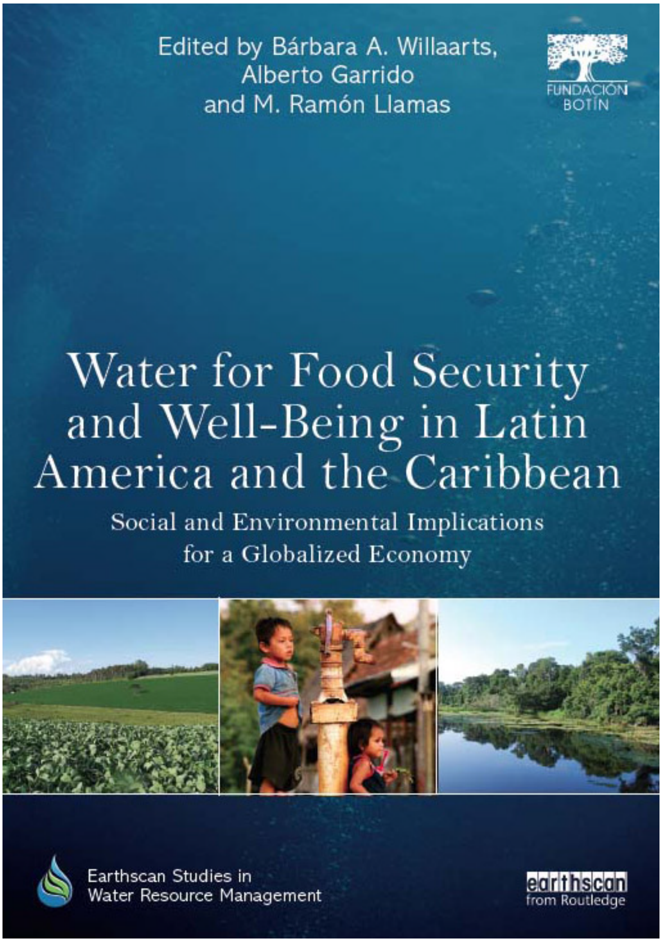

Chapter 3

Trends in land use and ecosystem services in Latin America

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3

TRENDS IN LAND USE AND ECOSYSTEM SERVICES

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Highlights

- The land used for agricultural production in Latin America and the Caribbean (LAC) comprises 26% of its total surface area: 10% for crops and 16% for livestock grazing. This share still remains below the global average land appropriation (38%).
- Between 1990 and 2010 LAC lost approximately 92 million hectares of forests, becoming the second most important deforestation hotspot worldwide, only preceded by Southeast Asia. Some 88% of this forest loss has occurred in South America and 12% in Mesoamerica. Brazil alone accounts for 60% of LAC's deforestation. In the Caribbean forest area has increased.
- Agriculture is the major driver of deforestation in LAC. In South America the cultivation of agricultural commodities, mostly oilseeds and grains, underpin much of the ongoing deforestation together with the sharp expansion of the livestock sector. In Mesoamerica, the low agricultural productivity keeps pushing the agricultural frontier in order to overcome national food in security problems.
- LAC has outstanding natural capital and contributes to the provision of multiple ecosystem services on a wide range of scales. Yet, land use changes are a major driver of ecosystem services loss even above climate change.
- The deep transformations that have occurred in LAC over the last two decades have had important impacts on the provision of key ecosystem services. Regulating services such as carbon sequestration and biodiversity conservation have experienced the largest impacts, with an average loss of 9%. Also, native agro-diversity has shrunk almost 6%. Cultural services like ecotourism has grown over 150% and provisioning services like forestry and water provision have also increased (35% and 6%, respectively).
- Deforestation rates are slowing down. Yet, the growth of agriculture in LAC is increasingly being decoupled from expanding the agricultural frontier and more based on increases in agricultural yields.
- To cope with the increasing world food demand while ensuring the conservation of LAC's natural capital and ecosystem services, it is necessary to develop integrated land use approaches, including agricultural oriented measures (e.g. land sparing and land sharing) and conservation initiatives (e.g. Reducing Emissions from Deforestation and Forest Degradation- REDD+).

3.1 Introduction

Latin America and the Caribbean region (LAC) is currently facing a daunting challenge: producing food, fibre, and fuel to satisfy an increasing internal and international demand and at the same time preserve its outstanding natural capital and related ecosystem services (ES) (Martinelli, 2012). Compared to other regions, LAC has a major advantage to achieve this double goal due to its rich natural endowment in terms of land, water and its low population density.

Ongoing pressure on LAC natural resources is linked to internal development but also to economic globalization, population growth and principally changing diets throughout the world. FAO (2009) estimates that by 2050 agricultural production will need to double in order to satisfy the increasing world food and biofuel demand. This future demand can partly be met by intensifying existing agricultural land and improving resource use efficiency (e.g. bridging the yield gap, the development of genetically modified crops-GMOs, etc.), however, most experts agree that between 50 and 450 million hectares of additional agricultural land will also be required (FAO, 2009; Fisher et al., 2009; Lambin and Meyfroidt, 2011). This additional land demand is most likely to be absorbed by developing countries that have the greatest land availability, primarily sub-Saharan Africa and LAC (Smith et al., 2010).

Food and fibre are key provisioning ES to LAC as they provide important benefits which are contributing to overcome local and global food insecurity gaps and at the same time allow for regional economic development. By 2011 annual gross revenues of LAC's agriculture accounted for over 120,000 million US$ (FAO, 2013), and generated approximately 18% of the employment (World Bank, 2013). In some of the major agricultural producing countries, like Brazil, agro-industry accounted for 22% of the national GDP in 2011 (CEPEA, 2013). A large part of this agricultural market expansion is taking place at the expenses of replacing natural ecosystems, mostly tropical savannahs and forests. The ecosystem productivity of these tropical forests ranks among the highest in the world due to their extension and quality, particularly along the Amazon basin and much of Central America (Pfister et al., 2011). Their replacement entails important trade-offs for the provision of other key non-market ES, like carbon sequestration, pollination, water flow regulation or biodiversity conservation. Balancing these ES trade-offs are key to LAC but also globally since the Amazon tropical forests play a key role in the global carbon and water cycle (Rockström et al., 2009; Gloor et al., 2012).

Despite the pressure, significant improvements in agricultural production have been achieved in many LAC countries, in an attempt to increase efficiency, decouple production from water and land resource consumption and thus minimize existing ES trade-offs. Efforts in this direction are critical since deforestation, as opposed to climate change, causes abrupt changes in ecosystems, limiting and often precluding opportunities for adaptation.

Accordingly, this chapter aims to explore: 1) what major changes in land use have occurred in LAC during the last two decades of significant economic changes; 2) what are the drivers behind these land changes; 3) how are those changes influencing the flow of ES across the region; and 4) what policy options are in place to safeguard LAC's natural capital while contributing to global food security.

3.2 What have been the main land use trends over the last decades?

As Chapters 4 and 5 describe, LAC has experienced significant changes over the last decades as a result of its great economic acceleration and the strong development of its agricultural sector. This growth has been accompanied by the expansion of LAC's agricultural area by almost 57 million hectares (see Figure 3.1). Such increase is related to the expansion of pastures for livestock production and arable land. Likewise, shrublands and secondary forests have also experienced an important area increase (≈ +27 million hectares). Much of these land uses have grown at the expense of replacing natural meadows and even more notably, natural forests, which have shrunk 92 million hectares, an area equivalent to the size of Venezuela. This forest reduction represents 46% of the total forest losses occurred in the southern hemisphere over the last two decades (FAO, 2010; Rademaekers et al., 2010), demonstrating that LAC, and particularly South America, is one of the most important global deforestation hotspots.

