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SPECIAL FEATURE: ORIGINAL ARTICLE

The EJAtlas: Ecological Distribution Conflicts as Forces for Sustainability

Trends in social metabolism and environmental conflicts in four Andean countries from 1970 to 2013

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Abstract In the global map of environmental injustices (http://www.ejatlas.com), the Andean countries (AC) report many ecological distribution conflicts. Our hypothesis is that the patterns of such conflicts are explained by the structural shifts of the economies and the concomitant changes in their metabolic profiles. Since the 1990s, these countries went through a strong reprimarization process, which changed their social metabolism as well as intensified environmental pressures and conflicts. In monetary terms, in the AC group of countries (Colombia, Ecuador, Peru and Bolivia), the primary sector increased its importance both in exports as well as in GDP. In the metabolic dynamics, the Domestic Extraction of materials (measured in tons) increased by a factor of 3.4 after jumping from 336 to 1145 MT between 1970 and 2012. This was driven by the fossil fuel and mining sectors. This reality was reflected in the environmental conflicts. Mining, fossil fuels, biomass and hydropower plants are the most conflictive sectors. The research in this article relies on a study of material flow analysis for the four AC carried out by the authors as well as 244 environmental conflicts reported in the EJAtlas until August 2016. The shifts in the metabolic–economic patterns help explain the dynamics and characteristics of the environmental conflicts in the AC. Such conflicts produce social mobilizations, which if successful, might help move society towards sustainability and environmental equity.

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Introduction

This article analyses the interrelation between the social metabolism of four Andean countries (Colombia, Ecuador, Peru and Bolivia) during the period 1970–2013 and the emergence of socio-environmental conflicts. The word "social metabolism" has origins in the 19th century (Martinez-Alier and Schlüpmann 1987; Foster 2000) but the methods for the study of the social metabolism (such as material and energy flows analysis) were not available until a few years ago. This article argues that there is a relation between the growth and changes in the social metabolism and the rise of the number of reported environmental conflicts. Indeed, some important activist environmental organizations (such as CENSAT in Colombia, Acción Ecológica in Ecuador) started their lives in the mid-1980s, as a response to such conflicts. Our purpose in this paper is to draw some conclusions from the analysis of many cases of environmental conflicts in four Andean countries in a framework of comparative, statistical political ecology. We delve beneath the surface manifestations of environmental conflicts related to mineral ores, hydroelectric dams, public infrastructures, biomass or fossil fuels extraction to uncover their root causes in the growth and changes in the social metabolism accompanied by changes in public policies and trends of the world economy. Environmental conflicts are caused by the growth and changes in the social metabolism, which also depend on existing social and political structures and their dynamics as well as decisions that occur in different national and international scenarios.

Information on conflicts draws upon the Environmental Justice Atlas (http://www.ejatlas.org) to which ourselves have contributed since 2012. The EJAtlas is a very large inventory of environmental conflicts, showing a concentration of conflicts in Latin America (LA) and in the Andean countries (AC). This responds to factors such as the ability to draw on activist knowledge from the region. Geographical coverage across the world is improving in the new phase of the EJAtlas project after 2016 (reaching 2200 conflicts worldwide by August 2017). However, there might actually be a larger incidence of environmental conflicts in LA than elsewhere. Deaths of environmental defenders (Global Witness 2016) are high in LA. Demonstrations and blockades are regularly reported in the press on mining and energy conflicts in the AC, as well as complaints because of infrastructure, urban expansion and pollution, land grabbing, monocultures. All such conflicts have a main cause: the growth and changes in the social metabolism. Hence, the disputes for control and appropriation of natural resources and environmental services, and also the struggle against pollution. The defence of the "territory" is often an important cultural factor in rural conflicts involving indigenous and peasant populations, and this is why environmental conflicts have been described by LA authors as "eco-territorial" conflicts (Svampa 2015).

There has been a large increase of the material extraction in the process of "reprimarization" of the region. This physical and economic trend has given birth to a new LA literature on *n*eo-extractivism (Gudynas 2013; Lander 2014; Slipak 2013; Svampa 2015), which suggests that the International Labor Division is a factor that increases the specialization processes in these countries toward the primary sector. From an ecological economics perspective, conflicts are a result of the material causes associated to social metabolism (Scheidel et al. 2017 this issue; Martinez-Alier et al. 2016a, b; Martinez-Alier 2002; Temper et al. 2015). From a broader view, conflicts can also be explained by World Systems theory showing how the countries of the South play a role as raw material providers from the new "commodity frontiers" (Moore 2000) submitting to an economic and ecologically unequal exchange with the industrialized countries (Wallerstein 1974; Hornborg 1998; Pérez-Rincón 2006; Vallejo 2010; Vallejo et al. 2011; Hornborg and Martinez-Alier 2016; Samaniego et al. 2017). Authors from the AC (Pérez-Rincón from Colombia, Vallejo from Ecuador) have been main contributors to the recent ecological economics literature on ecologically unequal exchange. It is wrong to call the international patterns of social metabolism and trade in energy and materials "the international division of labor"; they should be called the "international division of labor and nature". In this article, however, we do not focus so much on international conflicts on the (economic and ecological) terms of trade as on grassroots resistance.

Conflicts arise by microsocial factors related to the repercussions on communities' livelihood, corresponding to the material interests at stake and to the social values and worldviews in dispute. This is an argumentation laid out in the theory of the environmentalism of the poor (and the indigenous) (Guha and Martínez-Alier 1997; Martinez-Alier 2002). In this way, environmental conflicts are not solely for the control of material resources or the avoidance of pollution, they are also on the power to impose some "valuation languages", to generate certain definitions of reality or ontologies (Escobar 2014).

Finally, the environmental conflicts generated today in LA and AC cannot be understood without a long-term historical perspective which insists on the highly unequal power relationships existing in the region since the colonial period (Alimonda 2016). The importance of racism and colonial traditions is highlighted in contemporary scholarship (Quijano 2011; Mignolo 2011).

Such themes are germane to the main hypothesis of this paper, namely, environmental conflicts can be explained by changes in the economic structures, where "economic" does not refer to monetary valuations but to the social metabolism in terms of flows of energy and materials.

The article is organized as follows: after this introduction, we present the methodology used for building two data bases. First, the data base of material flow. Second, the inventory of 244 environmental conflicts in the EJAtlas. Afterwards, we work out the metabolic dynamics of the four AC economies (Colombia, Ecuador, Peru and Bolivia) and show how this physical analysis is to some extent mirrored in money terms. Social metabolism and material flow analysis are the core of the argument.

