Socioeconomic Uncertainties Associated with Climate Change

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Abstract

Over the past decades scientific evidence has shown the human influence on the variations that Earth´s climate system is experiencing. The main cause of climate change is due to the increases in the atmosphere of anthropogenic concentrations of greenhouse gases, which is altering Earth's energy balance. The certainty of global environmental change contrasts with the large number of resulting uncertainties, both physical and human. In this article some of the main uncertainties related to the behavior of natural carbon sinks as well as the regional socioeconomic impact of these uncertainties are discussed.

Keywords: climate change, carbon sink, development, environment

1. Introduction

Climate change is a true reality as long as we understand it as the crisis our planet's climate is undergoing, particularly marked since the middle of last century, and which in recent years, far from weakening, is progressively showing more clearly. We find the first references to this phenomenon in the year 1827. The French mathematician Jean Baptiste Fourier observes, for the first time, that certain gases, particularly carbon dioxide, retain the atmospheric heat. In his opinion this phenomenon is similar to that seen in greenhouses and thus creates the term "effet de serre". Since then, the "greenhouse effect" has been the generic name given to this phenomenon.

Scientific investigations continue and in 1860 the Irish physicist J. Tyndall, known for his research on light propagation through colloidal suspensions and for his ice melting studies, goes deep on the study of climate and deduces that CO_2 concentrations in the atmosphere and its variations affect the climate changes. His studies set a research trend in which other scientists, in the following years would delve arriving to more specific and detailed knowledge. In 1903 the Nobel Prize in Chemistry was awarded to the Swedish physicist Svante Arrhenius. "in recognition of his great merits gained for formulating his theories regarding the electrolytic dissociation and the development of chemistry."

The author of the theory of ions to interpret the laws of electrolysis and which explains the chemical properties of electrolyte solutions, was not just limited to these disciplines as he also conducted research on the weather, coming to the conclusion that doubling the concentration of CO_2 in the atmosphere, the temperature would increase 5 or 6 ° C. These conclusions have later been validated and are part of the knowledge applied in the extrapolating of the current climate situation which estimates a gradual warming of Earth's surface.

Over the last twenty-four years, the IPCC (Intergovernmental Panel on Climate Change) has presented four major reports, in 1990, 1995, 2001, 2007, and a fifth that is in its last stages of development and will be submitted by the end of 2014. With all that information the technical documents are written for the use of the public administration or for when other agreements require information on this topic.

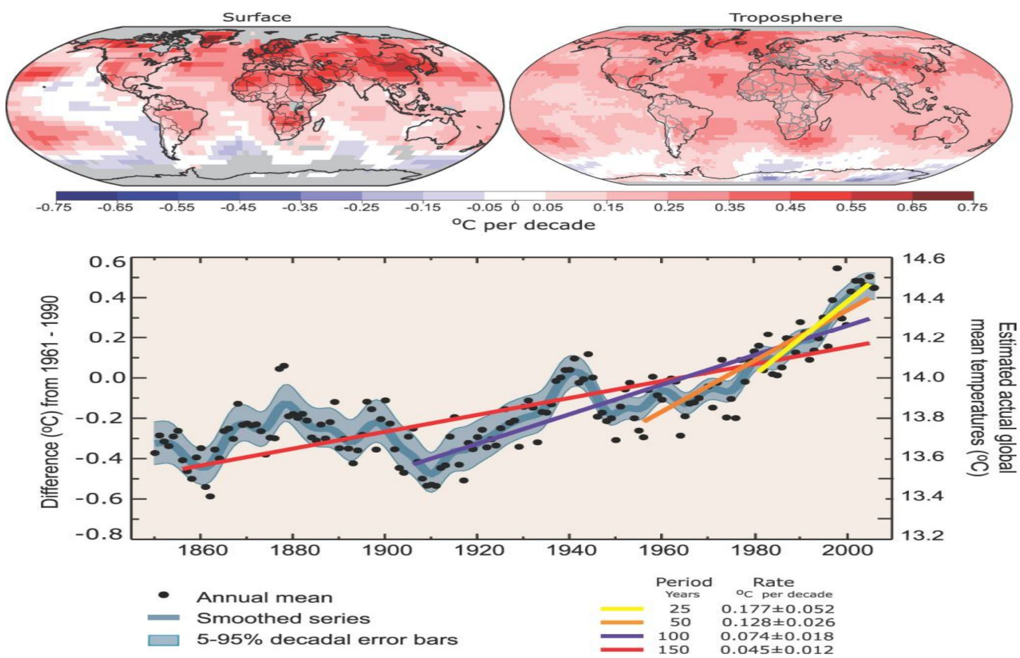
The scientific basis of the estimated climate change starts with the first measurements and evidence of changes in the chemical composition of the atmosphere. These were related to the marked increase of CO_2, a gas with a high absorption capacity of infrared radiation and very direct consequences on atmospheric warming. Therefore, the different climate models have attempted to estimate the intensity of the thermal increase or positive radiative forcing caused by CO_2, which man has been adding to the atmosphere since the industrial revolution.

