Climate Change in Latin-America and Caribbean Countries: Impacts, Vulnerability and the need for Adaptation

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This document bases on the synthesis of press releases developed by several Latin-American participants of the Fourth Assessment Report of the IPCC, Working Group II (IPCC-WGII, 2007) and on a recent contribution (Conde et al, 2007) for the UNDP Human Development Report 2007/2008. The text organizes as follows: Section 1 provides a brief results summary of research predictions on climate change at global level in order to serve as introduction to further presenting concrete expected facts for the Latin America and Caribbean region. Section 2 presents some recent natural hazards and discusses the main findings concerning climate change impacts from some study cases in Latin America. It discusses economic vulnerability and some adaptation measures as well. Section 3 concludes with a set of suggestions for further research to address climate change in the region.

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1. Introduction

The Fourth assessment report of the IPCC (IPCC-WGI, 2007; Pachauri and Jallow, 2007) states that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level". Averaged air temperature has rise 0.74ºC [0.56 to 0.92] for 1906 to 2005, and ocean temperatures have increase to depths of at least 3000 m.

The conclusion: "Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely (90%) due to the observed increase in anthropogenic greenhouse gas concentrations" is perhaps one of the most important findings in the IPCC Fourth Assessment report (IPCC; WGI).

This report also states that warmth of the last half century is unusual in at least the previous 1300 years and observed changes in climate include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones. Also, significantly increased precipitation in eastern parts of North and South America, northern Europe and northern and central Asia and more intense have been observed, as well as longer droughts observed since the 1970s, particularly in the tropics and subtropics, have been documented.

Future scenarios project that for the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios, and by 2100 temperature could increase between 1.8 to 4.0ºC above the 1980 – 1999 average. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. Sea level rise is projected to increase 0.18 to 0.59 m, and is very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent. It is likely that future tropical cyclones will become more intense, with larger peak wind speeds and more heavy precipitation.

Impacts are occurring now as a consequence of climate change and future possible impacts have been identified (IPCC-WGII, 2007). Water supplies stored in glaciers and snow cover are projected to decline, reducing water availability in regions supplied by melt water from major mountain ranges, where more than one-sixth of the world population currently lives. From 20 to 30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5ºC. At lower latitudes, crop productivity is projected to decrease for even small local temperature increases (1-2°C). At higher latitudes, crop productivity is projected to increase for temperature increases of 1-3°C, then decrease beyond that.

Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. The most vulnerable industries, settlements and societies are generally those in coastal and river flood plains, especially those whose economies are closely linked with climate sensitive resources, e.g. agriculture, and those in areas prone to extreme weather events, especially where rapid urbanization is occurring. Projected climate change-related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity.

2. Climate change in Latin America

In Latin America, during the last decades important changes in precipitation and increases in temperature have been observed, as well as land-use changes have intensified the use of natural resources and exacerbated many of the processes of land degradation (Magrin et al, 2007). The expected increases in sea-level rise (SLR), weather and climatic variability and extremes are very likely to affect coastal areas (high confidence). The projected mean warming for Latin America to the end of the century, according to different climate models, ranges from 1 to 4°C for the SRES emissions scenario B2 and from 2 to 6°C for scenario A2 (medium confidence); By the 2020s, the net increase in the number of people experiencing water stress due to climate change is likely to be between 7 and 77 million (medium confidence). By mid-century climate change is projected to lead to the gradual replacement of tropical forest by savanna in eastern Amazonia. It is projected that semi arid vegetation might be replace by arid-land vegetation (IPCC-WGII, 2007).

Further projections for Latin America consist of (Magrin et al, 2007):

- In drier areas (i.e. center and northern of Chile, coastal zones in Peru, northwestern regions in Brazil, west and northwest of Argentina, and large areas of Mesoamerica) climate change is expected to lead to salinisation and desertification of agricultural land;
- Sea-level rise is projected to cause increased risk of flooding in low-lying areas. Increases in sea surface temperature due to climate change are projected to have adverse effects on Mesoamerican coral reefs, and cause shifts in the location of south-east Pacific fish stocks;
- Under future climate change, there is a risk of significant species extinctions in many areas of tropical Latin America (high confidence);
- Future sustainable development plans should include adaptation strategies to enhance the integration of climate change into development policies (high confidence).