What are the relations between changing social metabolism and environmental conflicts? To answer this question, we study the 244 inventoried environmental conflicts in the EJAtlas for the AC, with classifications by metabolic sector (e.g., biotic or abiotic), and a periodization by the date when they started (before 1990, between 1991 and 1999, and the years since 2000). Finally we present the discussion and conclusion showing how the appearance of environmental conflicts responds over the decades to the changes in the social metabolism in terms of flows of energy and materials.

Metabolism and environmental conflicts

Material flow analysis

The Social Metabolism concept shows the economy's physical growth and its widening of the frontiers, scales

and extraction speeds at the heart of the environmental problems (Georgescu-Roegen 1971; Ayres and Simonis 1994; Pérez-Rincón 2014). Fischer-Kowalski and her co-authors from Vienna incorporated the material flows analysis (MFA) to the study of social metabolism (UNEP 2016). Societies can be seen as ecosystems that depend on the continuous material and energy flows, from and to its environment (Fischer-Kowalski 1997; Fischer-Kowalski and Haberl 2015). This framework is used in industrial ecology and also in ecological economics. The use of "metabolism" implies a similarity between the functioning of a biological system and the socioeconomic system, with two main objectives: (1) to express the dependence of the social and economic system from the natural environment and, (2) to show that the speed of production, reproduction and extraction of the economy has surpassed the scale of natural regeneration, producing socio-environmental impacts and conflicts. Ecological economics establishes that the sustainability of an economy should be estimated through biophysical indicators. The material flows (MF) signal the pressure a socioeconomic activity exerts on the environment. Such biophysical indicators along with the monetary indicators allow to contrast the biophysical structure of the countries with the economic growth policies and other socioeconomic dynamics, becoming instruments for the management of sustainability (Pérez-Rincón 2007).

In this sense, the material flow indicators have been used as a tool to quantify the extractive processes. For example in Chile, Giljum (2004) pointed out how the policies by Pinochet regime led to an increase in the anthropogenic pressures on the environment. Pérez-Rincón (2006) analyzed the material and monetary commercial flows for Colombia, finding evidence of ecologically unequal exchange. Russi et al. (2008) analyzed the material consequences of the neoliberal reforms favoring the extractive industries of Chile, Ecuador, Mexico and Peru, quantifying in material terms the growth of the mining sector in Chile and Peru, biomass and oil in Ecuador, and building materials in Mexico. Vallejo et al. (2011) later quantified the materials flows of the economy of Colombia showing relationships with socio-environmental conflicts. Vallejo (2015) had compared the economic trends with the use-of-materials pattern and discussed the growing ecological distribution conflicts in the Colombian, Ecuadorean and Peruvian economies. She was interested in the debates on the "curse of abundance". West and Schandl (2013) presented material flow statistics for almost all Latin America countries from 1970 until 2008. This was later taken up in the UNEP report on "Global Material Flows" (2016). Lastly, Martínez-Alier et al. (2016) related ecological distribution conflicts to changes in social metabolism in a comparative analysis for India and South America.

Environmental conflicts

A socio-environmental conflict (or ecological distribution conflict) emerges when there is a perception of unfair or unjust or disproportionate distribution of environmental burdens or access to natural resources or also when participation in the decision-making by the communities present in the territory is not allowed or even recognized (Orellana 1999; Ortíz 1999; Sabatini 1997; Martinez-Alier et al. 2010; Schlosberg 2007). In this sense, ecological distribution conflicts arise when one group benefits by the use of material resources while other groups are affected by damages to their livelihoods. The beneficiaries try regularly not to face the "liabilities" for such behavior.

We prefer the term "ecological distribution conflicts" (EDC) for the following reasons. The term was coined by ecological economists Martinez-Alier and O'Connor (1996) to describe social conflicts born from the unfair access to natural resources and the unjust burdens of pollution. Environmental benefits and costs are distributed in a way that causes conflicts. The terms socio-environmental conflict or EDC are in practice interchangeable but they arise from different framings (social movement theory, ecological economics). These two authors, trained as economists, were inspired by the term 'economic distribution conflicts' in political economy that describes conflicts between capital and labor (profits vs. salaries), or conflicts on prices between sellers and buyers of commodities, or conflicts on the interest rate to be paid by debtors to creditors (Martinez-Alier 2002). The term EDC stresses the idea that the unequal or unfair distribution of environmental goods and bads is not always coterminous with 'economic distribution' as, for instance, rents paid for by tenant farmers to landlords, or the international terms of trade of the Brazilian economy, or claims for higher wages from mining unions opposing company owners. 'Ecological distribution conflicts' is then a term for collective claims against environmental injustices. Such conflicts cannot be always pacified by economic compensation. There are "incommensurable values".

The capitalist industrial economy is based on systematic "cost-shifting" to poor people, and also to future generations and to other species. "Cost-shifting" is a crucial term introduced by Kapp (1950), to avoid talking of externalities, as neoclassical environmental economists would do. Sometimes, this pattern of injustice leads to open complaints and conflicts. In other terms, such conflicts can be defined as the manifestation of the contradictions in the nature–human relationship between two or more actors (communities, national or foreign private companies, State organisms), due to a human activity, which modifies the historical dynamics of a place or territory in relation to the use of the environment. This human activity generates impacts (environmental, social and economic) and/or the

disproportionate appropriation of natural resources and environmental services by different actors, causing an unfair access and use of them. This generates non-conformity, which might become manifest through collective actions in social mobilization (marches, other types of protests, writing of manifestos) or the use of legal mechanisms such as lawsuits. Inasmuch as social dynamics resemble each other, environmental conflicts lose their purely local character when the local groups participate in international environmental justice networks (Martínez-Alier et al. 2016; Temper et al. 2015).

To be active in ecological distribution conflicts often requires to be recognized previously as a valid social actor and to be allowed to participate in the debate. Issues of participation and recognition were emphasized by Schlosberg (2007).

Methodology

To perform the social metabolism analysis for AC, the methodology elaborated by the European Union Statistical Office, Economy wide Material Flow Accounts (Eurostat 2013), was applied. (These guidelines were first written by the Vienna group of Fischer-Kowalski et al. referred to above). UNEP (2016) report explains clearly the methodology, and applied it to Latin America. The material flow indicators used in this research are: domestic extraction (DE), direct material input (DMI), physical exports (X) and import (M), and the Physical Trade Balance (PTB).[1] DE includes all of the extracted materials from national territory to be used as input for the economic process; DMI comprises the total of the materials used for the economic activity, which includes domestic extraction (DE) and the physical imports (M); X are all of the materials which are sent outside of the national territory; and the PTB is computed by subtracting exports (X) from imports (M), contrary to the monetary commercial balance. All of the materials are measured in physical weight units—metric tons, MT—classifying them in biomass, metal ores, building materials and fossil fuels (see Table 1).[2]

[1] The regional domestic extraction was obtained from the simple summation of the physical statistics of each one of the four Andean countries. For the physical commercial balance and export data, the commerce amongst the same Andean countries were taken out to avoid double counting.

