatures in the last decade. Accordingly, 1990, 1998 and 2000 were recognised as the highest temperatures in the historical record (Lozan *et al.,* 2001). Studies along the Tropical Andes indicate a temperature increase of 0.11°C/decade, compared with the global average of 0.06°C/decade between 1939 and 1998. Eight of the twelve warmest years were recorded in the last 16 years of this period (Vuille *et al.,* 2003). High-altitude mountain regions are then strongly affected by rising temperatures, as ice masses are declining rapidly (Ramirez *et al.,* 2001; Francou *et al.,* 2003: Kaser *et al.,* 2005).

According to Hoffmann (2005), Bolivian glaciers represent around 20 per cent of the world's tropical glacier area. Several small glaciers are located in the country, which are more sensitive to climate, and in turn, retreat at higher rates than larger glaciers. Impacts of glacier retreat are most likely to be mainly local. The supply of potable water for the growing urban areas in the La Paz and El Alto metropolitan regions is probably the main area of concern for shrinking glaciers in Bolivia. Although an increase in glacier melting initially increases runoff, the disappearance of glaciers will cause abrupt changes in stream-flow, because of the lack of a glacial buffer during the dry season. This will affect the availability of drinking water, and of water for agriculture and hydropower production (Bradley *et al.,* 2006). The highest percentage of glaciers in the country are located in the Andean Range, which because of its location and characteristics, provide water resources for: i) human consumption in the cities of La Paz and El Alto; ii) irrigation in northern highlands, high valleys, and cattle-stock on the shores of Lake Titicaca; and iii) energy generation through hydroelectricity (Gutierrez, 2007).

There is evidence that the contraction of Andean glaciers has been rapidly evolving. Based on research undertaken during the last 20 years, estimates predict that at the current rate, the glacier of Chacaltaya will completely disappear in no more than 10 years (Ramirez *et al.,* 2003). The glaciers balances of Zongo and Chacaltaya determine a significant risk for water supplies in La Paz and El Alto (Mendoza and Francou, 2000), which are amongst the most important cities in the country.

In terms of water supply for human consumption, the Tuni-Condoriri water system would have a serious impact with social and economic implications, as this system is directly linked as the major source of water supply for the city of El

Alto and peri-urban areas of La Paz, known as *laderas* or hillsides. Studies undertaken by the GRANT Project quantified the reduction in the glacier surface of the Tuni-Condoriri showing that under current conditions, the glacier of the Condoriri watershed would disappear by the year 2045, while the glaciers from the Tuni watershed would not last longer than 2025 (NPCC, 2006). Therefore, potable water supply from this system in El Alto would receive 35 per cent less in water resources, seriously affecting the normal distribution for both El Alto and several urban and peri-urban regions of La Paz. This scenario would cause rationalisation and reduction in water supply.

If water-resource buffers shrink further and some watersheds disappear completely, alternative water supplies may become very expensive or impractical in the face of increased demand as population and per-capita consumption rise. As water resources are affected by reductions in seasonal runoff in Andean countries, where hydropower is the major source of energy for electricity generation, there would be the need to shift to other energy sources, resulting in higher costs and most probably, an increased reliance on fossil fuels (Bradley *et al.,* 2005). Disappearance of these glaciers would not only affect water supply but will also have an important impact on electricity generation, as the region of Zongo is the most important provider of hydroelectricity for the capital city. These impacts are estimated to be direct consequences of climate change.

Irrigation in highlands and high valleys located in the region of Palca would also be affected with serious consequences for agricultural and cattle activities in rural areas. PRAA – The Andean Regional Project for Adaptation to Climate Change suggests an alarming loss rate of glacier surface, from 10 per cent to 90 per cent in the period between 1987 and 2004. This reduction of water availability would impact agricultural activities by reducing agricultural productivity, loss of cultivation fields, increases in costs for agricultural inputs and reduction in cattle production. Most of these products are commercialised in neighbouring regions and cities and, therefore, it would mean a decrease in food supplies. Furthermore, it is considered that these situations would cause social impacts as a supply reduction of basic food would be felt in local markets, increasing migration rates from highlands to urban areas. Estimates of climate change impacts on tropical ecosystems suggest there will be important changes in lowlands and tropical areas located in the East and North of the country in relatively short periods of time. In addition, it is estimated that dry forests in the region of Santa Cruz would get drier and the Chaco region in the south would suffer a total desertification, having a direct impact in the loss of endemic species of reptiles (ABDES, 2005).