Research challenges for LAC

The IPCC-WGII (2007) Latin America chapter points out the following major concerns in the region and needs for future research on climate change: (*i*) weakness of the climate change projects and policies, especially when communicating risk to stakeholders; (*ii*) inter and multi disciplinary research is seldom performed; (*iii*) "constraints already identified in terms of facing current climate variability and trends, such as: lack of awareness; (*iv*) lack of well-distributed and reliable observation systems; (*v*) lack of adequate monitoring systems; (*vi*) poor technical capabilities; (*vi*i) lack of investment and credits for the development of infrastructure in rural areas; (*viii*) scarce integrated assessments, mainly between sectors; (*ix*) limited studies on the economic impacts of current and future climate variability and change; (*x*) restricted studies on the impacts of climate change on societies; (*xi*) lack of clear prioritisation in the treatment of topics for the region as a whole. In addition, other priorities considering climate change are: to reduce uncertainties in future projections of climate change paths and to assess the impacts of different policy options on reducing vulnerability and/or increasing adaptive capacity."

To address partially those issues, Conde et al (2007) reviewed some of the efforts performed by several vulnerability and adaptation research projects. Several studies performed by the Economic Commission for Latin America and the Caribbean[2] show that floods, landslides, hurricanes and droughts are the major hydrometeorological threats in the region. Even though the number of human deaths caused by those events has decreased over the past two decades, the number of affected population increased dramatically (ECLAC, 2003). Other studies (Zapata, 2006) show that the cost of those disasters have sum around 250 USD billion for the period 1972 to 2005, and are estimated to be near 50 USD billion from 2000 to 2010. These figures show that it is urgent to "adopt, as part of the development policies and to achieve the millennium goals, those measures that mitigate the vulnerability to increasing and multiple threats" (Zapata 2006).

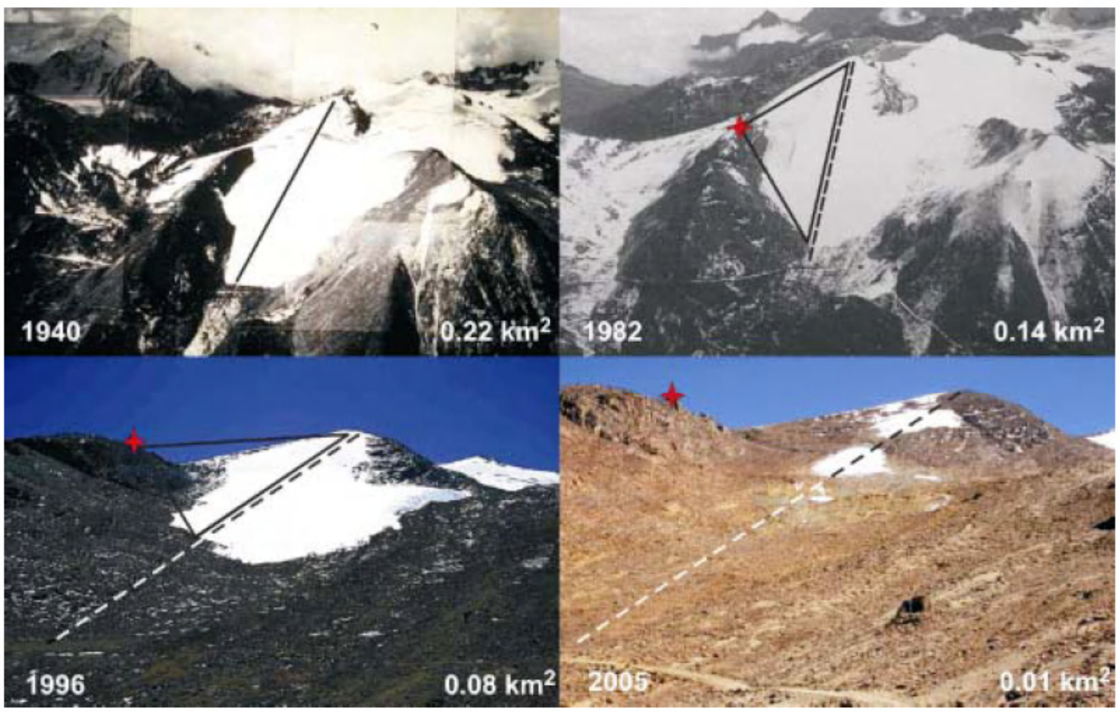

Figure 1. Areal extent of Chacaltaya Glacier, Bolivia, from 1940 to 2005
Source: IPCC-WGII 2007

Living conditions and livelihoods opportunities for millions of people will be in danger in Latin America (Stern 2006). Some scenarios under climate change conditions project that maize production by 2055 will drop by around 15% on average (Stern, 2006). This possibility will endanger the subsistence and food security of the majority of the rural population in the region. In addition, the landscape has been dramatically changing within a

[2] Turn to: http://www.eclac.cl/

relatively brief time period (see Figure above), threatening survivor of ecosystems, species, and, thus, stressing human livelihoods.