[2] Notice that water flows are not included in MFA, because they are one or two orders of magnitude larger than the MF. Notice also that a parallel Accounting of Energy Flows can and should be done to have a full picture of the Social Metabolism, but it is not done here for the sake of brevity. Production of electricity from coal, oil and natural gas is anyway indirectly reflected in the Material Flows, but not the electricity from water power (nor from wind power, or photovoltaic). There are many conflicts in AC because of hydroelectricity (as explained later), and also a few from wind energy—which are expressed as conflicts on land grabbing or land acquisition (Avila 2017 this issue).

The inventory of environmental conflicts derives from the Environmental Justice Atlas (http://www.ejatlas.org). Out of the 244 conflicts analyzed in this article, 192 were reported in EJAtlas by 2014; the Univalle group led by Pérez-Rincón contributed most of those from Colombia while those from Ecuador, Peru and Bolivia came from other groups. 52 conflicts described by the Univalle research group for AC during 2015 were added to the EJAtlas and to the initial 192 cases.[3] A database for the four AC was built which allowed classifying, characterizing and typifying the conflicts, doing some descriptive statistics. As sources of information activist, academic and journalistic public sources were used. The EJAtlas publicly available forms list published sources, including videos.

A world census of ecological distribution conflicts (or LA or AC countries) does not exist. The inventory for AC in this paper is large although incomplete. It contains rather notorious conflicts. The majority of them originate in the 1990s. Those from very recent years are under-reported.

Results

Economic dynamics and metabolic profiles

The LA economy, including its international market specialization patterns, had a strong structural change in the last 40 years, powered by the adoption of neoliberal policies. The debt crisis of the 1980s facilitated the imposition of adjustment policies, abandoning the road of industrialization preached by CEPAL (under Raul Prebisch) during the 1950s and invoking again the traditional theory of comparative advantages, arguing for the need to focus on what the subcontinent did best: produce commodities (Lander 2014). The chrematistic or monetary analysis for the AC as a whole shows a significant increase of the primary sector's importance in the GDP, when it went from 14% in 1997 to 24% in 2014. Energy and mining activities increased their participation while agriculture decreased in relative terms. These structural shifts reveal a strong process of deindustrialization, for it reduced the GDP participation of this sector from 21 to 13% between 1990 and 2014. In the exporting structure, the primary sector increased (again in money terms) from representing 64% of all exports in 1990 to 73% in 2014.

[3] The collection of the cases has been based on work with students, NGOs, academic centers and researchers, conflict observatories, a review of news and press web pages, consultations with those affected, and field visits.

Table 1 Descriptions and sources of information Source: adapted from Vallejo (2015)

Material categories	Description	Data sources
Classification of Material Flow		
Biomass	Biological materials moved by humans and livestock per year	
Primary crops	Cereals, roots and tubers, dry legumes, oleaginous plants, vegetables, fruits, fibers, and other primary crops	FAO (2015a)
Forage	Crop residues of sugar cane and cereals used as forage	FAO (2015a)
Grazed biomass	Demand for forage of livestock units	FAO (2015a)
Forestry	Wood harvested from forests, plantations, or agricultural lands: fuel wood, roundwood and wood roughly prepared. (15% moisture)	FAO (2015a)
Fish biomass	Captures of fish, crustaceans, mollusks, and aquatic invertebrates	FAO (2015b)
Minerals		
Metal ores	Production measured in its gross metal content. Run of Mine	USGS (2015)
Industrial minerals	Salts, clays, sulfur, feldspar, phosphates, others	USGS (2015)
Building material	Sand and gravel used for concrete and asphalt production, and other building materials employed	USGS (2015); UNSD (2015)
Fossil fuels	Production of coal, oil and natural gas	EIA (2015); USGS (2015)
Internal trade in physical units	Import and export data by processing level (ISIC Rev. 1) and the main material component	UNSD (2015)

Domestic extraction and main extracted products in the Andean countries

Coming now to physical accounting (in tons), the DE (domestic extraction) of AC went from 336 MT to 1,145 MT between 1970 and 2012 (Fig. 1), increasing over three times when growing at an average annual rate of 3%, evidencing a strong absolute materialization of the economy—which cannot be attributed only to population growth. A significant change took place in the biophysical structure of the regional economy, going from biotic extraction to abiotic.[4] While the participation of the biotic sector in the physical extraction total went down from 65 to 30%, the abiotic sector increased from 35 to 70% between 1970 and 2012 (Fig. 1). The category with the highest growth was the fossil fuels, increasing its participation from 7 to 19%, mainly explained by the behavior of Colombia (coal), Ecuador (oil) and Bolivia (natural gas). The natural gas of Camisea is recently changing Peru's metabolic profile (Silva-Macher 2016).

In second place stand the building materials doubling their participation from 12 to 24% from 1970 to 2012. Since building materials are scarcely tradable in foreign trade, this extraction is mainly explained by the internal construction of infrastructure and housing in general, which demands great quantities of sand, gravel and cement.

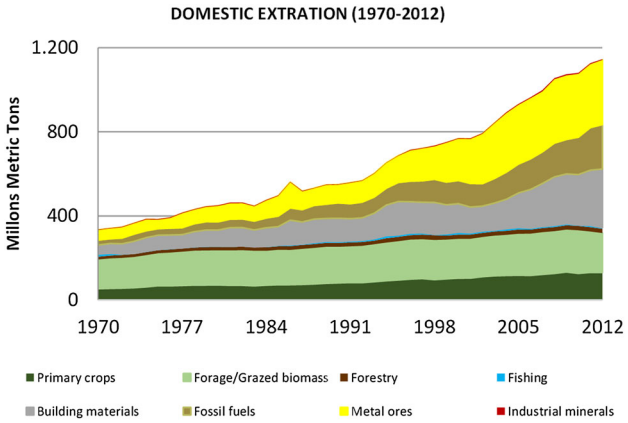

Fig. 1 Domestic extraction of the Andean countries

Metal ores stand close, almost doubling their importance when jumping from 14 to 27%, where copper, gold, zinc, tin and iron outstand. The metabolic profile shift towards the extraction of commodities intensive in abiotic natural resources, increased environmental pressures on the territories and on water use, and interrupted the traditional productive and cultural dynamics of the populations, giving way to the development of new environmental conflicts in the region.