2. Physical Bases of the Climate Change and the Socioeconomic Repercussions

Earth's climate can be defined as the sequence in time of the different spatial distributions of air temperature and rainfall on its surface. The history of mankind has run over these past million years. Since then, the climate has varied slowly. However, at present we talk about climate change. The climate system consists of the atmosphere, oceans, ice and biosphere subsystems. Although nuclear power presents problems for its use on the Earth, the energy for the movement of the particles that form the climate subsystems for plant growth and the metabolism of living organisms is provided almost entirely by a natural nuclear reactor in fusion mode which we call the Sun. A small portion comes from the nuclear reactions which constantly occur inside the planet and produce the tectonic movements.

The global average temperature of the planet is the annual average of the average air temperatures on the surface of each point of the earthly sphere. Like any physical body, the planet constantly emits radiation whose wavelength depends on the temperature of its surface. The radiation emitted from the surface of the earth is in the infrared range, which can be absorbed by some of the trace gases of the atmosphere. The presence in the planet´s atmosphere of the carbon dioxide, methane and water vapor trace gases, entails an increase in the air temperature in the low part of the atmosphere. For the same average global temperature in different geological stages, the air temperature depends on the spatial distribution of the emerged lands, the oceans and the circulation of water in them and on the concentration of trace gases in the lower part of the atmosphere.

Figure 1: Global Temperature Trends



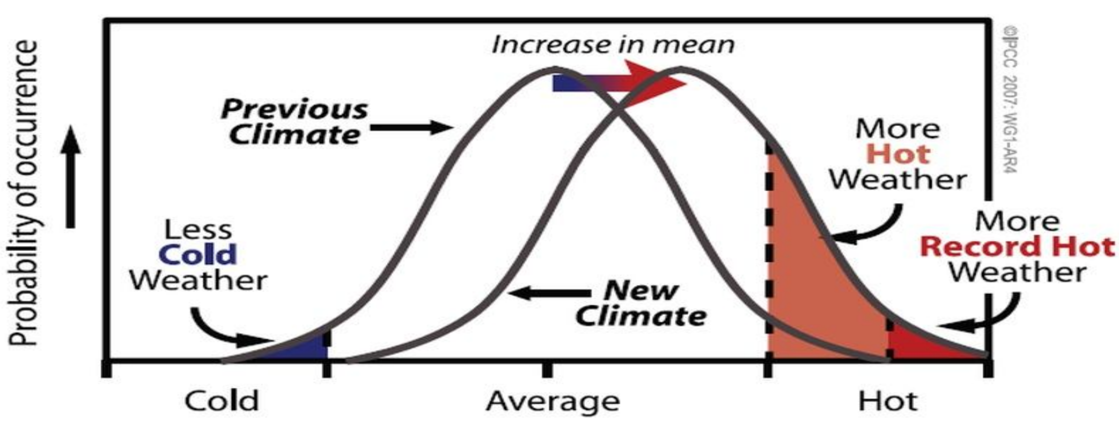
(Top) Patterns of linear global temperature trends over the period 1979 to 2005 estimated at the surface (left), and for the troposphere from satellite records (right). Grey indicates areas with incomplete data. (Bottom) Annual global mean temperatures (black dots) with linear fits to the data. The left hand axis shows temperature anomalies relative to the 1961 to 1990 average and the right hand axis shows estimated actual temperatures, both in °C. Linear trends are shown for the last 25 (yellow), 50 (orange), 100 (purple) and 150 years (red). The smooth blue curve shows decadal variations (see Appendix 3.A), with the decadal 90% error range shown as a pale blue band about that line. The total temperature increase from the period 1850 to 1899 to the period 2001 to 2005 is 0.76°C ± 0.19°C. Source: IPCC 2007, Figure TS.6.