In climate change conditions, agricultural activities are highly probable to significantly suffer of yield decrease for most Latin American and Caribbean countries (LAC), and probably pests will expand their territory and soil degradation processes will continue to increase. Droughts, floods, heat waves, frosts, hail and other climate extreme events have significantly affected agricultural activities in human history. The limited capacity to forecast those events, to communicate "useful" forecasts, but also to cope with them, determines not only the agricultural output, but, most important, the farmers' livelihoods and, in developing countries, even put at risk their food security.

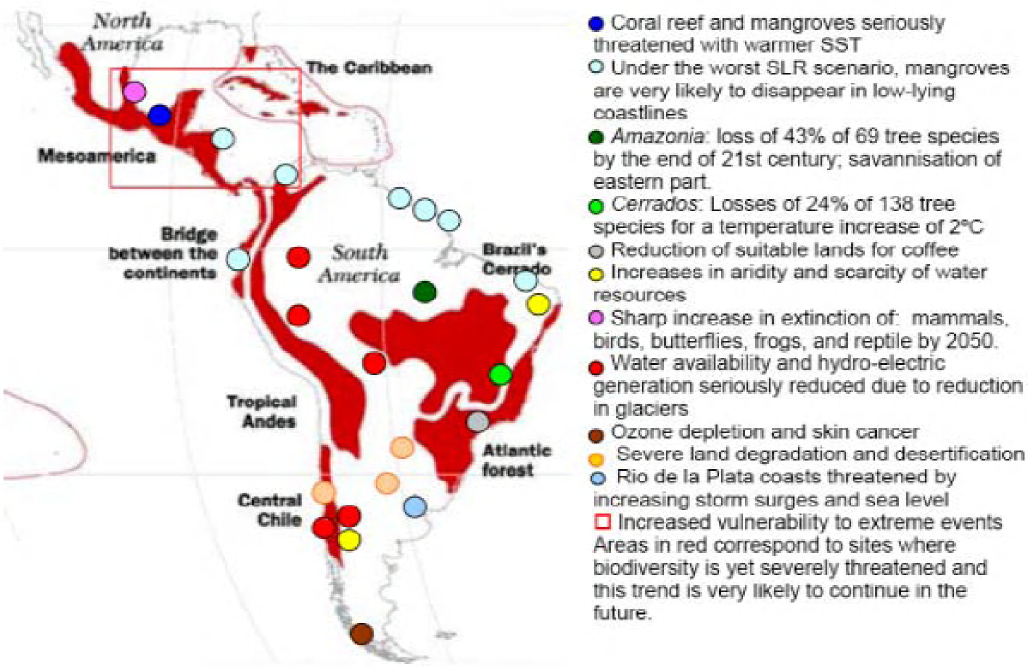

Figure 2. Key hot spots from climate change in Latin America and the Caribbean region
Source: IPCC-WGII 2007

2.1 Past and present impacts

In Latin America, *El Niño/Southern Oscillation* (ENSO) is the most important source of climate variability and has caused the largest economic and social impacts. From its part, hurricanes are increasing both frequency and severity in the North of the LAC region, concretely affecting the Caribbean Basin, Mexico and Central America.

2.1.1 Niños

Strong ENSO events have modified climate conditions and impacted severely, mostly, the rainfed agriculture. In the case of Mexico, changes in rainfall patterns are observed during the strong *El Niño* events (1982-183, 1997-1998) as well as during the strong 1988 – 1999 *La Niña* event. Almost in all the Mexican territory, severe summer droughts have affected the agricultural activities during strong El Niño events, leading, for example, to the economic loss of ca. 1.5 billion USD during the 1997-1998 event (Magaña *et al*, 1999, Conde et al, 1999). In Argentina, El Niño events are associated with enhanced likelihood of higher than the median precipitation anomalies during October-February along the main agricultural area, while lower than the normal precipitation during the same period was typical of cold ENSO events (Messina, *et al*. 1999; Ropelewski and Halpert, 1989).