On the other hand, the material intensity indicators in relation to the territory (DE/km^2) and per capita (DE/pc), give these results for the period 1970–2012: growth from 72 to 244 tons/km^2, and a per capita growth from 8 to 11 tons/pc. While the biotic sector diminished the environmental pressure in per capita terms, the abiotic sector

[4] The "metabolic profile" of a country or a region is defined by the amount of usage of the materials and its structure, where two big material groups are differentiated: biotic components (agricultural, forest and fishing biomass) and abiotic components (fossil fuels and the metallic, industrial and building materials).

increased both per capita as well as per km^2. The fall in the biotic material intensity per person (from 6 to 4 tons/pc) was compensated by food imports, which generates concerns in regards to food security. While, the increase in abiotic intensity threatens environmental sustainability due to the impact of mining and fossil fuel extraction, also boosting the environmental conflicts. However, there are also strong conflicts due to biomass access and land acquisition: mangrove destruction, Amazonian and Chocó deforestation, oil palm and forest plantations which destroy wetlands and affect biodiversity, amongst others.

External sector and patterns of productive specialization

The physical trade balance allows identifying the transfers of environmental loads associated to the functioning of the global economic system, aiding in identifying the ecological debt among countries (Krausmann et al. 2015). Ecological debt is an economic and environmental concept, which brings together two types of international ecological distribution conflicts. (1) The ecologically unequal exchange, defined as the fact of exporting products from poor regions and countries, at prices which do not take into account the local socio-environmental damage or resource depletion caused by these exports, in exchange for goods and services from the wealthier regions or countries. One metric to establish the reality of ecologically unequal exchange is that the export price per ton is systematically lower than the import price (Samaniego et al. 2017). Other metrics might also show inequalities in energy use, land use, use of labor, and use of water (Hornborg 2006, Hornborg and Martínez-Alier 2016). And, (ii) the tendency of the wealthy countries to disproportionally use environmental space (such as the atmosphere and the oceans to deposit Greenhouse Gases) without paying for it (Warlenius et al. 2015; Warlenius 2016).

The AC present a permanent deficit in the physical trade balance measured in tons (PTB), which jumped from 18MT in 1970 to 140 MT in 2013 (Fig. 2a): the region has been increasing its role of net material exporter during the whole period. One could say that there is a trade-related ecological debt accumulated in the period under analysis by the world towards the AC in biophysical terms close to 2235 MT. This figure is calculated by adding up the physical trade deficits. In Fig. 2a we see also the behavior of the monetary trade balance (MTB), which had a surplus trend until the 1990s. Then deficits arose, until the short-lived bonanza of the first decades of the 21st century when there were surplus in the AC monetary trade balances. Henceforth, there are against deficits in the monetary trade balance (the voluminous exports, Fig. 2b, are unable to pay for the imports). The AC trade balance reaches minus US$13,766 in 2015, this being related to the fall in the price of commodities.

The latter makes evident the reported paradox by Samaniego et al. (2017), which shows that a large portion of the South American countries combine biophysical deficits along with monetary deficits, which points out a contradiction that not even an elevated extraction of natural resources, which implies depletion and environmental degradation, is compensated with larger incomes for the countries. These commercial deficits can also lead to "deficits in the current account and from there could arise new needs of foreign financing" (ibid), and with that new pressures to increase material and monetary exportations in order to cover importation needs and payoff the debt's service (as it was already forewarned in Pérez-Rincón 2007). This situation reproduces an underdevelopment trap: productive specialization towards primary exports, larger detriment of the exchange terms, greater resource depletion, more environmental liabilities and more distributive-ecological conflicts, in accordance with the theoretical approaches of the Ecologically Unequal Exchange.

Now, when we examine the exporting dynamic of the four Andean countries, we find that it has grown to rates superior to the DMI: annual average at 5.4 vs. 3.4% (Fig. 2b). However, not all the sectors have grown the same. While the abiotic sector grew to 5.8%, the biotic sector did so at a 3.2% annual rate. Within the abiotic sector the ones which grew the most were: building ores (13%), fossil fuels (8.8%) and industrial ores (7.7%). In the case of metallic ores, an important extraction sector in Peru, Bolivia and Colombia,[5] the reported exportation numbers only register the mineral contained in the mineralized rock and the rest, classified as tailings, is left out of the foreign trade bookkeeping due to a lack of economic value. Because of this, the values that were registered in Fig. 2b are underestimated. If all the rock extracted were incorporated to these countries' exportations as it is done with the calculations of domestic extraction (DE), the exported values would jump from 11 to 37 MT in 1970 and from 21 to 168 MT in 2013. This would increase participation of abiotic exportations from 85% in 1970 to 94% in 2013, showing the real dimension of the energy-mining activity's importance within the metabolic dynamics of the region.

For its part, material biomass export also increased when it jumped from 6 to 20 MT; nevertheless, it grew less than mineral exports. The main exported goods in this sector correspond to agricultural commodities such as sugar cane, banana, oil palm, asparagus, quinoa, amongst

[5] Even though in Ecuador there is a great potential of copper franchised to Chinese companies, which generate conflicts as in Shuar territories in the south-east, in Intag in the north, and other cases.

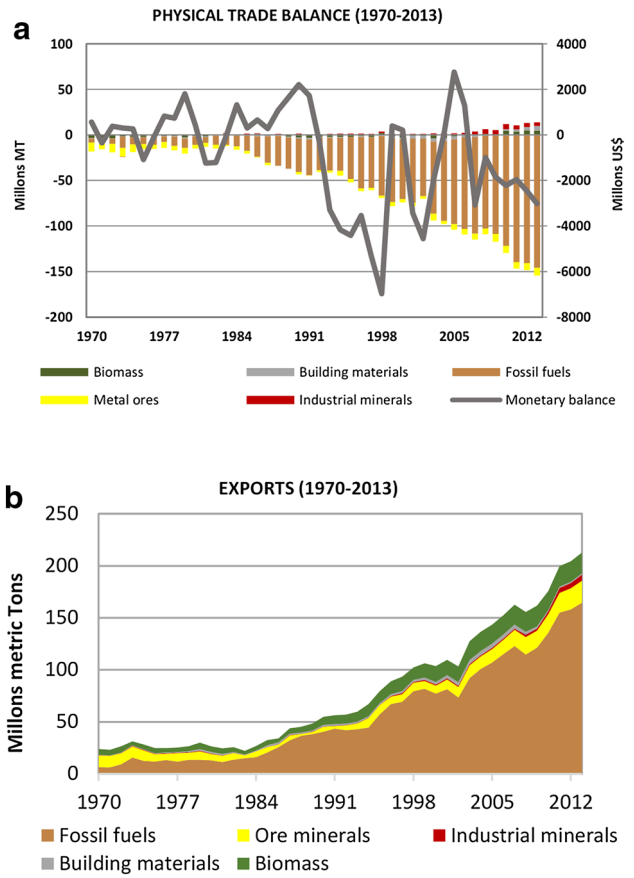

Fig. 2 Trade Balances and exports of the Andean region. 1970–2013 MT (metric tons). **a** Biophysical and monetary trade balance. **b** Exports

others; crops which demand a great amount of water and land, which imply greater environmental pressures.