There will be additional impacts on human health, particularly because of changes produced in the savannas of Beni and the alteration of the humid forest to tropical dry forest, which will increase the habitat for *Anopheles darlingi*, which is the main vector for malaria in the country (NPCC, 2000c). There may be increases in *leshmaniasis*, endemic of tropical regions in the country.

Additional studies suggest that the influence of climate change in the cities may be higher because of the effect of urban pollution of the atmosphere, water and soils. The level of pollutants such as nitrogen dioxide are above the limits in the cities of Cochabamba (Bascope, 2003), La Paz and El Alto, limits that would increase with further changes in the climate (Guisbert, 2003; Rocha and Palenque, 2003).

6. Policy Responses and Perspectives

Bolivia has ratified the Kyoto Protocol through the enactment of Law 1988 of July 22, 1999. This ratification was conditioned according to the principles of sustainable development, as the country had a specific policy and mandate to achieve sustainable development. One of the reasons for this ratification, behind the broad ratification made by most countries, was the interest in accessing incentives and economic benefits around clean development mechanisms. Furthermore, a proposal for a Carbon Law was presented in past years by the National Programme of Climate Change, which promoted the creation and development of a series of mechanisms for the certification of initiatives in terms of carbon sequestration and emissions avoidance. After several consultation workshops, it has been considered that there are very remote possibilities to establish a carbon market, with very few experiences. In this sense, these proposals have been put in stand-by if not rejected. However, on June 24, 2005, the Supreme Decree 28218 was enacted, declaring the implementation of projects and activities for climate change mitigation in forestry and energy sector as a national priority, in order to apply to CDM and other trade emissions schemes. This Decree shows the importance of projects and activities and the interest of policy-makers in these schemes as a way of generating short and long-term income.

Climate change mitigation in both sectors in this legal framework included the following areas: forestation and afforestation, fossil fuels substitution using natural gas, natural gas supply for residential, commercial and industrial consumption, renewable energies, energy efficiency, biogas, the efficient use of biomass and other project that reduce, capture, store and avoid greenhouse gases emissions. In December 2005, the historical election of Evo Morales and

his Movement towards Socialism party (*Movimiento Al Socialismo* in Spanish) with more than 54 per cent of the votes, initiated a series of reforms and different visions on natural resources particularly, under the so-called process of change. These reforms involve a series of structural changes based on the elimination of the neoliberal era, both politically and economically, and the dismissal of sustainable development as a national policy. The proposal of the current administration claims for a different role of the State and the nationalisation of natural resources, both renewable and non-renewable, which was accomplished in the first place with hydrocarbons and later with protected areas.

This process considers an active participation of the State for sustainable use and management of biodiversity and forest resources, (considered as strategic resources for income generation) both for primary production and for industrialisation in order to improve life conditions of the Bolivia population, particularly indigenous communities. These principles aim to re-establish the balance between nature conservation and economic needs for national development, under the concept of "Living Well". Under this framework, the current administration considers to strengthen the regulatory participation and promotion of the State for the exploitation of natural resources towards guaranteeing a sustainable management of natural resources and a fair distribution of benefits resulting in that use. The new government considers indispensable to consolidate the ownership by the State over natural resources and genetic variability. Through this vision, natural resources will not be able to become subjects of commercial exploitation. National policies are focused under the implementation of a holistic vision that takes from nature what is needed for the development of the country, but, at the same time, protecting it (PND, 2006).

Forests and its resources are being considered now as an entire property of the State, where the State commands and controls forestry resources even if these forests are located on private lands or are part of concessions to private actors, designated for management, use and exploitation. The National Development Plan presented by the government of Evo Morales in 2006 is the major instrument of public policies that would lead the road in this process of change.

In terms of climate change, a significant background for carbon sequestration has increased based on the results of the Climate Action Project conducted in the Noel Kempff Mercado National Park, which is located in the department of Santa Cruz. This project has been conducted for the last ten years, having generated more than one million tons of CO_2 in certified carbon credits. Nevertheless, there are political positions claiming that these markets and

market-based mechanisms for ecosystem services will provide the basis for these services to be sold as commodities, including the sensitive issue of water, with social and environmental impacts. These ideological conceptions are creating some increasing opposition for the implementation of projects on payments for environmental services, which are considered as part of a market-based mechanism and neoliberal approach.