In some study cases of Argentina, farmers identified floods, droughts, and hailstorms as the most important events affecting their activities, of which floods caused comparatively more damages (Riverola et al, 2002; Seiler et al, 2002; Seiler and Vinocur, 2004). For example, five of the ten wettest years since 1980 occurred during El Niño years in Cordoba, and also severe droughts were recorded in 1988-1989 (La Niña year) and important losses in maize yields occurred during 1986-1987 (El Niño year).

During the last 25 years, three major flood episodes have occurred in a study region in Cordoba, Argentina. It has brought clear production drops as well as remaining socioeconomic damages lasting for years in the affected areas. The flooding area corresponds to the poorly drained plains in the south of the region. In addition to natural climate variability, in the south of Cordoba it is perceived increase variability possibly as a consequence of climate change (see Box 1). Fluctuation of the climate during the seasons, the occurrence of anomalous temperature and precipitation, as well as soil moisture availability exert in the region the greatest influence upon both intra and inter annual onset of the crops season and in the consequent crops growth, development and yield (Gay et al, 2006).

Box 1. Measuring a vulnerability index for Argentina (Final AIACC report)

The whole Cordoba province is about 16.532.100 hectares, 83% of it devoted to agricultural activities. This province is in the center of the Argentina and ranked fifth in size among all the argentine provinces. Cordoba contributes about 14% of the national agricultural GDP (Gross Domestic Product), 14% of the national livestock, 17% of the cereal and 25% of the national oilseed production. The agri-food and agro-industrial systems are the most dynamics and important in the economy, representing 25% of the state GGP (Gross Geographical Product) (INTA, 2002). This province is the second largest maize producer in the country contributing about 32% of the total national production (SAGPYA, 2004).

The South of the Cordoba region comprehends 6 of the 13 different agro ecologic zones (AEZ) of the Province. The main agriculture systems are cash crops and livestock. Focus groups, interviews and a survey (similar to the one applied in Mexico) were implemented to construct indicators related to resources (human, financial, social), management capacity/diversity, previous risk mitigation actions, climate information and impacts, economic strategies, public institutions and decision making. Four localities were selected to implement the survey, namely Laboulaye, Río Cuarto, Marcos Juárez and Oncativo. Climate Sensitivity and adaptive capacity indicators were obtained for 16 farmers groups and each of the indicators represents one or more variables from the survey data.

These indicators aimed to identify producers' sensitivity to different adverse climate events and the main resources available for farmers to respond to stress and uncertainty. The overall vulnerability of each farm group was assessed qualitatively by comparing the aggregate scores for the sensitivity and adaptive capacity indices.

Only two farmers' groups can be distinguished within the *low vulnerability class*, representing only 13% of the surveyed farmers. Both groups are in Marcos Juárez area, where climatic risks are lower, belonging to the humid pampas, less exposed to hail storms and few flooding problems. This class is comprised of the groups with the lowest sensitivity indices.

The *high vulnerability class* is represented by five of the sixteen defined groups and represents 43% of surveyed farmers, exposed to floods (those in Marcos Juárez and Laboulaye areas), hold the highest sensitivity to hail storms (Río Cuarto and Oncativo areas), or highly exposed to drought (Oncativo area). The *moderate vulnerability class*, representing half of the surveyed population, shows different combinations of agricultural systems, sensitivity (due to different climatic exposure) and, adaptive capacity (landholding size, soil quality, management of the farm) that reflect climate variability incidence on farmers' livelihoods in the studied region. The diagram in figure 4 show the synthesis of the vulnerability classes and the weighted indicators described above.

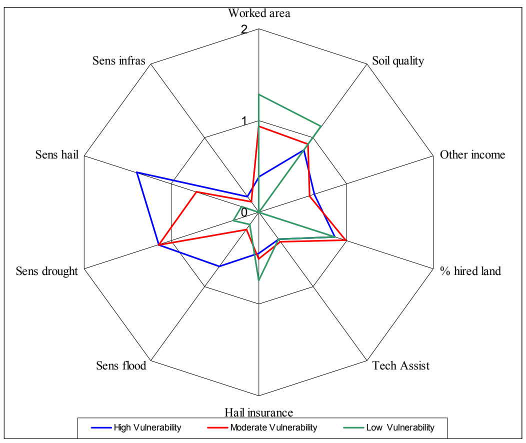

Figure 3. Synthesis of the vulnerability classes and the weighted indicators

Source: (AIACC final report, Wehbe et al, 2005)