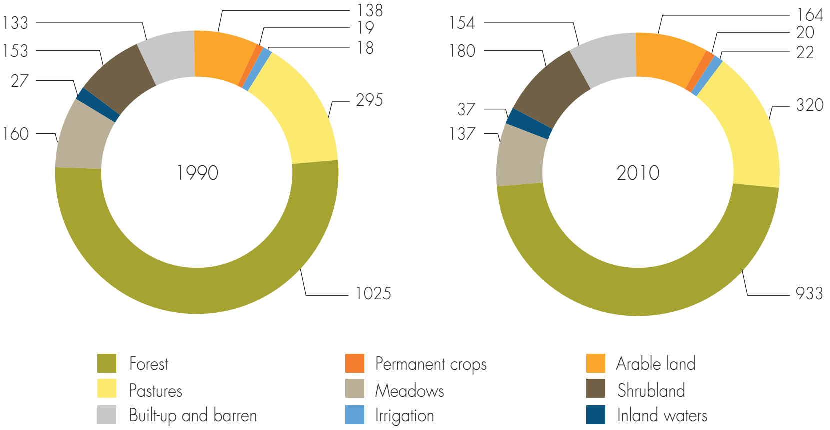

Figure 3.1 Land uses in Latin America and the Caribbean (LAC) in 1990 and 2010 (in million hectares). *Source: own elaboration based on FAO (2013)*

Within LAC, the most important deforestation hotspots are located in Brazil and to a lesser extent in Venezuela, Bolivia and Argentina (Table 3.1). Since 1990, Brazil alone has lost over 55 million hectares, although the rates of deforestation have slowed down significantly over the last years. According to the National Institute for Space Research (INPE) deforestation rates in the Brazilian Legal Amazon have diminished from about 2.9 million hectares per year in 2004 to 0.47million hectares per year in 2012

(INPE, 2012). Deforestation rates in other Brazilian biomes (e.g. Cerrado, the Brazilian savannah) remain high, but overall it is patent the progressive regression of deforestation on a national level. This slow down in forest cover loss has not been observed yet in Venezuela, Bolivia and Ecuador, where deforestation rates have remained stable or even increased in the last years. In Mesoamerica, the largest forest losses have occurred in Mexico, Honduras, Nicaragua and Guatemala. In the Caribbean region the trend points into a different direction, since forest area has increased over 10,300 hectares between 2000 and 2010 (FAO, 2010).

Table 3.1 Deforestation rates across Latin America between 1990 and 2010. Figures have been rouded to the nearest decimal.

	ANNUAL RATE OF DEFORESTATION (million ha/yr)			TOTAL DEFORESTATION (million ha)
COUNTRY	1990–2000	2000–2005	2005–2010	1990–2010
BRAZIL	2.9	3.1	2.2	55.3
VENEZUELA	0.3	0.3	0.3	5.8
BOLIVIA	0.3	0.3	0.3	5.6
ARGENTINA	0.3	0.3	0.2	5.4
ECUADOR	0.2	0.2	0.2	4.0
PARAGUAY	0.12	0.2	0.2	3.6
PERU	0.1	0.1	0.2	2.2
COLOMBIA	0.1	0.1	0.1	2.0
MEXICO	3.5	1.2	0.8	5.5
HONDURAS	1.7	0.6	0.6	2.9
NICARAGUA	0.7	0.4	0.4	1.4
GUATEMALA	0.5	0.3	0.3	1.1

Source: FAO (2010)

Figure 3.2 shows the prevailing land use trends across LAC's territory since the 90s.[1] Overall, LAC's territory has been very dynamic during the last two decades, with 40% of the territory (over 900 million hectares) experiencing either a change in land use or in land cover. This dynamism is the result of two major trends: (1) a pronounced reduction of the forest cover, either due to large-scale deforestation for cultivation or through small to

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[1] The land use trends have been obtained from the land use transition matrix created by combining the 1993 Global Land cover (USGS 2008) and the 2009 Glob Cover Map (ESA 2010) for LAC. Map sources have different spatial resolutions and legends, therefore figures on land use trends need to be considered as a first gross approximation to the real size of ongoing land use trends in LAC.

medium-scale forest clearing for cattle, mining and subsistence agriculture; and (2) a less pronounced but growing trend of reforestation, which combines processes of secondary natural succession, human-induced afforestation and woody encroachment on previous cultivated areas.

Deforestation and expansion of the agricultural frontier has been the dominant trend in LAC in the last two decades (Figure 3.2). The greatest expansion of pastures and arable land has occurred in South America, mostly in Brazil, Argentina and Paraguay. In Mesoamerica, countries like Nicaragua, Honduras, Panama and Guatemala have also seen an increase of their agricultural area, mostly arable land but also permanent pastures for grazing.

Although less intensive, the progressive trend of forest degradation observed in many parts of the region is still important. This can be seen along the northern part of Mexico, in the region of Los Llanos in Venezuela, northwest of Colombia, the Amazonian belt in Brazil, and along much of the Andean region of Peru, Ecuador and Colombia. This trend of forest degradation comes from the clearing of natural forest and shrubs to be turned into pastures. The underlying reasons of this trend might be diverse but some common causes include the extended practice of slash and burn agriculture, extensive livestock grazing, gold mining, illegal logging and crop plantation.

Despite this reduction in LAC's forest area, symptoms of forest recovery, the so-called 'forest transitions' (Mather, 1992), are emerging in some areas. The clearest example of this forest transition is the emergence of new forests on previously cultivated areas or pastures. These new forests are either naturally regenerated or planted (afforested). Such trend is widespread in the southeast and northeast of Brazil and across various areas of northern Mexico (Figure 3.2). Another important reforestation trend is the development of new shrub areas in previously cultivated or grazed areas. The development of this woody vegetation is a natural ecological response to the abandonment of agriculture or grazing activities. In grasslands the ceasing of agriculture normally ends with the encroachment of shrubs, whereas in forest areas, the appearance of this woody vegetation could represent an early successional stage of forest regeneration. Across LAC, this shrub encroachment has mostly occurred in the central-north region of Brazil and in the Argentinean Pampa. These processes of forest recovery largely overlap with the reforestation hotspots identified by Aide et al. (2012), although the size of the reforestation trends seem to be greater in our study. Differences in methodologies, scales and data sources might explain the divergences found across both studies, highlighting the need for further investigation and the difficulties in providing precise figures. Overall, according to our analysis, reforestation in all its forms i.e. through forest natural succession, afforestation, or woody development represents at least 20% of the current forest area in LAC. The extent to which these new 'secondary' forests have or fulfil the same ecological processes as those of primary forests remains unclear and needs further investigation (Lambin and Meyfroidt, 2011).