In the specialized literature, an extractive economy is identified as that which exports a significant portion of the total of available materials for economic use (X/DMI). 14%, which corresponds to the world average, can be considered as the limit value in order to consider a country to be extractivist or not (Bunker 1984; Krausmann et al. 2008). When examining the evolution of this indicator in the AC by considering the total of extracted material (including the tail), an economic shift towards extractivism is observed when it goes from 10 to 27% between 1970 and 2012. When analyzing this indicator within large metabolic sectors, it is shown that this extractive dynamic mainly arises in the abiotic sector, which shifts from 22 to 37% in relation to the biotic sector, which increased from 4 to 9% within the same period. When observing this same indicator by country, the results show the Peruvian economy as the most extractive with an increase from 21 to 36%; followed by the Colombian which went from 5 to 27%; this indicator, in Bolivia, increased from 8 to 22% and in Ecuador from 5 to 21%. Although not all South America behaves this way, there are "biotic extractivisms" such as is the case of Argentina (Pérez Manrique et al. 2013) and from certain areas in Brazil.

Environmental conflicts in the Andean countries

Figure 3 shows the map of the 244 inventoried and analyzed AC environmental conflicts (or equivalently, ecological distribution conflicts). They are approached from two perspectives: (1) in light of the conflict-generating metabolic sectors; and, (2) according to the periodization of the environmental conflicts. Other aspects will be dealt with in future publications (the private or public firms involved, the social groups mobilizing including indigenous groups, etc.).

Metabolic sectors and environmental unrest

EJAtlas classifies conflicts in ten major categories, which are mutually exclusive. In our inventory, the main conflict-generating sector in the AC is mining, with 90 cases (37%) out of the 244 cases (Fig. 4); in Peru, Colombia and Bolivia these conflicts represent 63, 36 and 29% of the total conflict cases, respectively. The main products in these environmental disputes correspond to mineral ores, where gold (20.7%), copper (8%) and silver (5.2%) stand out.

Fossil fuel extraction turns into the second most conflict-generating activity, accounting for 21% of the inventories cases (52); in Ecuador, Bolivia and Colombia, this sector is responsible for 27, 29 and 23% of the cases, respectively (Fig. 5). In Ecuador, many conflicts occur associated to oil extraction, generated by multinationals and by the state oil companies (Petroecuador or Petroamazonas); in Colombia, conflicts are related to oil as well as to coal extraction; and in Bolivia to oil and gas.

Biomass and land grabbing conflicts have turned into another dispute-generating factor, combined with the specialization towards agro-industrial exporting sectors. This sector concentrates 17% (40) of the reported environmental conflicts (Fig. 4); in Ecuador, 29%; in Colombia 14% and in Peru and Bolivia 12% of the cases in each country (Fig. 5). The main conflictive commodities are sugar cane, oil palm, shrimp and timber. Another conflict-generating metabolic sector is that of water management (mainly hydropower plants) with 12% (30) of the cases (Fig. 4). In Bolivia this sector represents 21% of the conflicts and in Ecuador, Colombia and Peru it represents between 10% and 13% of the cases.

The infrastructure sector generates 5% (12) of the inventoried conflicts, especially in Colombia with the construction of roads and ports for product exportation. Waste management accounts for 4% (10) of the conflicts, related to the location and management of landfills. The

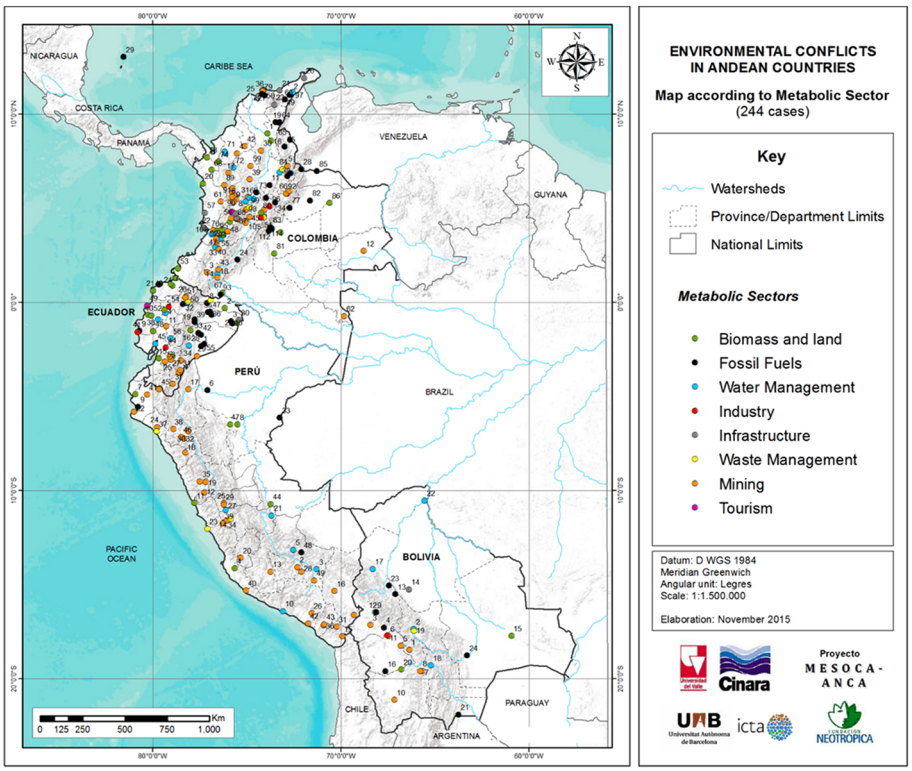

Fig. 3 Map of environmental conflicts in Andean countries (1920–2015)