2.1.1 Hurricane exposure of the Caribbean Region

The very strong, extreme climatic events that increasingly hit the Caribbean Basin warns us of potential forthcoming damages as long as no action to reduce climate change impacts is taken both at global and, most important, domestic level. Such events have exposed the different degrees of coping capacity of countries and states in the LAC region, exemplifying how vulnerability varies greatly in accordance with the level of their development. In the Caribbean Basin, countries and states are recurrently affected by Atlantic tropical systems ranging from tropical storms and depressions to category five Hurricanes (Saffir-Simpson scale). However, the link between development and risk and disaster management varies widely among this region, embracing those appropriate disaster response and management (as in Cuba), minor global impact on the national GDP but with relevant local economic consequences, e.g. Florida and Yucatan, significant impact on the whole economy of a small island development state, e.g. Grenada, Cayman Islands, and spillovers of losses to the total economy, e.g. Jamaica and Dominican Republic (ECLAC 2004a). Economic losses from hurricanes have been significant in the Caribbean, frequently exceeding 100% of the GDP value when a hurricane hits, as the case of Grenada (212%) and the Cayman Islands (138%) during the 2004 hurricane season (ECLAC 2004c). From its part, growth paths tend to decline following hurricanes in this region, as the case of the Bahamas, whose 2003 GDP growth prospects from the World Bank before hurricanes Frances and Jeanne were estimated at 3.0%, but after these events it dropped to 1.3% (ECLAC 2004b).

2.2 Vulnerability: economic development and poverty

One has to admit the need for joining LAC to global efforts and actions towards mitigating climate change. However, this region contributes with only ca. 3.5% of global greenhouse gasses emissions (GHG), and, roughly speaking, so on for further drivers of climate change (IPCC 2007). Even though it is relevant achieving sustainable economic growth to prevent potential future increases in GHG emissions from this region, the mere fulfilling of current mitigation commitments in LAC will not certainly prevent this region of suffering negative impacts from climate change. It suggests, then, the need for setting vulnerability at the top of priorities in the research and policy agenda concerning climate change in this region. Despite the dramatic evidenced losses from natural disasters and the forecasted negative impacts from climate change in the LAC region, there are still enormous research blanks on/in LAC concerning vulnerability analysis. Although vulnerability has not a unique meaning for different research communities (Downing and Downing and Pathwardhan, 2005; O'Brian et al, 2004), the IPCC Fourth Assessment Report (IPCC, WGII, 2007) defines vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity". Analyzing vulnerability demands (i) to identify affected agents, e.g. societies, economic sectors, livelihoods, ecosystems, etc; (ii) the concrete hazard, e.g. extreme weather events, and; (iii) the way agents and hazards interact. In analyzing that interaction, social and economic conditions play a crucial role.

2.2.1 Economic vulnerability to climate change

In the economics literature, vulnerability is considered as a situation in which least developed countries (LDC) find themselves in a dominance and dependence relationship *vis-à-vis* the developed countries Todaro (1982). In this view concretely, LDC are said to be economically vulnerable to the decisions of rich nations in areas such as trade, private foreign investments, foreign aid, technological research, development, etc. This is a useful concept whose asymmetry component is closely interconnected with other concepts from the economics of development, like the center-periphery relations and terms of trade in the works of Raúl Prebisch (1950, 1973). In-line-with the Todaro's definition, the United Nations Conference on Trade and Development (UNCTAD) defines economic vulnerability as the structurally more exposed position of LDCs than most other developing countries to external economic shocks. Also, UNCTAD points out that economic vulnerability implies consequences of major global and regional economic and financial disturbances and increases in the prices of critical imports such as energy products; The typical export dominance of a single commodity or service sector makes their economies particularly vulnerable to adverse physical or economic shocks (UNCTAD 2001), especially in the case of mono-crop economies.

Box 2. Productive re-orientation, a structural adaptation measure

The practically mono-crop economy in a surveyed region of Chiapas (Saldaña 2005), provide evidence of the amplifying negative impacts from climate adversity and sudden trade changes. The main agricultural products of the interviewees are white maize (46%) and coffee (41%). It increases their vulnerability given the decreasing prices of white maize and coffee experienced over the last 20 years. The neo-classical approach of economic theory considers mono-crops as positive in that of exploiting local comparative advantages, producing scale economies, as well as due to the benefits derived from high specialization in the sense of the *work division* of Adam Smith. Nevertheless, these advantages counteracted when the respective commodity markets turns highly volatile or price drops dramatically, as in this case.