Grau and Aide (2008) argue that a main driver underpinning reforestation in LAC is related to the industrialization of agriculture, which has contributed to the concentration of production to the most fertile areas, while marginal agriculture has progressively been abandoned, leading to ecosystem recovery. In addition to the changes in the agricultural production system, the strong rural–urban migration flow together with the implementation of conservation policies in many rural areas (*ibid.*) has also favoured forest regeneration. Such evolution of the land use pattern, in which agricultural areas have become highly intensified on the most fertile or suitable lands, and natural areas tend to stand along the slopes or less accessible zones, resembles the land use path followed by other regions such as Europe. Box 3.1 summarizes the complexity of the factors underlying forest transitions and reforestation processes in southeast Brazil.

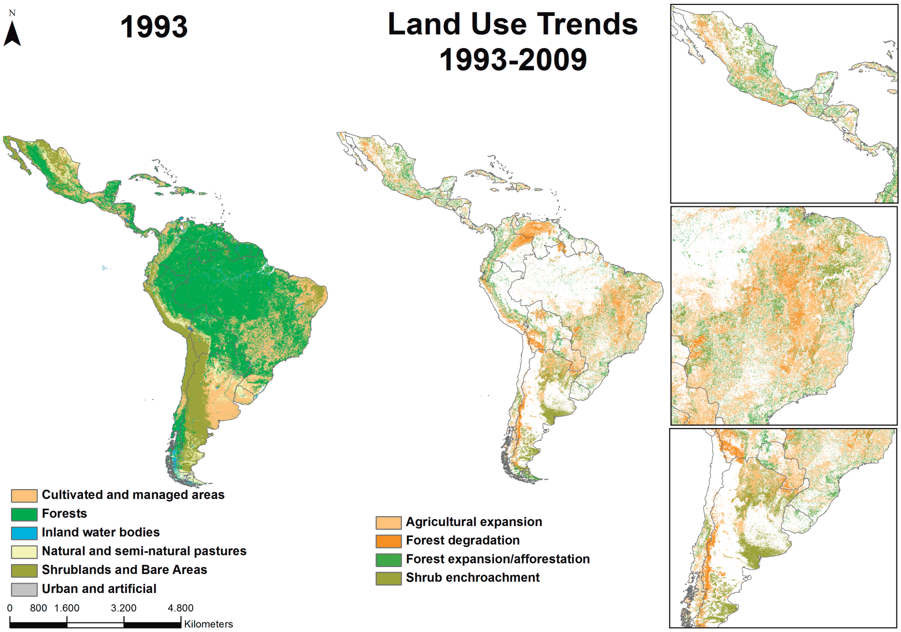

Figure 3.2 Land use and land cover changes occurred in Latin America and the Caribbean between 1993 and 2009. *Source: own elaboration based on 1993 Global Land cover (USGS, 2008) and the 2009 Glob Cover Map (ESA, 2010)*

Overall, agricultural expansion is the predominant land use trend in LAC, although deforestation rates seem to be slowing down and in some cases even reversing. As described in Chapters 1, 5 and 7, the growth of the agricultural sector in LAC is largely related to a growing internal demand for food and energy and ongoing dietary shifts, but is also driven by the rising international demand for oilseeds and cereal grains. To understand past, but foremost, future land use decisions in LAC and develop possible solutions for curbing deforestation and environmental degradation, it is crucial to understand the drivers underpinning the increasing need for agricultural land in this part of the world.

Box 3.1 Drivers of forest transition: theory and practice in São Paulo, southeastern Brazil

Forest transitions – the change in land use characteristics from a period of constant reduction of forest cover to a period of net forest increase – have diverse drivers, including a variety of socio-economic, cultural and political factors. In the last decades some 'pathways' have been proposed to explain the processes and factors behind observed forest recovery across countries (see e.g. Rudel et al., 2005; Lambin and Meyfroidt, 2010). The most common argument is the so-called 'economic development' pathway: economic development associated with industrialization, urbanization, and land use intensification results in agricultural land abandonment and reforestation through secondary succession or tree planting. Also, forest transition would occur when a lack of forest products prompts governments and landowners to plant trees – the 'forest scarcity' pathway (Rudel et al., 2005).

Much of the research conducted in LAC countries like Argentina (Grau and Aide, 2008), Brazil (Perz and Skole, 2003; Baptista, 2008; Walker, 2012), El Salvador (Hecht et al., 2006), and Mexico (Klooster, 2003; Bray and Klepeis, 2005), raised doubts about the broad applicability of forest transition models based on economic development or forest scarcity, emphasizing the importance of a variety of factors linked in a complex network of institutional, social, biological, cultural and physical interactions. In this sense, Lambin and Meyfroidt (2010) proposed the 'globalization', the 'state forest policies' and the 'smallholder, tree-based land use intensification' pathways, which offer more refined explanations of processes involved in forest transitions.

In Brazil, although deforestation rates are greater than forest recovery, forest increase seems to be occurring in some regions. In São Paulo, a southeastern state, evidence suggests that a forest transition took place in the 1990s at the state level, which coincides with a period of overall economic growth in the country (Farinaci and Batistella, 2012) (see Figure 3.3).

Considering only a broad scale, it would be reasonable to explain the forest transition in São Paulo in terms of the 'economic development' pathway, as the state became increasingly urbanized, industrialized and wealthy. However, analysing the processes occurring on a smaller spatial scale, Farinaci (2012) concluded that the transitions observed in municipalities in eastern São Paulo were more influenced by crises and economic stagnation in late 1980s and 1990s – a period in which sustainable development became part of the political discourse in different sectors of society – than by the acceleration of economic growth during the 2000s. Moreover, at the intra-municipality level, forest recovery was not driven by local economic development or agricultural adjustment, but rather by the failure of production systems to ensure the livelihoods of rural population. In São Luiz do Paraitinga, which exemplifies changes occurring in rural areas in eastern São Paulo over the last few decades, the decline of dairy farming was the most important factor influencing recovery of native forest,

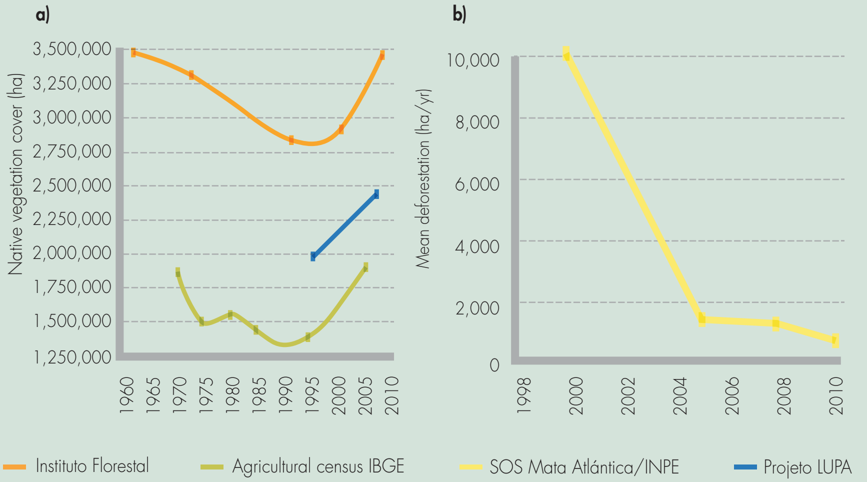

Figure 3.3 Evidence of forest transition in São Paulo State (Brazil) according to four different data sources. *(a) Temporal variation on native vegetation cover (b) Deforestation rates between 2000 and 2010 (annual mean values for each period) - (Sources: Kronka et al., 1993, 2005; SIFESP, 2010; Fundação SOS Mata Atlântica and INPE, 2008, 2009, 2010; IBGE (2009); SAA, CATI and IEA (2009).*