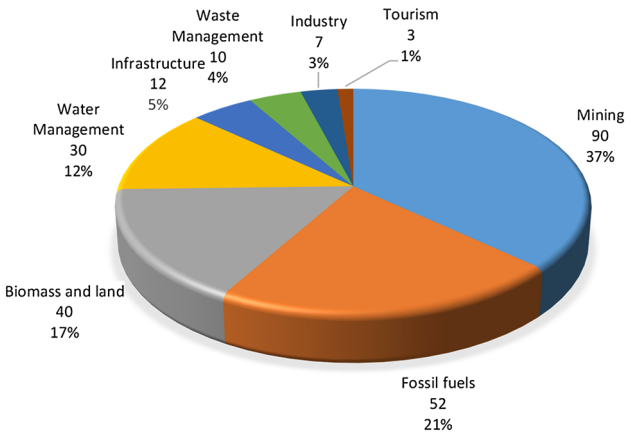

Fig. 4 Environmental conflicts in Andean countries by metabolic sector

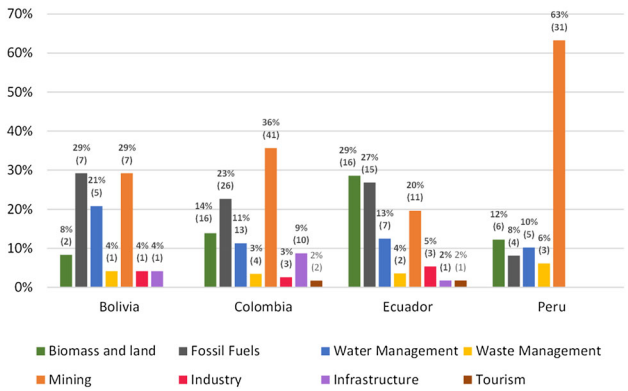

Fig. 5 Environmental conflicts by country and metabolic sector

industrial sector only represents 3% (7) of the identified conflicts related to the production of cement, asbestos, steelmaking and meat products.

Periodization of the environmental conflicts in the Andean countries

In the early 1970, industrialization by the substitution of imports with a view to consolidating the domestic market ("inward" development) was abandoned in favor of exports ("outward" development) (Bielschowsky et al. 2011; Kalmanovitz and López 2006). With the pro-market policies in the 1990s, the economic model explicitly advocated economic growth through natural resource extraction and exports. This was the "Washington consensus". Later, this was renamed the "commodities consensus" and even the "Beijing consensus" (Svampa 2013).

Based on this discussion, we divide the temporal analysis of the conflicts into three major periods: (1) before 1990, previous period to the economic opening; (2) the 1990s, to identify the dynamics of the conflicts related to the open economic policies and, (3) all along the 21st century to see the evolution of environmental unrest.

From different sources, there is evidence that in the AC, the quantity of social conflicts involving civil society

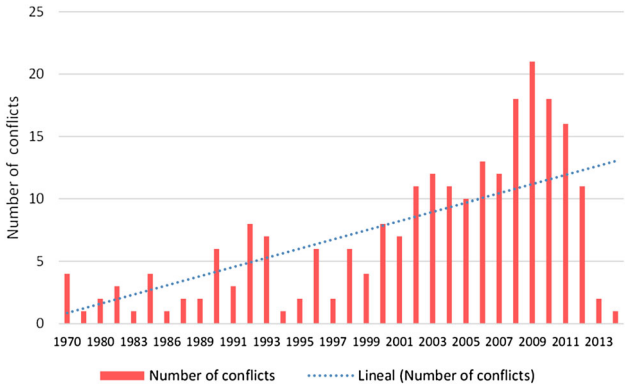

Fig. 6 Temporal dynamics of environmental conflicts in Andean countries (1970–2014)

groups defending of the environment and human rights increased during the last four decades. In Colombia, starting from the 1990s, there is a growing tendency of social struggles, being 2007 and 2013 the years with the highest accumulations, exceeding 1000 cases (Archila et al. 2014), from CINEP's social struggle data base (http://www.cinep.org). On Ecuador's side, socio-political unrest has also been rising since the 1980s, showing its peak towards the end of the 1990s, with more than 4000 conflict recorded, which fell during the first years of 2000, but increase again towards the end of the first decade of the new century up to almost 3000 cases (Ramírez Gallegos 2010). In Bolivia, there is also a growing dynamic of social unrest, starting with close to 100 conflicts per year during the seventies, rises to 800 cases in the eighties, it stabilizes at around 300 conflicts until 1997 and, from then on, it increases showing a high peak in 2005 with almost 650 cases (Laserna and Villarroel 2008). For its part, the Peruvian Ombudsman Office, which has records of the active social conflicts since 2004, also shows a growing tendency. It starts off with 551 in the first year, increasing to 2435 in 2009, stabilizes at around 1900 cases until 2014 and rises again to 2486 active conflicts in 2015 (Defensoría del Pueblo 2016).

In our AC inventory of ecological distribution conflicts, we find a similar tendency (Fig. 6).[6] Before the 1990s, a total of 28 environmental conflict cases started in the AC (11% of the total); in the 1990s, a total of 45 cases appeared (19%). In the 21st century, the number of new cases rose to 171, which represent 70% of the inventoried conflicts. In the last few years, there is under-reporting to be corrected as the EJAtlas continues its March.

[6] This graph identifies the quantity of environmental conflicts started in different years since 1970. The EJAtlas database form registers the starting year (and the final year, if appropriate) of each environmental conflict.

Many conflicts previous to the 1990s are related to biomass extraction, such as sugar cane, banana, oil palm and flowers (grown in greenhouses); infrastructure development and water management (constructions of roads and hydropower plants), and, incipiently, some mining conflicts. The conflicts of the 1990s are related to mining, biomass and fossil fuels. The mining cases surge predominantly due to gold and copper in Peru and building materials in Colombia; biomass conflicts are produced by shrimp, timber and oil palm in Ecuador and Colombia, as well as quinoa in Bolivia; and in the case of fossil fuels, they are associated with oil extraction projects, mainly in Ecuador, and coal in Colombia. During this decade, specific pro-extractive policies started developing in the four countries. In the case of Peru, they are associated to Fujimori's government (1990–2000), promoting initiatives for liberalizing the Peruvian economy and for mining expansion through the Mining Law of 1992. This Law protects the mining activity at a small and medium scale, and promotes the large transnational mining industry by favorable tax conditions and irrevocability of the concessions (Vélez-Torres and Ruiz-Torres 2015).

In Ecuador, since 1992 a similar process to Peru took place standing out the reform to the Hydrocarbons Law, promoting foreign investment in extractive sectors through state concession and investment policies in infrastructure projects. A similar policy was followed in Bolivia where the first government of Sánchez de Lozada (1993–1997) set forward the so-called Capitalization process through private investment; the Hydrocarbons Law led to the privatizing of the company Yacimientos Petrolíferos Fiscales Bolivianos (YPFB) (Perreault and Valdivia 2010). In Colombia, this turn took place through the "economic opening" which began with Gaviria's government in 1991, radically liberating the economy to imports and the massive arrival of capital, with financial, environmental and labor flexibility; this is in addition to the decrees during the 1980s where the mining industry was classified as being of public utility. These reforms answered to the requirements of the world economy.

The policies in the AC during the 1990s were consolidated as of 2000, yielding as a result a significant rise in the DE. The abiotic sector is responsible for this dynamic by growing at a 5% average annual rate, while the biotic sector grew only 0.5% per year. This accentuated the specialization towards mining and hydrocarbons.