Low rural incomes in this region are considered a result of a complex economic-climatic process, whose solution should embrace not only social programs, rural-urban emigration, and post-disaster aid, but also issues of inequity, productive reorientation and implementation of disaster prevention instruments. Productive reorientation seems to be a feasible economic response to adapt to negative terms of trade of- and within the agricultural sector. The low dynamism of the industrial sector of the past two decades in Mexico has impeded the urban economy of absorbing most the additional workforce released from the left-behind agricultural sector. For that reason, the productive re-orientation should still be projected within the agricultural sector itself. Otherwise, the current increasing trend of slums proliferation in large cities as well as illegal emigration to, mainly, the USA, will become harder to manage. It implies finding means of both diversifying crops to reduce the probability of getting affected given sudden prices drops in the mono-crop, as well as moving to more rentable crops, that is, whose market prices are relatively higher, with a more stable demand and suitable to regional environmental and climatic conditions. In a study in the state of Veracruz, Mexico, Gay et al (2004) analyze the high vulnerability to extreme climatic conditions in a coffee producing region, which is being increasingly affecting the region, and warns about the low viability of growing coffee there once internalized some negative effects of policy changes and market instability for this sector.

From the Chiapas study, 58% of interviewed farmers stated to have plans to diversify to higher profitability crops given current trends of decreasing prices of traditional agricultural products. Over 87% farmers crop maize and coffee, whose prices have been decreasing over the past ten years. In counterpart, cropping fruits and vegetables represents higher profitability to farmers in this region given favorable climatic conditions and relative prices. Based on a World Bank report, fruits and vegetables are considered to have higher comparative and competitive advantages to the Mexican agricultural sector, especially to export to North-America in the framework of the North America Free Trade Agreement (NAFTA) (Lederman et al 2003). Even despite higher freight and insurance costs in the South to export to the USA and Canada, the relative greater water availability in the South may make the said crops highly rentable –of course, once constructed the due water management infrastructure. Under such circumstances, there is widespread demand –from interviewees and stakeholders- to promote more actively the current governmental productive re-orientation process, as well as to operate in a more participatory manner in order to achieve realistic and sustainable results.

In the stakeholders' views, there is also a widespread feeling concerning the absence of an effective and long-term sustainable strategy to strengthen the coping and adaptive capacity of subsistence farmers in this region to external shocks, which is an obstacle for accumulating assets. The prevailing conditions of marginalization and low educative levels in this region may explain the passive attitude of the self affected population to come up with initiatives to reduce vulnerability. It demands a more active promotion from the public. The insufficient government investments in infrastructure, limited credit granting, insufficient subsidies to crop insurance, and lack of investments in more rentable crops, greatly reduces the communities' coping capacity when hazards strike, which in turn is soaring emigration and social instability levels in the region.

So, in the early 1990s, UNCTAD developed a first attempt to construct an index of economic vulnerability[3], and in 1994 the Programme of Action for the Sustainable Development of Small Islands Developing States (SIDS) adopted an index of economic vulnerability, expected to demonstrate that SIDS were generally more vulnerable to global change than other developing countries. So, the UNCTAD Economic Vulnerability Index was constructed as a composite indicator based on three fundamental dimensions: (1) the magnitude of external shocks beyond domestic control (measured through indicators of the instability of agricultural production and exports); (2) the exposure of the economy to these shocks (estimated through the share of manufacturing and modern services in the gross domestic product, and an indicator of merchandise export concentration), and; (3) the structural handicaps explaining the high exposure of the economy (taking into account economy's smallness, measured by a proxy demographic variable) -UNCTAD 2003.

In the view of Briguglio (2002), a country can be economically vulnerable and yet register a relatively high GDP per capita. So, countries like the SIDS are particularly economically vulnerable due to their limited ability to exploit economies of scale, lack of natural resources, low diversified economy, dependence on narrow range of exports, and high dependence on imports of strategic goods, i.e. fuel and food. Notwithstanding, what essentially makes a country economically vulnerable in the definition of Briguglio, is its exposure to economic forces outside its control. Thus, the *peripherality* condition of an economy goes beyond geographic insularity and remoteness (leading to high costs and marginalization from world trade), but also includes inability to influence international prices (price-taker economies).

[3] *Cfr*. Briguglio, L. (1992). Preliminary study on the construction of an Index for ranking countries according to their economic vulnerability. Report to UNCTAD, 1992.