predominantly via secondary succession. Modernization of the dairy sector, shortage of rural jobs, lack of public investment on rural infrastructure, and competition with other regions contributed to a decline in dairy farming. Moreover a reduction in soil fertility and rugged relief restricted the possibilities for alternative land uses. Concurrently, an increasing number of people who are willing to purchase land for second residences or tourism activities, often motivated by conservation values, favoured forest recovery. In addition, laws restricting tree cutting and hunting, improvement of fire monitoring systems, and protected areas were important prompters of forest conservation and reforestation. When smaller-scale processes are considered, and put into socio-economic, political and cultural contexts, it is clear that the 'globalization' pathway in association with the 'state forest policies' pathway, as proposed by Lambin and Meyfroidt (2010), provide more comprehensive explanations of the processes leading to forest transitions as observed by Farinaci (2012) in São Paulo.

3.3 What are the drivers of the observed deforestation trends?

Deforestation and land appropriation is an ancient and constant process throughout human history, although driving forces have evolved over time. Around the tropics, deforestation between the 1970s and the early 1990s was largely 'state-driven' to promote rural development (Rudel, 2007). Government policies varied from region to region, but generally provided incentives for the colonization of remote forests, such as cheap land, and investments in infrastructure (e.g., road building) in order to foster the development process. In the case of LAC, since the 1990s different structural adjustment programmes endorsed by the World Bank, International Monetary Fund (IMF) and other international donors favoured the development of trade liberalization policies. Ever since then, deforestation in LAC has been primarily 'enterprise-driven', particularly by large multinationals (Rudel, 2007). Yet, governments still contribute to these efforts indirectly, e.g. through tax incentives for businesses to settle and also by developing infrastructures, which facilitate and speed up the transportation of goods and natural resources to the nearest harbours (Rudel et al., 2009; DeFries et al., 2010). Tree felling, agricultural industrialization, trade, mining and biofuel are the dominant drivers of current deforestation in many tropical countries (Butler and Laurance, 2008).

Figure 3.4 summarizes some of the main drivers explaining ongoing deforestation trends in LAC.[2] Economic globalization (Factor 1), and particularly the specialization of LAC's economies in the exportation of agricultural commodities (e.g. cereals and oilseeds), explains approximately 21% of the observed forest losses in LAC between 1990 and 2010. This factor is the underlying reason for most of the deforestation in South American countries like Brazil, Bolivia, Argentina, Ecuador and Paraguay. Despite the migration of rural population to the cities, the ongoing efforts to increase the area under protection and the yield improvements, deforestation in these countries has not halted. Whether deforestation is likely to continue in LAC is very much linked to the major drivers underpinning the expansion of agriculture (e.g. international food and biofuel demand, agricultural specialization) and undoubtedly the set of policy instruments and economic incentives (e.g. increases in agricultural productivity, Reduced Emissions from Deforestation and Forest Degradation – REDD+) that may be put in place to reverse deforestation and promote a greener economy. According to FAO (2010), Brazil is responsible for almost 60% of current LAC deforestation, therefore this country is called on to play a key role in this respect, and more recent data suggests that government measures are starting to be effective (Table 3.1).

Nevertheless, the globalization of LAC's economies does not always lead to deforestation. In fact those countries with a high GDP per capita, high agricultural productivity, greater agricultural investments (e.g. in machinery) and with a powerful forestry sector (e.g. Chile or Uruguay) have experienced a net forest area increase despite their strong exporting policies. The extent to which these new secondary forests provide an equivalent flow of ES as the native ones requires further investigation as was mentioned previously.

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[2] To assess the factors underpinning ongoing land use trends in LAC we conducted a multivariate factor analysis (FA) by combining information from twenty-four different socio-economic variables. All variables represent national values for the time period 1990–2010.

Another critical factor of LAC deforestation beyond globalization is the high reliance of many countries on a primary-based economy (see Figure 3.4. Factor 2). High rates of deforestation overlap with countries where agriculture and mining represent a large percentage of their GDP. This factor could explain much of the deforestation observed in Mesoamerican countries like Guatemala, Honduras or Nicaragua, where around 23% of their national GDP is linked to agriculture. These countries have low yields and are mostly land stressed, i.e. they have a low land per capita availability and over 67% of the actual agricultural area is used to produce staples like maize, beans and export crops like coffee. Deforestation in these countries is probably less related to the growth of agricultural exports, and more influenced by the expansion of agriculture to overcome food insecurity problems. The development of the mining industry, mostly in South American countries like Brazil, Peru, Colombia and Ecuador, also appears to be influencing deforestation. Likewise, the development of the livestock sector is an important driver of tropical deforestation. The majority of cattle in LAC is produced extensively in pastures, making the growth of this sector highly dependent on land availability. Since 1990 livestock production has increased 21% in the Caribbean, 44% in South America and 53% in Mesoamerica (FAO, 2012). The value of livestock products in two decades has increased by almost 10,000 million US$ in Mesoamerica and up to 32,000 million US$ in South America (World Bank, 2013). In the Caribbean region, the predominance of a service-oriented economy largely relying on fuel exports and tourism has contributed to preserve and even augment the forest area.

Nevertheless, and despite the importance of the two drivers mentioned above, agricultural expansion and forest area change are also influenced by many other socio-political and legal aspects. For instance, in Colombia much of the reforestation observed between 2001 and 2010 (about 1.7 million hectares) is due to the coca crops eradication programmes enforced by the government (Sánchez-Cuervo et al., 2012). Land tenure and undefined property rights may also be a driver on land use change and its influence will depend on site specific socio-economic dimensions. In Mexico, Bonilla-Moheno et al. (2013) show that the private-common-pool dichotomy was not the dominant explanatory dimension for deforestation; since the greatest differences occurred between types of common-pool systems. Physical variables like altitudinal differences, usually not included in most models of deforestation, can also play an important role in identifying intraregional drivers. One example can be seen in the differences between lowland and montane forest cover changes in Colombia, due in part to the accessibility of forests and differences in wealth and economic activities (Armenteras et al., 2010). The energy sector (e.g. dam construction) is most likely to be an important driver of actual deforestation but no data was found to include this variable in the assessment. All these factors need to be jointly considered in order to identify sustainable land use options at the local level and hence providing opportunities for development and the minimization of environmental trade-offs.