These policies favored metabolic growth and its structural shift towards the abiotic sector. A consequence was the rise of environmental conflicts. During this period (2000–2015), 171 conflicts started many of them related to mining, fossil fuels and water management. When analyzed by country, it is found that in Colombia there are 84 conflicts (73% of the country's total) and in Ecuador there

are 33 (58%), in which mining, fossil fuels, water management and biomass are involved; in Peru 37 (75%), mainly in mining and biomass sectors; in Bolivia 16 (66%), the largest part related to mining and fossil fuels.

The results as regards metabolic trends and trends in conflicts are independent from the ideological bias of the governments of the four countries. Since 2002 in Colombia, the political lines of Alvaro Uribe (2002–2010) and Juan Manuel Santos (2012-to-date) are associated to so-called "Investor Confidence" and "The Minero-Energetic Locomotive". In Ecuador and Bolivia, under the government of Rafael Correa (2007–2017)[7] and Evo Morales (2006-to-date), there was a turn to nationalist rhetoric but neo-extractivist policies were promoted in practice although reinforcing the role of the State in a new relationship with capital. This has been called "redistributive extractivism", i.e., increasing royalties and curtailing repatriation of profits by foreign firms, so that profits from the extractive sectors go in a larger share to public investment and to welfare programs (Latorre et al. 2015; Samaniego et al. 2017). The downfall in prices after 2008 and particularly after 2012, undermines now this policy of "redistributive extractivism" in Bolivia and Ecuador.

In Peru, there is strategic continuity with neoliberal policies, which have been ongoing for the last 25 years, mainly as mining is concerned. During the government of Ollanta Humala in 2014 and 2015, laws which created even better conditions for private investment were promoted in detriment of the protection of the environment as well as people's health (Vélez-Torres and Ruiz-Torres 2015). An explicitly neoliberal president, P. P. Kuczynski, was elected in 2016.

It could be argued that our "metabolic hypothesis" leaves aside a rich literature on social movements. For instance, we could develop an analysis of the "resources" deployed in environmental conflicts (in terms of money, support from different organizations, activist work) (McCarthy and Zald 1977). In fact, the study of environmental justice movements certainly draws from and belongs to social movement theory and to social history (Martinez-Alier et al. 2016). For instance, it might seem that the occurrence of environmental conflicts could be better explained by "political opportunity structures" (McAdam et al. 2001) than by changes in the social metabolism. Thus, in Ecuador in the "long neoliberal night" before 2007 (in President Correa's own terminology), presidents were regularly deposed by demonstrations in Quito, and it was easier to complain against copper or oil extraction in the country side than under Correa's more firm government (2007–17) that "criminalized" so many activists. Or in Colombia in 2017, a situation has arisen that favors a wave of popular consultations against metal mining and fossil fuel extractions. These, we would argue, are, however, mere comings and goings in a long-term trend of increasing and changing metabolism that causes the birth and consolidation of social movements for environmental justice. Clearly, the growth of metabolism does not come from nothing; it comes from different decisions at different scales and institutional scenarios, also influenced by different power structures, which drive these extractive activities that are reflected in the growth of the flow of materials and energy.

Similarly, there is no denying that political cultures and other factors explain much of the prevalence or absence of violence and other outcomes of conflicts. We have noticed how Peru's environmental conflicts are more violent (against the environmental defenders but also against the police) than in Ecuador, or indeed in today's Chile. Also, the defence of communities (by appealing to Convention 169 of ILO) can be exercised in some countries better than in others. Law 70 of 1993 in Colombia recognizes Afro-American palenques. The Constitution of Ecuador of 2008 recognizes the Rights of Nature. Such politico-cultural specificities are important and could be brought into a more nuanced analysis of patterns of environmental conflicts and valuation languages. This article paints instead with a fat brush as a first step the link from metabolic changes to environmental conflicts and movement for environmental justice (with data from ecological economics and the study of social metabolism, and with data from the EJAtlas).

Discussion of results

So far we have three main results, and the main novelty of this research consists in putting them together: (1) an impressive growth of the social metabolism in the AC region (as shown in our own research and also in the new UNEP publication of 2016) which means an increase of the overall pressure on the environment and on the territories; (2) an ever-growing amount of physical exports, and an "extractivist" economic model whatever the political countenance of governments; (3) a rise in the number of reported environmental conflicts in the AC, related to the metabolic sectors with highest rates of growth. Here we have profited from the great human effort of filling in database forms (of 5 or 6 pages each with coded variables) in the EJAtlas, to which we ourselves have contributed.

Social metabolism growth in terms of material flow has taken place in absolute terms (material intensity per km^2) and also per capita. This is due in part to internal demand but it is also strongly connected to North–South relations. The transition to an energy-mining model aimed to the

[7] Since May 24, 2017 there is a new president in Ecuador: Lenín Moreno Garcés.

foreign markets (and also plantations forests and crops), produces a widening of commodity extraction frontiers towards new territories (often, with indigenous populations) and intensifies the use of the already productive grounds. There is not only international ecologically unequal exchange but also what could be described as "internal colonialism" (González Casanova 2006; Stavenhagen 1963).

Both the extractive patterns as well as environmental grievances are concomitant with the policies implemented in the AC since the 1970s, at the service of international economic growth and with a rising presence of China. This is why terms like "Extractivism" and the "Commodities Consensus" (Gudynas 2013; Svampa 2013) are increasingly used in LA green-left opposition politics. The doctrine of comparative advantages of international trade legitimizes specialization in the production of goods which use resources that abound in their territory. That supposed abundance comes at a large environmental and social cost. Thus, when the metals grade is reduced, strip mining is used. Also, when the EROI of oil diminishes (i.e., the energy cost of obtaining energy increases), extraction is displaced to highly environmentally sensitive territories of threatened ethnic populations in Amazonia. This specialization pattern entails greater ecological and social costs. This is partly evidenced with the physical deficit in the foreign trade balance. If we add now to the physical deficit the monetary deficit of the trade balance, we guess that the pressure on the environment will now increase again in the attempt to increase physical exports in order to finance imports and service the external debt. For instance, Peru is extracting more and more copper (competing with Chile), as the price of copper went down after 2012. Ecologically Unequal Exchange takes place at times of bonanza and even more in times of crisis (Hornborg 1998, 2009; Hornborg and Jorgenson 2010).

In the AC, there is evidence of an increase in environmental conflicts in four sectors: the mining sector, fossil fuel extraction, new biomass forms, and hydropower plants. Hydropower (which as we wrote in footnote 2 above is not considered, by an accounting convention, in the Material Flows), it is causing and will cause very relevant conflicts. There are 21 hydropower conflicts among the 244 conflicts of our database (2 in Bolivia including Chepete—El Bala, 10 in Colombia, 4 in Ecuador and 5 in Peru), which if all plans were finished, would provide a large capacity of about 14,000 MW. One environmental activist in this field is Ruth Buendía, an Ashaninka from Peru against the Pakitzapango dam, whose resistance was recognized with a Goldman Prize 2014.