The history of mankind has run over the past million years, and it is likely that many of the social changes in the records would be related to the sequences of glaciations, melting and interglacial periods. It is interesting to see that the last glacial period ended about 8000 years before the Christian era. The legends about floods may have had something to do with this, and we can remember that a new form of social life of the human race also began at that time. As the climate is a temporal sequence, it is difficult to understand what we mean by "climate change." The climate is constantly changing, however what we have been detecting in the last 100 years is a much faster rate of change than those that correspond to the time sequence recorded for earlier historical periods, and in a very different way.

The data submitted so far indicate that the average global temperature will rise at least 4°C in about 200 years, from 1900 to 2100, and this is due to the concentration increase of greenhouse gases in the atmosphere. ¿Does this raise any problems in human society? Humans have adapted to all kinds of time sequences of temperature and precipitation, and live in the tropics as well as in the hot deserts and the ice deserts. Therefore, we may assume that a rise of 4ºC in the global average temperature will not prevent the existence of the human race to continue. But the question is not so much the continuation of the species, but how the species will adapt to the new conditions. We should not forget that the average global temperature between an ice age and an interglacial period like the current one is only between 3ºC and 6°C. This shows the gravity of the described climate predictions for this century. Along with this, the present rate of change exceeds in speed the rate of human life, so many people will notice these changes throughout their lives.

The expected increase of the average global temperature is associated with a wide range of potential impacts with significant regional differences. And extreme climatic events are also likely to increase. Global warming itself is not due to bad weather, but this makes it more likely (Sagan, 1997). Extreme and non-extreme weather or climate events affect vulnerability to future extreme events by modifying resilience, coping capacity, and adaptive capacity. Also, a changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events. It is virtually certain that increases in the frequency and magnitude of warm daily temperature extremes and decreases in cold extremes will occur in the 21st century at the global scale. It is very likely that the length, frequency, and/or intensity of warm spells or heat waves will increase over most land areas (IPCC, 2012).

Figure 2: Extreme Weather Events



Schematic showing the effect on extreme temperatures when the mean temperature increases, for a normal temperature distribution. Source: IPCC 2007, Box TS.5, Figure 1.

It is quite clear that the impacts of climate change will not be equitable. The poorest countries will suffer earlier and more, despite having contributed less to the global warming. Moreover, developed countries as a whole will be less vulnerable to climate change for two reasons: a) their ability to adapt is higher due to their greater financial resources, increasing their resisting capacity to climate change; b) they are situated (in general) in colder latitudes, and therefore farther from the thermal thresholds that affect health and agricultural activities. Professor Stern reminds us: "It´s an unfortunate twist of fate that the most affected countries are often those who have contributed least to create the problem and can´t cover the costs of adaptation. However, they can still allow themselves less not to adapt "(Stern, 2006).

3. Uncertainties about Carbon Sinks

As Professor Rose points out, carbon sinks are considered a solution to mitigate the effects of climate change. However, diverse direct and indirect studies demonstrate the uncertainties of this apparent solution. There are arguments against the idea of sinks which can be classified into five types: 1) Environmental factors affecting sinks, 2) possible inefficiency of sinks, 3) time limitations, 4) adverse effects of actions such as injection of CO_2 in the oceans and massive reforestation and 5) lack of knowledge of the mechanisms responsible for the operation of sinks.

There are not few students of these subjects who as Houghton *et al*. (1999) state that the rate of accumulation of carbon in terrestrial ecosystems, and the mechanisms responsible for the operation of sinks are uncertain. This is the most relevant point of the discussion concerning sinks because an effective solution is not possible without knowing what that effectiveness entails. (Sundquist, 1993; Houghton *et al*. 1999; Smaglik, 2000). This effectiveness is also influenced by several factors, among which is climate change itself (Cao and Woodward, 1998; Sarmiento *et al*, 1998; Tian *et al*, 1998; Schimel *et al*., 2000). For example, the El Niño phenomenon acts as a control of terrestrial carbon storage (Keeling *et al.*, 1995). If the temperature increase does not stimulate the rate of decomposition of carbon in forest soils (Giardina and Ryan, 2001), sinks would continue to be useful in the long term regardless of global warming. Even Schimel and collaborators (2000) found that the effects of climate and of CO_2 in carbon sequestration in the United States are probably equal or less than the effects of intensive forest management and agricultural abandonment.

Soil fertility and excess rain can also decrease CO_2 sequestration (Oren *et al.*, 2001, Sarmiento et al 1998.). These factors may be determining the inefficiency of sinks and implying economic repercussions increasing in the long term (IGBP., 1998, Cox *et al*, 2000). In addition, there may be a number of harmful effects such as the alteration of ecological interactions in the ocean due to CO_2 injection (Dalton, 1999) and the increased absorption of solar radiation by the massive planting of forests (Betts, 2000 effects).