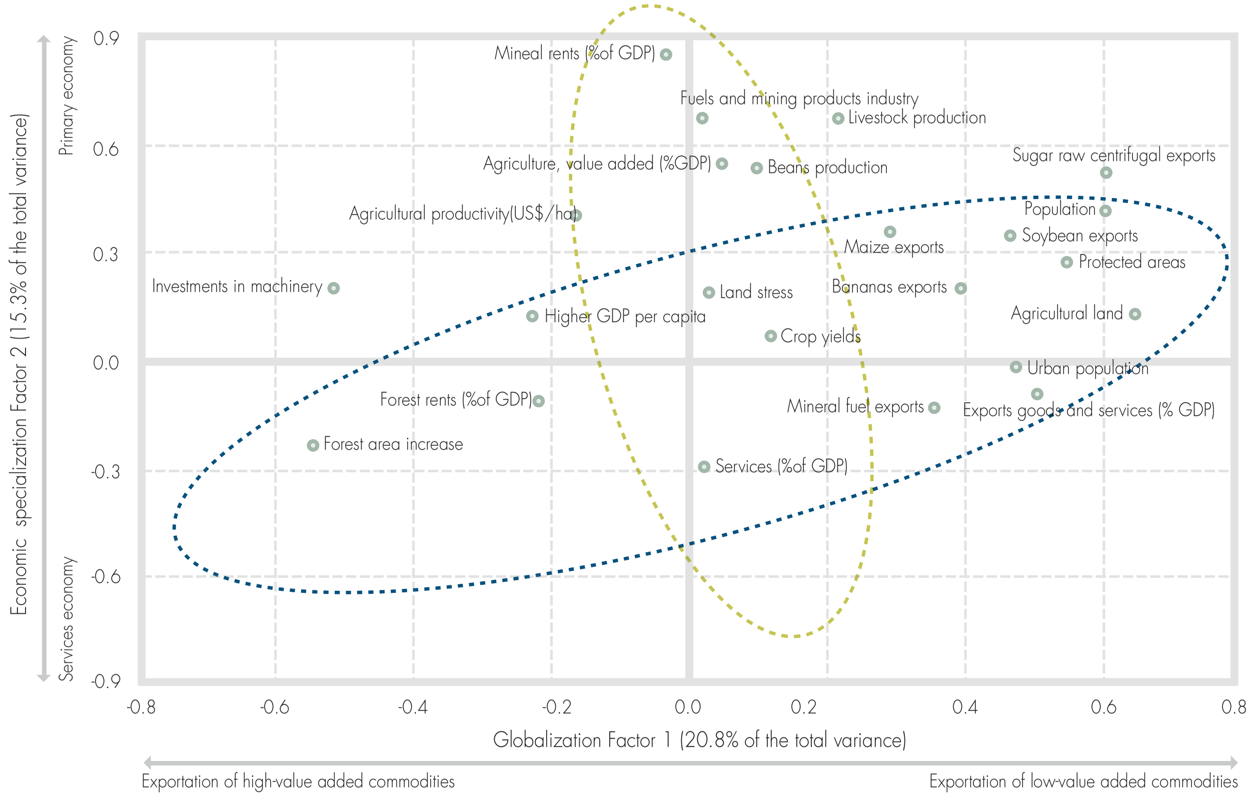

Figure 3.4 Factor analysis explaining drivers of forest area change in Latin America and the Caribbean between 1990 and 2010. Factors I and II explain the percentage of total variance. Variables' values represent the correlation with the two factors. *Source: own elaboration based on FAO (2012) and World Bank (2013)*

3.4 Impacts of land use changes on ecosystem services

The observed changes in land use in LAC have deep implications for the provision of ES. Yet knowledge of the performance of ES in LAC is sparse across countries but overall significant (Balvanera et al., 2012). Much of the existing knowledge on ES is primarily focused on provisioning services, e.g. timber production and freshwater provisioning and regulating services such as water flow regulation or carbon sequestration (*ibid.*). However, less knowledge is available on other key ES, e.g. pollination and pest regulation. Figure 3.5 summarizes the quantification of six ES at the national scale and their trends between 1990 and 2010.

3.4.1 Carbon sequestration

Carbon (C) stocks vary depending on the type of biome and the management practices. Across LAC, the largest aboveground C pools are found in the native tropical forests of Brazil, Peru, Colombia, Venezuela and Bolivia (FAO, 2010). Together these countries store 87,280MtC (million tons of carbon); around 84% of the total aboveground C stock of LAC. The importance of these stocks is related to the extension of their tropical forests but also to the average C content per hectare (>105t/ha), which is above the LAC average.

Between 1990 and 2010 approximately 8,600t C have been lost which is equivalent to 10% of LAC's total C stock. Some 80% of these C emissions have occurred in the aforementioned countries (Brazil, Peru, Colombia, Venezuela and Bolivia). Nowadays land use changes, and particularly deforestation, is the most important source of green house gas emissions (GHG) across most LAC countries, and therefore represents a major driver of climate change (see Figure 3.6). Among some of the most important initiatives currently under negotiation to halt deforestation and mitigate climate change in LAC is through the Reducing Emissions from Deforestation and Forest Degradation (REDD+) (see Box 3.2).

Box 3.2 Enhancing forest conservation through Reducing Emissions from Deforestation and Forest Degradation (REDD+)

Since the end of 2006 negotiations have been held under the United Nations Framework Convention on Climate Change (UNFCCC) to support developing countries in reducing greenhouse gas emissions (GHG) and enhancing forest carbon sinks as a key mitigation strategy. Initially only emission reductions from deforestation and forest degradation were considered, the so-called REDD strategy. But soon given the different national circumstances and the position on the forest transition curve (Perz, 2007a and b) of tropical developing countries, in addition to reducing emissions from deforestation and degradation, the negotiations expanded to further include the conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks. This wider scope was agreed upon to allow broad non-Annex I parties (mostly developing countries), based on differing national circumstances, and was renamed REDD+. This climate change solution for developing countries has been endorsed by different initiatives (e.g. the UN-REDD programme, the Forest Carbon Partnership Facility (FCPF) and the Forest Investment Program (FIP), hosted by the World Bank). Currently the UN-REDD programme supports different activities in forty-six countries, including Bolivia, Panama and Ecuador.

Negotiations relating to REDD+ can be traced back to the 11th session of the UNFCCC Conference of Parties (COP) in Montreal (2005), where it was raised as an agenda item that later initiated a two-year process under the UNFCCC's Subsidiary Body for Scientific and Technological Advice (SBSTA), including several technical workshops on the issue. This lead to the introduction of REDD+ as part of the Bali Action Plan at COP13 in 2007, as Decision 2/CP.13, that also provided some early methodological guidance. At COP 15 (Copenhagen in 2009), several principles and methodological guidelines were defined further (Decision 4/CP.15). Parties at COP16 (held in Cancun, 2010), adopted Decision 1/CP.16, section C, defined guidance and safeguards, the need of a phase approach and the five activities under REDD+ in its paragraph 70 by saying: 'Encourages developing country Parties to contribute to mitigation actions in the forest sector by undertaking the following activities, as deemed appropriate by each Party and in accordance with their respective capabilities and national circumstances: Reducing emissions from deforestation; Reducing emissions from forest degradation; Conservation of forest carbon stocks; Sustainable management of forests; Enhancement of forest carbon stocks.'

Since the Bali Action Plan (2007) put forest in the UNFCCC agenda, there is not one single understanding of REDD+ and even greater diversity of views on how best to slow or halt deforestation, but there is a wide recognition of the complexity and that progress is being made in understanding diversity and the importance of national circumstances and drivers of the deforestation and forest degradation. For example, some view REDD+ strictly as a mechanism that provides financial payments for verified emission reductions while for others it is a broader suite of actions and incentives that, when combined, reduce emissions from deforestation and forest degradation.