However, being vulnerable is not only a question of poverty and smallness of a country, as this work approaches. Vulnerability accrues to also countries of big population and large economies, whose vulnerabilities are less visible at a glance, and only through more detailed analysis exhibit differential vulnerabilities due to dualistic characteristics (Rodriguez 1980). So, above all, Latin American countries like Mexico, Brazil, and Argentina should not be considered as entirely vulnerable, but unequally vulnerable, whose rich and poor societies, high productive and left-behind economic sectors, etc. coexist at differential degrees of vulnerability (Rodriguez 1980, Colosio 1979). In sum, economic vulnerability is the susceptibility of an economic agent to absorb extern shocks, e.g. natural hazards, negatively, given its coping capacity, e.g. assets possession and entitlements system, as well as its implemented adaptive measures, e.g. risk management and protection measures (Saldaña 2006a). Coping capacity can be defined as the ability of a unit to respond to a harm occurrence as well as to avoid its potential affectation, whereas adaptive capacity is the ability of a unit to gradually transform its structure, functioning or organization to survive under hazards threatening its existence (Kelly and Adger 2000).

2.2.2 Climate change and assets accumulation

Increasingly, scholars argue that poverty is not only a lack of income or consumption, but also a lack of assets (Haveman and Wolff 2000, Oliver and Shapiro 1990, Sherraden 1991). So, asset poor involve those households with insufficient resources to invest in their future or to sustain household members at a basic level during an economic disruption (Fisher and Weber 2004). Among other authors, Chambers (1989) cautions about the relevance of increasing assets in low-income families, since this improves human conditions beyond poverty just in terms of flows, but also structural vulnerability. He affirms that vulnerability is even more interlinked with net assets than poverty. For authors like Vatsa & Krimgold (2000), vulnerability is a broader and more dynamic concept, which involves the poor, but also households living above poverty line at risk of falling below in case of an income shock, that is, the “new poor”. Given that linkage, factors that obstruct an accumulation of assets are, in turn, impeding poverty reduction and putting additional population into poverty. For instance, losses from increasing natural disasters or income reductions due to depressed agricultural prices impede rural households in accumulating assets, creating a vicious cycle of inefficient risk management strategy, low return, low consumption and low savings and investment (Saldaña 2006a).

2.2.3 Relative vulnerability of the poor

One of the main issues increasing vulnerability to extreme climate events in Latin America is the acute poverty. By 2005 (CEPAL 2006), 28.9% of its population (209 million people) lived in poverty conditions, and 15.4% (81 million) were extremely poor. Though being poor does not necessarily imply being vulnerable, but poverty makes individuals relatively more vulnerable to a given hazard. People worldwide living in adverse economic conditions is less able to invest in all items, including those to manage risk and increase disasters protection. Developing countries have historically been more severely damaged compared to developed countries (Benson and Clay 2000). On the one hand, total economic losses tend to be higher in rich countries in absolute terms, but compared to economy value, losses are much higher in developing countries (Saldaña 2006a). A given natural hazard with identical intensity can hit in different degree two distinct countries. Differences in civil protection system, health facilities and public financial ability (i.e. for reconstruction) make countries to absorb hazards differently. As Cannon (1994) points out, what turns a natural hazard into a disaster is not simply a question of money, but also of economic and political system. The way countries structure societies determine that a similar hazard lead to very different impacts among societies.

2.2.4 Coping capacity of the poor

Given current entitlements, the poor is the most prone stratum to suffer of natural disasters, especially in developing countries. The distribution of human assets in many developing countries reveals high inequity. The most productive and safe terrains belong to middle- and upper classes, whereas less productive and/or unsafe areas were left to the poor. Most of the victims of Guatemala's Earthquake in 1976 were poor (23,000 deaths), who lived in ravines and gorges, areas very prone to disaster in case of earthquake or landslides. The river Oder, which divides Germany from Poland, overflowed in 1997 producing severe floods. Lack of maintenance of dykes and flood defenses, together with poor people living along the river in the polish side, produced disgracefully notoriously higher damages there than at the German side (Vatsa & Krimgold 2000). That reveals, on the one hand, budgetary differences to mitigate disasters between these countries. On the other hand, it reflects differences in living conditions within population in these countries as in both countries assets of lower incomes people got more affected. Additional evidence in the same way is found in Honduras with hurricane Mitch (Vatsa & Krimgold 2000), El Salvador Earthquake in 2001 (ECLAC 2001), Dominican Republic with hurricane Georges (Butterfield 1998), the United States of America when hurricane Kathrina hit in 2005 (O'Brien 2005), among others.