According to the National Development Plan (NDP), carbon sequestration and certified emissions reduction (CERs) of greenhouse gases represent an important opportunity for income generation at a national level. This opportunity is based in the emerging international markets through clean development mechanisms, and the framework on climate change and environmental services. The national development plan has declared a specific policy on the reduction of greenhouse gases and carbon sequestration as part of the national development policies on environmental resources. In this policy, it has been designed that the State participates as the owner of natural resources in the generation of economic surplus through certification, international negotiation, sale and fair distribution of benefits produced by the commercialisation of carbon bonds in international markets. This plan conceives the strategy of income generation by carbon sequestration and CERs through forestation, reforestation and conservation, as part of environmental services. Three programmes have been proposed to implement this strategy:

a) CERs, carbon sequestration and conservation towards the promotion of clean development strategies and mechanisms for international markets, aiming at generating higher income for the country and local communities based on a fair distribution of benefits. This programme promotes investments of CDMs and other relevant schemes.

The main project is related to forestation and reforestation of 10 thousand hectares in tropical valleys in the department of Cochabamba aiming at sequestering CO_2 through production of biomass in forestry plantations and community agro-forestry systems in a 30-year period. The government aims to commercialise CERs from this project, as well as achieving rehabilitation of degraded lands of this region through the integration of native ecosystems with appropriate forestry and agro-forestry systems, which are incorporated to local traditions and uses. Carbon sequestration and potential income generated by the commercialisation of environmental services represent an important incentive for local communities. Effective and permanent participation of local communities, municipalities, national authorities and the private sector has been

considered as a key factor in this process. Nevertheless, the participation of the private sector in general may have been restricted because of changes introduced by the government and a very unfavourable investment climate which resulted in having the lowest private and foreign direct investment rates in the country since 20 years.

b) National Programme of Carbon Sequestration. According to the National Development Plan, this programme aims to reduce deforestation rates in protected areas and buffer zones, which are threatened by human intervention, by avoiding illegal logging in protected areas and surrounding buffer zones. It aims to promote the certification, negotiation and commercialisation of carbon credits based on the experience of the Climate Action Project in the Noel Kempff Mercado National Park. This project runs from 1997 to 2025 and is estimated to produce CERs for more than 990 t CO_2 during the project life cycle (Ulloa, 2006). The project has the participation of local communities and two key components: i) To stop industrial timber harvesting by avoiding further timber extraction and damage to vegetation; and ii) Avoiding slash-and-burn agriculture through community development programmes. It is expected that similar schemes will be created and replicated in other protected areas based on regional and local projects.

c) Transformation and Change of the Energetic Matrix for CERs: This programme is based on the proposal to change the energy matrix and energy efficiency to obtain CERs through the implementation of related projects. This is part of the major component of the new government, which aims at strengthening the domestic demand of energy for social benefits. This policy framework was supported and strengthened by the participatory construction of an official proposal on climate change presented in September 2006 by the National Programme on Climate Change. This proposal was prepared and discussed with the participation of more than twenty institutions, including the academia, national agencies and municipal governments, as well as NGOs and local organisations from the forestry, environmental and climate change sectors. The proposal, which was presented in September 2006 and coordinated with other developing countries, acknowledged and promoted the clear need to include avoided deforestation as a recognised mechanism for emissions reduction. This is because there is a lack of an international agreements taking place under the Kyoto Protocol to address this important source of carbon emissions and valid alternatives to tackle these causes.

A key factor in terms of policy responses is that there are few specific policies (outside of protected areas) and measures in the National Development Plan and other sector-related policies in order to reduce deforestation, particularly in the Bolivian lowlands and the Amazon. This scenario represents a major challenge for biodiversity and sustainability.

7. Concluding Thoughts

Bolivia will benefit from the CDM in a meaningful way only if forest protection and reforestation projects are eligible under this scheme. Activities related to land-use change and forestry issues are responsible for more than 83 per cent of CO_2 emissions in Bolivia by 2001 (NPCC, 2001), which have increased to around 89 per cent by 2006. Moreover, around 97.7 per cent of Bolivia's CO_2 abatement potential is in this sector, which is equivalent to 903 million tons of CO_2, according to the national strategy study prepared in 2001 for the participation of Bolivia in the CDM. This study identifies a mitigation potential for land use, land-use change and in forestry projects of 73.5 million tons of CO_2 per year on average. The average potential in the energy sector is 1.8 million tons of CO_2 per year, even making CO_2 conservative assumptions for both of these estimates.