In light of the new challenges, the lessons learnt during the past three years and the recent discussion at COP18 in Doha, it seems several pathways may be considered for the financing of REDD+ activities and allow countries to adopt alternative development pathways in which deforestation is reduced by tailoring the measures to their needs and national circumstances. However, when creating a forest protection climate agreement, which includes international incentives, it is important to note that if markets have to be considered, deeper commitments from major emitters, with their large mitigation potential, would be required if they need to be environmentally acceptable or politically palatable.

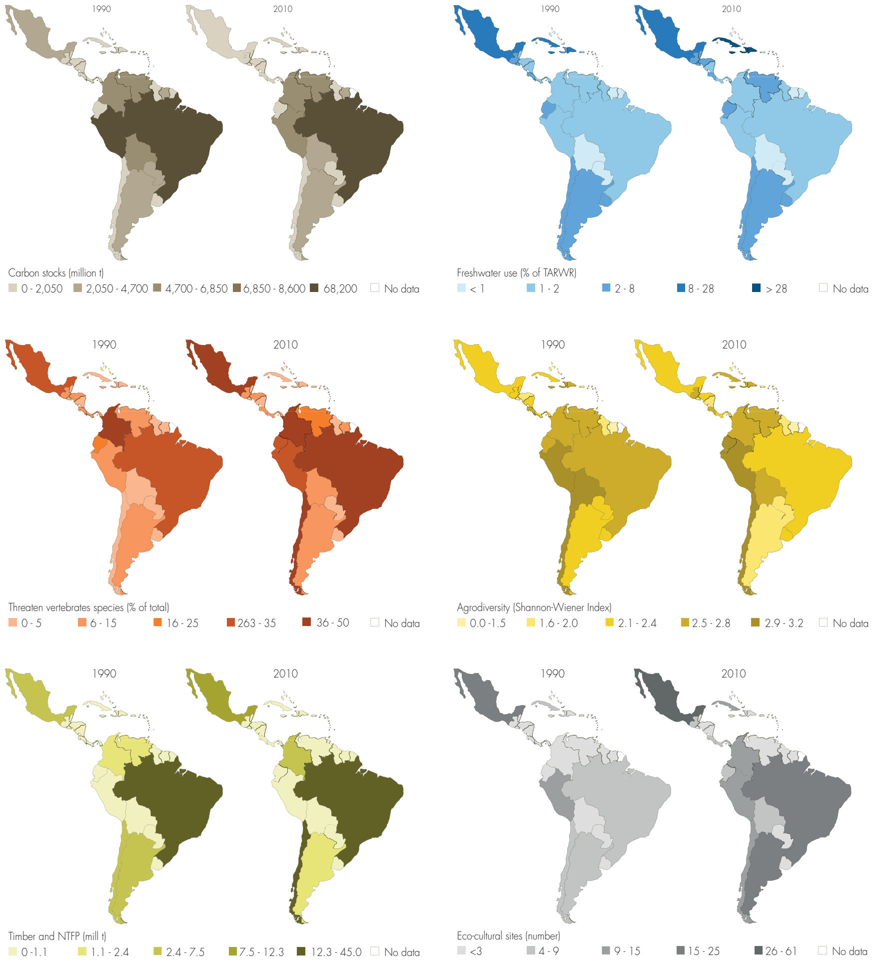

Figure 3.5 Trends in Ecosystem Service provision in Latin America and the Caribbean between 1990 and 2010. *Data and indicators to measure the ES performance are as follows. Carbon sequestration was measured using data on aerial carbon pools obtained from the Global Forest Resource Assessment (FRA) performed by FAO (2010) and the indicator used accounts for the total amount of carbon stored aboveground. Soil carbon stocks are not considered here. Freshwater use data was obtained from FAO (2013) and refers to the % of total actual renewable water resources (TARWR) withdrawals for human uses. Biodiversity data was obtained from the Red-list database of the International Union for Nature Conservation (IUCN, 2013). In order to account for the LAC's agro-diversity, we used the Shannon-Wiener index to measure the variety of crops grown in each country and the relative importance of each one (in terms of area dedicated to its cultivation) during two time periods (1990–2000 and 2000–2010). Timber and non-timber forest products (NTFP) data was obtained from FAO (2010) and the number of ecosites represents the sum of World Heritage Sites (WHS) and Biosphere Reserves (BR) by country and was obtained from UNESCO (2013).*

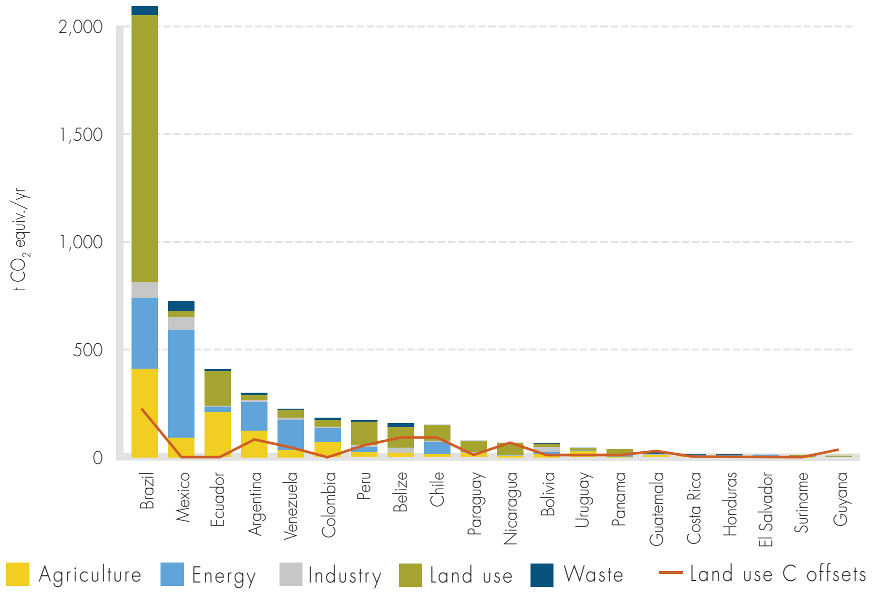

Figure 3.6 Greenhouse Gas Emissions (GHG) by sector in LAC countries. *Source: own elaboration UNFCCC (2013)*

3.4.2 Freshwater use

LAC is an extremely well-endowed region in terms of blue water availability. As described in Chapters 2 and 6, this region holds one-third of the global renewable blue water resources and the average blue water availability per capita for the whole region exceeds the 30,000m^3/cap/yr (FAO, 2013). Over the last few decades water withdrawals have increased, both as a result of endogenous factors such as irrigation development, population growth and urbanization and as a result of exogenous factors such as the globalization of LAC's economies and the increase in exports of agricultural virtual water trade (see Chapter 7).

Freshwater abstractions in LAC have increased nearly 5% between 1990 and 2010, from 277 million cubic metres in 1990 up to 290 in 2010 (FAO, 2013). Such increase implies that 5% of the total actual renewable water resources (TARWR)[3] of LAC is extracted for human uses (Figure 3.5). Only in Mexico, Cuba or Dominican Republic water extractions surpass 15% of the national TARWR. Despite these positive figures, regional water scarcity problems exist in countries like Mexico, Chile, Argentina or Brazil where at least 13% of the population lives in water-scarce basins (see Table 6.3, Chapter 6). Also, as Chapter 6 also outlines, in the majority of countries, pollution rather than over-abstractions represents a greater threat for maintaining this provisioning ES in the medium and long run.