Box 3. Crop insurance coverage: lessons to learn inside Latin-America

As an adaptation measure, risk-sharing in the form of crop insurance in Latin-America presents still a number of challenges to face. Low coverage and insufficient penetration tend to be the most remarkable, whose causes vary widely among countries. Whereas Uruguay experiences high coverage even without governmental subsidy, insured cropland in Chile is increasing thanks to discriminatory subsidies combined with the participation of private insurers. By contrast, Mexico continues to maintain low coverage even despite governmental subsidies and the facilities conceded to private insurers. From its part, Argentina presents both low coverage as well as the absence of governmental subsidy.

Uruguay. So far, Uruguayan government does not provide any subsidy to crop insurance. However, insurance coverage in this country is greater than in most subsidized agricultural schemes in the world. Since the 1970s, self-insurance (*autoseguro agricola*) has been an intensively employed instrument. It consists of a shared-risk pool funded by farmer's arrangements. This instrument covers especially hail risk of mainly winter crops. Unlike the rest of Latin-American countries, the increasing natural disasters occurrence experienced over the 1980s in Uruguay led to the emergence of a number of private crop insurance companies, leaving behind the state monopoly in this market.

Chile. Chilean agriculture is recurrently hit by frosts –due to the dominating *Andes*-, droughts in the North –besides the Atacama desert- and heavy rains throughout most the territory. In 2000, the Ministry of Agriculture established the agricultural insurance company (COMSA), which is operated by private insurance companies. COMSA grants subsidy depending on farmer production scale. Crop insurance in this country embraces climate and market risks. The subsidy consists of financing 50% of net premiums on average, plus a fix fee (ca. US$ 36) per insurance contract. The subsidy grants small-scale producers with 80% of the premium price; 50% for medium farmers; and less than 50% for large scale farmers. The subsidy covers up to US$1,320 per farmer/season, and embrace most crops types. Since 2001, net weighted surface coverage of the subsidy exceeds 50% of cropland, noteworthy high compared to Mexico (10%) and Argentina (7.7%). Besides risk management, resources allocation matter: per-farmer subsidy in Chile is around four-fold higher than in Mexico.

Argentina. Only 2 of 26 millions of hectares of cropland are covered by insurance in Argentina. Mainly due to budgetary constraints, the government is reluctant to subsidize. It exacerbated after the 2002 economic crisis. 70% of existing insurance contracts cover exclusively hail, 29% are multi-peril, and 1% covers livestock. Despite the fast growth of the crop insurance market during the present decade (annual 12%), insurance coverage is still expensive for producers: premiums cost fluctuates between 3 and 6% of production costs. During this period, increasing pressure from social and economic actors demand the government to implement crop insurance subsidy in light of the increasing risk associated to the adoption of enhanced technologies along with the climatic variability. The exports boom of agricultural goods (mainly soy bean) and livestock to China over the past five years has generated unexpected revenues to the country, which is being the main argument to give agricultural some subsidies in return.

Source: Saldaña 2006a

3. Research challenges and further directions

The lack of integrated assessments of climate change seems to be a crucial constrain in the LAC region. Prevailing insufficient observation and monitoring systems has led to poor technical capabilities to generate reliable information for research and policy.
Only few isolated studies on the impacts of climate change on societies have so far been conducted in this region. Concerning economic sectors, there is a need for projecting investments and credits for the development of infrastructure, especially for the rural economy in sight of its, comparatively, higher exposure to climate change. In sum, limited studies on the economic impacts of current and future climate variability and change are leading to the lack of clear prioritisation of topics for the region as a whole.

Although –mainly due to the lack of research and study cases- the present document does not embrace the whole LAC region, but it provides useful highlights for a number of countries sharing environmental and human conditions. As observed along some surveyed regions, illustrated in Boxes 2 and 3, the adaptation to climate change of subsistence farmers is being constrained by current trends in institutional change and agricultural policy and just transitory facilitated by the markets. In addition, insufficient capacity building imply dramatic results if extreme climate events continue to increase in frequency and/or severity. It demands a more active role of the government to fulfill that gap. Public policy has still to face the challenge of integrating better climate change and variability research into practices and policies. In the case studies of Mexico and Argentina, key stakeholders came up with concrete adaptive measures, e.g. greenhouses, irrigation, credit, among others. However, technical instruments like these cannot last for long if coping capacity does not embrace a continuous learning process to program adaptation options based on climate and markets predictions. Currently, the risk management and disaster prevention measures in most LAC countries should overcome institutional and technological barriers for their optimal operation. Future research must center efforts in analyzing barriers and opportunities these measures represent, particularly if, as most likely, new technologies and policies might be needed in sight of the forthcoming global change conditions.

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