These four sectors account for 87% of the reported environmental conflicts for the AC, and specifically in each country: 83% in Colombia, 88% in Ecuador, 94% in Peru and 88% in Bolivia, with a common trend. The rise of conflicts is mainly fostered by oil, coal, gold, copper, hydropower, oil palm, sugar cane and timber. This coincides with the metabolic–economic sectors, which grow the most and basically related directly and indirectly to the foreign market. There are some conflicts in other sectors (including waste management, with another Goldman Prize awarded to Nohra Padilla of Colombia, for her role in the urban waste recyclers' movement in Bogota).

Most environmental conflicts fit exactly into the framing "increased metabolism leads to more conflicts". Some others do not fit so well. For instance, gold mining is done not only to obtain gold as a raw material for jewellery or other industries but also to be transformed in ingots deposited in banks. Gold goes out of the earth at great socio-environmental cost and goes back to the earth. There are also other conflicts, such as tourism conflicts, that do not fit so well into the general framing. In the EJAtlas for the four AC countries we have only three tourism conflicts registered, all caused by "tourism for the (relatively) rich".

We suggest that unrest and conflict have to do with two of the elements pointed out by Merlinsky (2013): the expansion of legal tools and legal activism in the environmental field; and, the transformations within the models of collective actions.

Regarding the first aspect, the AC, driven by the World Summit held in Rio in 1992, and despite the neoliberal mood and policies of the times, widened environmental protection through a new conglomerate of laws, opening up two scenarios: (1) higher possibilities of legal and constitutional support to affected communities, for instance through the EISs; and, (2) a scenario of legal contradictions and conflicts amongst the different levels of territorial government (Merlinsky 2013). For instance, the courts would support sometimes the right of communities to previous consultations while the executive would undermine them. The existence of court decisions in favor of the weaker part of the conflicts empowers communities and intensifies environmental conflicts (Sabatini 1997). Communities which also learn to use new international legal instruments, such as the ILO Convention 169 for indigenous communities, and the protection of human rights by the CIDH.

Changes in civil society and government in the last decades in the AC transformed the models of collective action. New citizen and environmental movements led by social actors with a high degree of autonomy in relation to the State and the market appeared in the 1980s and 1990s (such as CENSAT in Colombia, CONACAMI for some time in Peru, CEDIB in Bolivia, Acción Ecológica in Ecuador) and their "activist knowledge" on environmental conflicts became available to researchers. These organizations themselves produced numerous reports. Besides NGO

(or EJOs, environmental justice organizations) with international links, there are also grassroots political and social actors such as environmentalists, women groups, religious groups, local scientists, indigenous peoples, afro communities, sometimes connected with global environmental justice movements. They raise a variety of issues such as the validity of the companies' experts technical knowledge, the rights of nature, the territorial exclusions, and race and gender discriminations (Albuquerque 2004). There is also repression, with many dead "environmental defenders" as pointed out by the Global Witness organization and also collected by EJAtlas; as well as government administrative onslaughts (as in Bolivia and Ecuador) against civil society organizations such as CEDIB or Acción Ecológica threatened with "dissolution".

Such a variety of new actors and social movements, strengthened by alliances, become important agents against the growth and changes in the social metabolism. They promote sustainability even when not using the term. In particular, ethnic and rural communities play a significant role in conservation from below, given that their cultural values often conceive nature and human beings as one. That is why when the environment is damaged, not only their livelihood is damaged but also their territory, their culture and their traditions are also directly damaged. In that sense, social movements generated from the quest for environmental justice are a new force simultaneously promoting socio-environmental sustainability and equity.

Conclusions

There has been a large growth of the social metabolism (the flows of energy and materials) in the economies of the Andean countries. This growth goes together with economic growth (driven to a large extent by the export sector), and has caused structural changes of the metabolic profiles of these countries towards the abiotic sector. Such changes have come together with pro-extractivist policies applied in the region during the period of analysis, which at the same time depend on worldwide political and economic structures, which determine the areas of economic specialization across the world. In other words, comparative advantages and specialization processes are of a historical character, they do not 'exist' by themselves as 'natural' events which emerge from ecological and social 'nature' of a region, but instead they are politically constructed and later on 'naturalized' in economic thought as if they were unavoidable. In short, they are the result of political decisions, forced by means of investment and tax policies, property rights and power relations strategies.

Environmental damage and exhaustion of resources are as a rule excluded from economic (chrematistic) accounting. Nevertheless, large environmental impacts and conflicts are generated due to the extractive model regarding the use of land, water and other natural resources. In this sense, even if the market and states politics deny the existence of socio-environmental liabilities (or ecological debts), the social metabolism growth causes social conflicts. Such conflicts are generated between old and new entrepreneurial actors and the local communities or neighborhoods, which have a different way to relate with nature and amongst each other. For example, Chinese companies start to emerge in the conflicts of the last years. The conflicts over extractive activities (and also sometimes over waste disposal) frequently coincide with the presence of disadvantaged ethnic or peasant communities and/or what García Canclini (1990) denominates "hybrid cultures", which largely depend upon environmental services provided by nature, cultures which generally do not rely on active government policies and have little institutional support. There is an attempt to exclude communities from the use and enjoyment of natural resources and environmental services on which such communities subsist, affecting their customs and livelihoods, their social networks, their cultural structures and their customary rights in regards to the common goods on which they highly depend on, giving rise to dispossession of water, land, communal territories and biodiversity in general. Most of the 244 ecological distribution conflicts in our database belong into such a description.

Finally, both the metabolic dynamics as well as the conflicts, show that the AC governments are at a crossroads. On the one hand, policies in accordance with the worldwide prevailing model, bet on a pattern based on intensive nature-use sectors aimed at the foreign markets. This has been the case for both neoliberal and progressive governments. On the other hand, communities and social movements aim to satisfactory lives with socio-environmental justice and sustainability. The way out of this crossroads will depend on politics; in our view, sustainability and equity is more likely to be achieved by social mobilization and the strengthening of many hegemony-resisting networks, than by agendas promoted by international organisms, the State and local economic powers. This is because decisions promoted by the "mainstream approach" are guided by the belief in static comparative advantages, which drive productive specialization toward the primary sector. This implies a less sustainable and more environmentally conflicting path. A more strategic and concerted approach shows us that, the agendas of eco-efficiency and "dematerialization" of the economy would get additional force from an alliance with grassroots resistance and the movement for environmental justice.

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