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[3] TARWR stands for total annual renewable water resources

3.4.3 Biodiversity conservation

LAC is home to seven out of twenty-five world biodiversity hotspots for Conservation Priority (IUCN, 2013). Mega-diverse countries such as Brazil, Colombia, Ecuador, Mexico, Venezuela and Peru alone cover less than 10% of the world's terrestrial surface but contain approximately 70% of the world's mammals, birds, reptiles, amphibians, plants and insects (*ibid.*). Yet 11% of the total number of vertebrate species identified in LAC are threatened (IUCN, 2013) as shown in Figure 3.5. Yet the countries with the largest ratio of threatened species are: Chile (50%), Brazil (43%), Colombia (42%) and Mexico (41%). Countries with ranges of threatened species varying between 20 and 40% are: Ecuador (32%), Peru (28%), Argentina (25%) and Venezuela (20%). The underlying drivers of this decline in order of importance are (IUCN, 2013): agricultural expansion and habitat change (in 25% of the cases); tree felling and wood harvest (22%); urbanization (13%); agricultural and forestry pollution (12%); and alien and invasive species (10%). In less than 10% of the cases climate change was the underlying driver of species pressure, which highlights a key fact: among global drivers, land use changes by far exert the largest pressure on biodiversity, even above climate change.

3.4.4 Agro-diversity

LAC is the home to some key food components of our diets. The highest agro-diversity within LAC is found in the Andean region and Brazil, although in the last two decades, this agro-diversity has decreased sharply (see Figure 3.5). This loss of agricultural diversity is very much related to the progressive trend of agricultural specialization into oilseed and cereal grain production (mostly soybeans, maize, wheat, barley) and also into bio-fuels such as sugar cane. Among all the crops grown in LAC, over sixteen were originally domesticated in this part of the world (see Table 3.2). Cotton, beans and sunflower are the native crops that have experienced the greatest reduction in area cultivated since the 1990s. Maize on the other hand has experienced a sharp increase, particularly in Argentina, Paraguay, Brazil and also Nicaragua and Venezuela. Much of the loss in agricultural area of native species has been due to the expansion of non-native crops like soybean, which has increased its area 2.5 times since 1990. Sugar cane area has also increased substantially. Soybean expansion in Brazil is mostly related with the increasing demand of animal feed by the EU27 and more recently China, whereas sugar cane production has mostly increased as a result of internal biofuel demand.

3.4.5 Forest products

Commercial forestry in LAC is mostly oriented towards the production of non-timber forest products (NTFP) such as pulp. This pulp comes predominantly from softwood tree plantations of Eucalyptus spp. and *Pinus radiata* and it is used to produce paper. The development of the paper industry in LAC is relatively new compared to other parts of the world. To a large extent this has been driven by government policies that have boosted forestation based on high-yielding species to promote the paper industry. Brazil, Chile and Uruguay are currently the three leading countries in the paper industry within

Table 3.2 Trends of native and non-native agricultural crops cultivated in Latin America

	COMMON NAME / SCIENTIFIC NAME	ORIGINALLY FROM	DOMESTICATION DATE	AREA 1990 (ha)	AREA 2010 (ha)
NATIVE	Beans *Pachyrhizus ahipa* *Pachyrhizus tuberosus* *Phaseolus vulgaris*	Andean Region	<1000 BC	8,178,705	6,788,716
	Squash and pumkins *Cucurbita pepo*	Mesoamerica	7000 BC	152,556	6,788,716
	Maize *Zea mays*	Mesoamerica	6000 BC	24,893,987	28,735,226
	Manioc/cassava *Manihot esculenta*	Lowland South America	6000 BC	2,744,838	2,697,564
	Avocado *Persea americana*	Mesoamerica	2000 BC	160,276	272,564
	Chilli peppers *Capsicum annuum*	Mesoamerica	5000 BC	139,843	237,227
	Chilli peppers *Capsicum baccatum*	Andean Region	4000 BC		
	Cotton *Gossypium hirsutum*	Mesoamerica	5000 BC	3,723,923	1,617,139
	Sunflower *Helianthus annuus*	Eastern North America	2000 BC	2,948,417	2,054,437
	Sweet potato *Ipomoea batatas*	Andean Region	4000 BC	252,571	273,136
	Tobacco *Nicotiana tabacum*	Andean Region	1000 BC	473,209	609,169
	Pinaple *Ananas comosus*	Lowland South America	<1000 BC	96,227	222,481
	Cocoa *Theobroma sp*	Mesoamerica	2000 BC	1,490,618	1,529,507
	Quinoa *Chenopodium quinoa*	Andean Region	4000 BC	47,585	99,499
NON-NATIVE	Soybean *Glycine max*	East Asia		18,035,280	46,181,492
	Sugar cane *Saccharum ssp*	South Asia		7,932,457	12,014,797
	Wheat *Triticum spp*	Near East		10,673,991	8,819,368

Source: own elaboration based on Pickersgill (2007) and FAO (2013)

LAC. The availability of space for cultivation together with the advantageous climatic conditions are two important factors explaining its comparative advantage and much of the growth of this sector, particularly since the mid-20th century (Lima-Toivanen, 2012). In fact Brazilian and Chilean pulp and paper producers are among the most profitable companies producing fast-growing eucalyptus trees and have become cost leaders in the production of market pulp (Gurlit et al., 2007).

Brazil, Chile and Mexico are the largest producers of pulp and accrue over 80% of the continental production. Argentina used to be an important producer in the 1990s, but lately it has lost its market share within LAC (from 11% of total LAC pulp production to less than 2%). According to FAO (2010), since 1990, pulp production has increased sharply among the largest producers and also amongst medium producers such as Colombia and Uruguay (see Figure 3.5).

3.4.6 Eco-tourism

The rich diversity of species and ecosystems found in LAC together with its diverse indigenous cultures, provide a wealth of opportunities for recreation and tourism. On the continental scale it is difficult to measure the performance of this cultural ES, as it is determined by a large set of natural, cultural and economic factors. As a proxy indicator to account for the eco-cultural importance of LAC we used the number of World Heritage Sites (WHS) and Biosphere Reserves (BR) as defined by UNESCO (2013).

Mexico, Brazil and Peru are the countries holding the largest number of WHS and BR, here grouped under the name of 'eco-cultural' sites (see Figure 3.4). These three countries also account for the majority of the new WHS and BR declared since 1990. The Caribbean region, except Cuba, has a very small number of 'eco-cultural' sites. In South America, countries like Argentina and Bolivia have experienced a significant increase. The number and progress of WHS and BR in a way represents the effort that regional and national governments are performing to preserve important natural and cultural features and promote them amongst national and international tourists.