A number of potential CDM projects in the forestry sector have been proposed, presenting an assortment of mitigation options, and whose CO_2 mitigation effects could be demonstrated as being measurable and sustainable in the long-term. These projects would not only reduce emissions at very competitive costs, but also would be able to produce numerous collateral and value-added benefits for environmental conservation, local communities and biodiversity. Projects of this sort are related to the introduction of sustainable agro-forestry production methods, alternatives for rural population to shift away from traditional slash-and-burn agriculture, and the introduction of low-impact logging, all of which will aim for more efficient protection of protected areas, and provide economic incentives for local populations.

Despite the significant potential in the forestry sectors, Bolivia could also offer a variety of mitigation options in the energy sector (for residential, commercial, industrial and transportation sectors). Even considering that gas fired plants and hydroelectricity produce a major part of electricity in Bolivia, a potential for greenhouse gases emissions reduction also exists in the power generation sector (NPCC, 2001). Switching from diesel and gasoline to compressed natural gas, especially under the official decisions and policies of this administration to prioritise domestic use and demand of natural gas, is also a very interesting

mitigation option in the Bolivian transport sector, which has great potential of GHG emissions reduction.

Mitigation options exist as well in rural areas and emissions reductions can be achieved in this context. In such areas, dispersed populations are not connected to the grid and electricity is usually and commonly produced by diesel power generators, -particularly in the Bolivian Amazon, which can be replaced by small hydroelectric plants. There exists an interesting hydroelectric potential not yet developed in the country, as well as wind and solar energy. However, current policies in terms of hydroelectricity still focus on old-fashioned megaprojects, instead of providing the appropriate support and investment for small and mini plants that would cause less environmental impacts while producing social benefits and opportunities for CDM projects. This is the case of the San Miguel del Bala hydroelectric dam, located in the northern part of La Paz, in the Madidi National Park buffer zone. This project was initially conceived in the late 1950s, reconsidered and rejected in the decade of 1990s, and officially supported again by the current administration through the enactment of the Supreme Decree No. 29191 of July 2007.

It is clear that the highest CO_2 emissions in Bolivia are directly related to deforestation and slash-and-burn practices both in forests and savannas in the lowlands region, which are undertaken annually in order to expand the agricultural frontier for cultivation and cattle ranching. In contrast, land-use GHG emissions in 2000 at a global scale represented only 18 per cent, according to the Stern Review. Avoided deforestation has been promoted for both specific-related sectors because of the deficiencies in the absence of a global climate agreement that values forests. With the recent outcomes of Bali, of critical significance is the decision that governments decided to encourage actions to reduce emissions from deforestation, and agreed to consider how to reward those countries who take immediate action. With this encouragement, tropical-forest governments could feel confident that efforts undertaken now could build the institutional and technical capacity needed. In addition, it was also acknowledged to consider efforts that not only reduce emissions from deforestation and degradation, but options to encourage the maintenance of carbon stocks found in countries with large intact tropical forests, such in the case of Bolivia, in order to prevent future emissions. It is expected that under these recent outcomes, the consideration of the role of indigenous and local communities will be moved forward to ensure that forest-dependant communities and those most directly connected to forests are not negatively impacted or undermined.

Three key areas would push the climate change agenda forward locally: economics, the media and political issues. In terms of economics, there is interest not only in the costs and impact of climate change but the opportunities for income generation through CDM schemes, and more significantly, by implementing deforestation avoidance and similar proposals. The media has gained a great space nationally and internationally since the release of *An Inconvenient Truth* and, currently, climate change is an unavoidable subject on the news. There is ground for political support based on the increasing outcomes and interest in both areas. In the case of Bolivia, political interest is framed under the policy framework which recognises the importance of climate change for future impacts and, especially, for the potential opportunities for income generation. Nonetheless, unless avoided deforestation and other similar schemes are put in place, deforestation will continue with high probabilities of not reducing current rates. On the contrary, deforestation rates may increase. Actions on such schemes are not only related to economic benefits and income generation, although there is enormous interest in those schemes based on the resulting economic benefits, but the need to include social and environmental benefits and the participation of rural and indigenous communities that could be most negatively affected. These impacts were clearly seen in the recent flooding of February 2008, particularly in the province of Beni. Otherwise, deforestation will undoubtedly continue to represent the major source of CO_2 emissions with significant values at the national level, although not on a global scale. Nevertheless, the main impact will result in a continue loss of habitat and biodiversity, which would have irreversible consequences.