Table 3.3 summarizes the trends in ES performance across LAC regions between 1990 and 2010. The general trend points towards a reduction in performance of regulating and some cultural services, whereas production and other cultural services such as eco-tourism opportunities are increasing. The Caribbean region, however, follows an

Table 3.3 Changes in ecosystem service supply (expressed in percentage) across Latin America and the Caribbean between 1990 and 2010. Green values refer to an increase in service supply, whereas orange values stand for service's reduction. Note: ES classification is based on MA (2005)

	REGULATING		CULTURAL		PROVISIONING	
REGION	Carbon Stocks	Biodiversity	Ecosites	Agro Diversity	Forest Products	Water Extraction
AMAZONIAN	-8	-15	200	-5	71	0.1
ANDEAN	-7	-8	88	-2	8	0.1
CARIBEAN	33	-2	213	11	-14	-1.2
SOUTH CONE	-8	-14	128	-13	24	0.2
MESOAMERICA	-15	-7	166	3	39	0.4

Source: own elaboration based on data from FAO (2010), FAO (2013), IUCN (2013) UNESCO (2013) inverse trend, with a general increase in the provision of regulating and cultural services and a general decrease in the demand of provisioning services.

As Chapter 4 outlines, human well-being indicators have improved for the most part, which raises the question about to what extent the observed loss of ES diversity is a consequence of having improved the living conditions of LAC inhabitants. For instance, Rodrigues et al. (2009) found a boom-and-bust pattern in levels of human development (life expectancy, literacy and standard of living) across the deforestation frontier in the Brazilian Amazon, where human development increased rapidly in the early stages of deforestation and then declined as the frontier advanced. Per capita timber, cattle and crop production also reveal a boom-and-bust pattern across the deforestation frontier.

3.5 What options are available in order to spare land and halt deforestation?

Taking into consideration the different drivers of deforestation across LAC, it is clear that a pool of different measures is needed in order to overcome the existing competition for land and develop regional land use strategies to balance food production, rural development and the maintenance of LAC's ES in the long run.

One possible solution is to unwind land competition in LAC as a further intensification of agriculture. Strategic and sustainable agricultural intensification, in terms of elevating yields of existing croplands of under-yielding nations, might be the solution to meet the global crop demand without causing irreversible ecosystem damage (Tilman et al., 2011). In countries like Honduras, Guatemala and Nicaragua, staple crops such as maize have yields below 2.1t/ha/yr, two and three time smaller than those obtained in Brazil or Argentina at present (FAO, 2012). In order to bridge this yield gap, rural development programmes need to be fostered, together with further investments to modernize agriculture, and ensure greater legal certainty to secure such investments, e.g. a better definition of tenure rights (IICA, 2013).

Despite the existing yield gaps across some countries, LAC's agricultural productivity as a whole has increased substantially during the last few decades (Ludena et al., 2010; Maletta and Maletta, 2011). Soybean yields in major producer centres such as Brazil increased at twice the US rate, from a much lower base since 1990 (FAO, 2012), and the yield of tree plantations for wood and pulp in Chile, Brazil and Uruguay is three to four times the level that can be achieved in Europe (FAO, 2010). Soybean, maize and wood-based fuels are the key actors in the agricultural and livestock sector and industries in LAC, and improvements in their productivity may help to spare land. In fact when assessing the evolution of the agricultural sector, it is clear that in the last decade, agriculture growth is mostly being attributed to increasing efficiency and becoming more and more decoupled from land inputs (Figure 3.7).

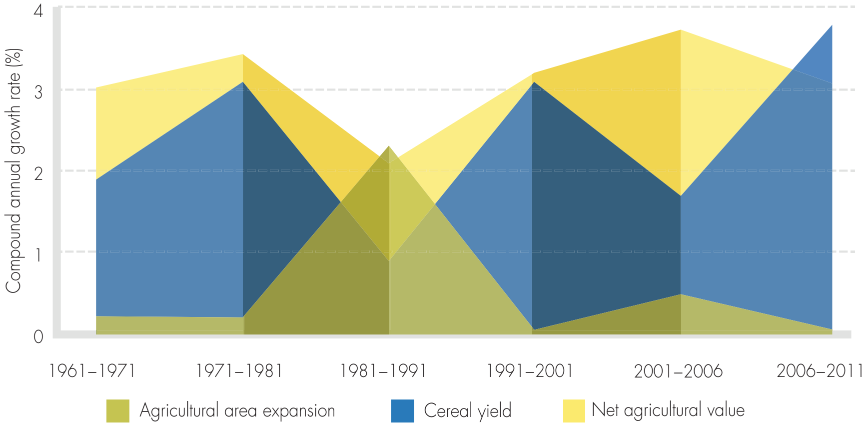

Figure 3.7 Annual growth rates of agricultural land, yields and net production value. *Source: own elaboration, based on FAO (2012)*

Nevertheless, the land-sparing argument, based on modern agriculture, has been criticized for neglecting some important environmental side-effects. It is well known that modern intensive and unsustainable agriculture frequently leads to soil degradation and watershed contamination (Matson et al., 1997; Tilman et al., 2002). Also, natural ecosystems interspersed between highly intensified and productive areas are often forest patches with a low conservation value (Tscharntke et al., 2005; Vandermeer and Perfecto, 2007).

Land sparing through agricultural adjustment has been the predominant land use model followed in Europe and the US. As Tilman et al. (2011) argues, probably the only path to sustain future food demand without causing further ecosystem services losses is through a sustainable intensification of current land use policies, including land use efficiency, together with agricultural practices that avoid depleting soil and biological properties, e.g. agro-forestry practices. Also, a deeper understanding of the environmental implications linked to this land use intensification path is needed (*ibid.*). This will require: determining how land sharing can deliver sufficiently high yields and ecosystem services, assessing trade-offs between increasing yields and environmental benefits across different circumstances and spatial scales, and exploring policy and market mechanisms that enhance sharing initiatives (Garnett et al., 2013).

Nevertheless, Tittonell (2013) recalls on the importance of not falling in to the 'intensification trap', that is the risk of oversimplifying the challenges of feeding a growing population just by intensifying existing agricultural land and balancing environmental trade-offs. He warns against this primarily because intensifying existing agriculture goes hand in hand with larger energy and fertilizer demand, which creates and exacerbates other related societal and environmental problems.

A different argument brought up in support of a less intensive landscape matrix is related to the promotion of organic and wildlife farming agriculture. However, critics argue that organic agriculture may have lower yields and would therefore need more land to produce the same amount of food as conventional farms, resulting in more widespread deforestation and biodiversity loss, and thus undermining the environmental benefits of organic practices. Differences in yields differ greatly depending on the crop type and the region where it is cultivated. According to Seufert et al. (2012), organic to conventional yield ratios of common key LAC products such as soybeans are on average high (0.9). Lower ratios, however, are found for cereals: maize (0.85), barley (0.7) and wheat (0.6).

Overall, and in addition to the pool of measures that can be adopted to overcome land use conflicts between agriculture and nature in LAC, it is important to promote also measures directly aimed at preserving existing nature, e.g. through payment for ecosystem services (see Chapter 14), incentives to reduce deforestation and forest degradation (Box 3.2) and sustainable management of forests and landscape restoration including reforestation. Besides the collection of measures directly targeting at increasing efficient production in the field, off-site efficiency improvements (e.g. along the supply chain) would help to reduce food waste and increase production per unit of land. As IMECHE (2013) highlights we produce about four billion metric tons of food per annum, but it is estimated that 30–50% (or 1.2–2 billion tons) of all food produced never reaches a human stomach due to poor practices in harvesting, storage and transportation, as well as market and consumer wastage. Any such measures should be accompanied by a more transparent food chain with information that will allow consumers to make informed choices.

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