Acknowledgments

This paper is based on the author's doctoral research project, which was completely conducted in Bolivia, as part of the DPhil degree at the Oxford University Centre for the Environment (OUCE). I would like to express my gratitude to Prof. Diana Liverman, head of the Environmental Change Institute, Ruth Saxton, Academic Administrator at OUCE and Jackie Davies at Green College, Oxford University. Also, the author wishes to thank Pablo Pacheco, CIFOR scientist in Bolivia for his support, advice and discussions on deforestation and forests management, Juan Carlos Ledezma GIS expert at Conservation International Bolivia for his collaborative work in data and maps generation, and Adam Fench and Indra Fung Fook at Environment Canada. The opinions in this paper are from the author and do not represent the views of CIFOR.

References

ABDES (2006) Diagnóstico y Lineamientos para avanzar hacia el Desarrollo Sostenible. Alianza Boliviana de la Sociedad Civil para el Desarrollo Sostenible. La Paz, Bolivia.

ABDES (2005) Informe Bolivia: Implementación de los Objetivos de desarrollo del Milenio relativos a la pobreza, la sostenibilidad ambiental y la gobernanza. Observatorio de Sostenibilidad. Alianza Boliviana de la Sociedad Civil para el Desarrollo Sostenible. La Paz, Bolivia.

Anderson, K. (2002) Can decentralization save Bolivia's forests? An Institutional Analysis of Municipal Forests Governance. Dissertation Series No. 9. CIPEC, Indiana University.

Andersen L. (2005) Conservación y Desarrollo humano en el Corredor Amboro-Madidi. Cuaderno de Trabajo, Programa de las Naciones Unidas para el Desarrollo (UNDP). La Paz, Bolivia.

Avissar, R. (1995) Recent advances in the representation of land-atmosphere interactions in general circulation models. Rev. Geophys. 33, 1005-1010.

Bascopé, D. (2003) Red de monitoreo de la calidad del aire en Cochabamba. Seminario Taller sobre elaboración de Normas de Calidad del Aire, La Paz.

Betts, R. (1999) Self-beneficial effects of vegetation on climate in an Ocean-Atmosphere General Circulation Model. Geophys. Res. Lett. 26, 1457-1460.

Bradley, R. Vuille, M., Diaz, H. and Vergara, W. (2006) Threats to Water Supplies in the Tropical Andes. Science, vol. 312, pp.1755-76.

Camacho, M., Martinez, I. and Rojas, D. (2001) Tasa de deforestación en el Departamento de Santa Cruz: 1993-2000. Santa Cruz, Proyecto BOLFOR:

Clabbers, B. (2004) Possible role of LULUCF in future regimes. Center for Clean Air Policy. Future Actions Dialogue Meeting, Mexico City. November.

Claussen, M. (2002) Does landsurface matter in climate and weather? In Vegetation, water, humans and the climate: a new perspective in an interactive system part A. A synthesis of the IGBP core project, Biospheric Aspects of the Hydrological Cycle.

Conservation International (2005) Landscape Conservation Program. Integrating Governance, Participation and Sustainable Economic Growth for Biodiversity Conservation in the Amboro-Madidi Corridor. La Paz, Bolivia.

Contreras, A. and Vargas, M. (2002) Social, Environmental and Economic Dimension of Forest Policy reforms in Bolivia. Forest Trends, Washington DC.

Davies, J. Magriños, E., Osinaga E. and Bojanic, A. (2000) Is natural forest management a viable land use option in a colonisation zone in Bolivia. Overseas Development Institute, London.

FAO (2001) The global forest resources assessment 2000. Summary report. Food and Agricultural Organization o the United Nations. Committee on Forestry. Rome

Forestry Superintendence (2007) Las Cifras del Sector Forestal. Superintendencia Forestal, INE, Cámara Forestal de Bolivia. Santa Cruz

Francou, B. Vuille, M., Wagnon, P., Mendoza, J., and Sicart, J. (2003) Tropical climate change recorded by a glacier in the central Andes during the last decades of the twentieth century: Chacaltaya, Bolivia, 16°S. Journal of Geophysics Research. 108.

GEOBOL (1978) Memoria explicativa: Mapa de uso actual y potencial del suelo. La Paz, Bolivia.

Guisbert, G. (2003) monitoreo de la calidad del aire en la ciudad de El Alto. Seminario Taller sobre elaboración de Normas de Calidad del Aire, La Paz.

Gutierrez, J. (2007) Mayores evidencias de la retracción de los glaciares. Programa Regional Andino de Adaptación al Cambio Climático. Boletín Informativo No. 4. Programa Nacional de Cambio Climático. La Paz.

Gutierrez, R. and Palenque, E. (2000) Medidas de dióxido de carbono en la Amazonia boliviana. Primera conferencia cientifica del LBA. Junio 26-30. Belén, Brazil.

Hecht, S (2001) When Solution Became Drivers in Soybeans, development and conservation on the Amazon Frontier. Development and Change, 36(2), 375-404.

Hoffman, D. (2005) Socioeconomic impacts of glacier retreat in the Bolivian Andes. Presentation at the Open Science Conference "Global Change in Mountain Regions. Perth, Scotland. 2-6 October.

Kaimowitz, D., N. Erwidodo, O., P. Pacheco, and W. Sunderlin (1998) Considering the Impact of Structural Adjustment Policies on Forests in Bolivia, Cameroon and Indonesia. Unasylva 49: 57-64.

Kaimowitz, D., Thiele, G. and Pacheco, P. (1999) The effects of Structural Adjustment on Deforestation and Forest degradation in Lowland Bolivia. World Development Vol 27, No. 3, 505-520.

Kaimowitz, D. (1997) Factors determining low deforestation: the Bolivian Amazon. Ambio, 537-540.

Kaser, G. Georges, C., Juen, I., Molg, T. (2005) Low latitude glaciers: Unique global climate indicators and regional contributors to fresh regional water supply. A conceptual approach, in Global Change and Mountain Regions: A State of Knowledge Overview, Huber, U.m Bugmann, H, Reasoner, M. (eds) Kluwer, New York.

Killeen, T. (2007) Una Tormenta Perfecta en la Amazonia. Desarrollo y Conservación en el contexto de la Iniciativa para la Integración de la Infraestructura Regional Sudamericana. Advances in Applied Biodiversity Science No.7. Conservation International.

Killeen, T., Calderon, V. Steininger, M., Harper, G., Siles, T. Solorzano, L. & Tucker, C. (2005) Forty years of land-use change in Bolivia: Who, where, why and how much. Conservation International.

Ibisch, P. & G. Mérida (2003) Biodiversidad: La riqueza de Bolivia. Estado de conocimiento y conservación. Editorial Fundación Amigos de la Naturaleza. Santa Cruz, Bolivia.

Ledezma, J.C. & Painter, L. (2005) Método para el Mapa de Estado de Conservación. Trabajo No Publicado. Conservation International, La Paz.

Lozán, J. Grassl, H. and Hupler, P. (eds) (2001) Climate of the 21st century: Changes and risks. Hamburg, Germany.

McKibbin, W. and Wilcoxen, P. (2002) The Role of Economics in Climate Change Policy. The Journal of Economic Perspectives, Vol. 16, No. 2, pp. 107-129.

MDSMA (1995) Memoria explicativa: Mapa Forestal. Ministerio de Desarrollo Sostenible y Medio Ambiente, Secretaría Nacional de Recursos Naturales. La Paz, Bolivia.

Mendoza, J. and Francou, B. (2000) Chacaltaya: evolución de un pequeño glaciar en los Andes de Bolivia. In Memorias del Simposio Nacional de Cambios Globales, Argollo, J. and Miranda, G. (eds). La Paz, Bolivia.

Nobre, C., Sellers, P. and Shukla, J. (1991) Amazonian Deforestation and Regional Climate Change. Journal of Climate, Vol. 4, pp 957-988

NPCC (2000b) Escenarios Climáticos: estudio de Impactos y Opciones de Adaptación al Cambio Climático, La Paz, Bolivia.

NPCC (2000c) Vulnerabilidad y adaptación de la salud humana ante los efectos del cambio climático. La Paz, Bolivia.

NPCC (2001) National Strategy Study for the Participation of Bolivia in the CDM. Ministry of Sustainable Development and Planning. La Paz, Bolivia.

NPCC (2003) Inventario Nacional de Emisiones de gases de efecto invernadero de Bolivia para la década 1990-2000 y su análisis tendencial. La Paz, Bolivia.

NPCC (2006) Boletín Informativo. Boletín No. 3. La Paz, Bolivia.

Pacheco, P. (1998) Estilos de Desarrollo, deforestación y degradación de los bosques en las tierras bajas de Bolivia. CIFOR, Centro de Estudios para el desarrollo Laboral y Agrario. Serie Bosques y Sociedad. La Paz, Bolivia.

Pacheco, P. (2006) Agricultural expansion and deforestation in the Lowlands Bolivia: The Import Substitution versus the Structural Adjustment Model. Land Use Policy, 23, 205-225.

Palenque, E.R. (2003) Los efectos de la RUV Solar sobre plantas y materiales de uso tecnológico, In La Radiación Ultravioleta en Bolivia, Zaratti, F. and Forno, R. (eds). OPS/LFA, La Paz, Bolivia.

Peredo, B. (2005) Oportunidades y Desafíos para el Desarrollo Humano Sostenible: Beneficios de la Biodiversidad y de Servicios Ambientales. Cuaderno de Trabajo, Programa de las Naciones Unidas para el Desarrollo (UNDP). La Paz, Bolivia.

Pielke, R.A., Marland, G. Betts, R. Chase, T., Eastman, J. Niles, J., Niyogi, D. and Running, S. (2002) The influence of land-use change and landscape dynamics on the climate system: relevance to climate change policy beyond the radiative effect of greenhouse gases. The Royal Society, London. Vol. 360, pp. 1705-1719.

Pielke, R. A. (2001) Influence of the spatial distribution of vegetation and soils on the prediction of cumulus convective rainfall. Rev. Geophys. 39, 151-177.

Ramírez, E. (2003) Studies on Chacaltaya glacier. 1st Symposium on Mass balance of Andean Glaciers. 13-14 March. Valdivia, Chile.

Ramirez, E. Francou, B., Ribstein, P., Descloitres, M., Guerin, M., Mendoza, J., Gallaire, R., Pouyaud, B., and Jordan, E. (2001) Small glaciers disappearing in the Tropical Andes: a case study in Boliva – Glacier Chacaltaya. Journal of Glaciology, 47: 187-194.

Reed, D. ed. (1996) *Structural Adjustment, the Environment and Sustainable Development*.. Westview Press, Boulder, Colorado.

República de Bolivia (2006) Plan Nacional de Desarrollo. La Paz, Bolivia.

República de Bolivia (2005) Decreto Supremo No. 28218 del 24 de Junio. La Paz, Bolivia.

Rocha, J. and Palenque, E. (2003) Determinación de NO_2 troposférico utilizando muestreadotes pasivos. Revista Boliviana de Química. La Paz.

Rojas, D., I. Martinez, W. Cordero, and F. Contreras (2003) Tasa de Deforestación de Bolivia. Proyecto BOLFOR, Santa Cruz, Bolivia.

Silva-Chavez, G. (2005) Reducing greenhouse gases from tropical deforestation by applying compensated reduction to Bolivia. In Tropical Deforestation and Climate Change, edited by Moutinho, P. & Schwartzman, M. Amazon Institute for Environmental Research, IPAM, Brazil and Environmental Defense, Washington DC.

Steininger, M. Tucker, C. Ersts, Townshend, J., P. Killen, Desch, A., Bell, V. and Ersts, P. (2000) Tropical deforestation in the Bolivian Amazon. Environmental Conservation 28: 127-134.

Superintendencia Agraria (2001) Mapa de cobertura y uso actual de la tierra y memoria explicativa. Superintendencia de Regulación de Recursos Naturales. Santa Cruz, Bolivia.

Trujillo, R. (2006) Boletín Informativo No. 3, Programa Nacional de Cambios Climáticos. La Paz, Bolivia.

Ulloa G. (2006) Bolivia's experience of forest management and emissions avoidance. Presentation by the Clean Development Office. National Programme of Climate Change. Bolivia.

Vuille, M. Bradley, R., Werner, M. and Kieming F.T. (2003) 20th Century Climate Change in the Tropical Andes: Observation and Model Results. Climate Change 59, 75-99.

World Bank (2002) Performance Assessment Report. Biodiversity Conservation Project, Bolivia

World Bank (2003) Sustainable Development in a Dynamic World, World Development Report. Washington DC.