The evaluation of the contribution of land use and vegetation growth is a critical point in the planning of strategies to mitigate the accumulation of carbon dioxide in the atmosphere (Caspersen *et al.*, 2000). For example, Smaglik (2000) notes that if there is an increase in vegetation growth, storage potential is increasingly uncertain (see Table n.1.).

Table 1: Negative Interpretation Investigations, Regarding Carbon Sinks

Argumentos		**Referencias**
Environmental factors affecting sinks	- Soil fertility can reduce the response of carbon retention in wood, in relation to the increase in atmospheric carbon dioxide	Oren *et al.*, 2001
	- The absorption of anthropogenic emissions by terrestrial and oceanic ecosystems is sensitive to:	
	- The concentrations of carbon dioxide	Schimel *et al.*, 2000.
	- The Climate Change	Cao and Woodward, 1998; Sarmiento *et al.*, 1998 ; Tian *et al.*, 1998; Schimel *et al.*, 2000.
	- El Niño is a control of terrestrial carbon storage	Keeling *et al.*, 1995
	- Increases in temperature can accelerate the decomposition of organic carbon in forest soils and, consequently, global warming may increase the release of organic carbon from the ground to the atmosphere	Cao and Woodward, 1998
	- The ocean is affected by the increase of rain which causes water stratification to occur, reducing the carbon flow to the depths and the heat loss to the atmosphere. The result is a decrease in the sequestration of anthropogenic carbon dioxide.	Sarmiento *et al.*, 1998
Inefficiency	- The accumulation of carbon in deep soil layers of forests is not evident, so carbon sequestration is unlikely in them	Schlesinger y Lichter, 2001
	- There is a reduction of 6 Pg* of carbon per year in the sinks. Storing carbon dioxide has been estimated at 200$ per ton of avoided carbon emissions. Therefore, the cost of compensating an annual loss of 6 Pg in the carbon sinks would be of 1.2 billion dollars per year.	Sarmiento, 2000
	- If jungles are growing in response to changes in land use (new forest growth) ,the sink will saturate when they recover their initial biomass	Caspersen *et al.*, 2000; Smaglik, 2000
	- The high concentration of carbon dioxide causes a further increase in the flow of carbon than in its storage.	Hungate *et al.*, 1997
Time Scales	- The sequestration of carbon by sinks can compensate for fossil fuel emissions only temporarily.	IGBP, 1998
	- The biosphere will act as a sink until 2050, but after that it will be a source	Cox *et al.*, 2000
Harmful Effects	- Injecting carbon dioxide to the ocean may change its chemical composition with harmful ecological consequences	Dalton, 1999
	- Carbon sequestration by forest planting can increase warming in some high latitude regions. The reason is the ground surface darkening by trees which implies more absorption of sunlight.	Betts, 2000
Ignorance	- The rate at which carbon is accumulated in terrestrial ecosystems and the mechanisms responsible for the functioning of sinks are uncertain	Sundquist, 1993; Houghton *et al.*, 1999; Smaglik, 2000

Source: own elaboration, through the works of Rosas, C.A

The downside of relying on sinks as a solution to mitigate the effects of climate change is partly due to their fragility. Anthropogenic activities can quickly remove these reservoirs, as in the cases of deforestation (Chambers et al., 2001) or the use of fire (Smaglik, 2000). The burning of forests has, among others, the problem that it is not adequately controlled by competent authorities. However, the increase of forest land followed by fire elimination causes carbon storage in forests (Tilman et al., 2000). The conservation of forests, unfortunately, is not included in the Clean Development Mechanism of the Kyoto Protocol (Bonnie et al. 2000). Nevertheless, it is clear that their conservation generates significant profits locally and globally, as for example, regarding the use of the timber resources and agriculture (Kremen et al., 2000).

The problem is that, nationally, the financial benefits of these two types of activities are greater than those of conservation. For this reason, Kremen and collaborators (2000) suggest that the Kyoto Protocol could overcome this obstacle by creating markets for the protection of tropical forests to mitigate climate change. These markets should be efficient as costs remain high for the compensation of yearly losses in sinks (Sarmiento, 2000).

Terrestrial carbon sequestration is only a partial solution on the control of the increase in CO_2 emissions to the atmosphere (Chambers et al., 2001). It makes no sense to base all the effort to mitigate the effects of climate change in the use of sinks. Nor does arguing, even if it was true, that the land used for farming and grazing are sinks, only to ignore the problem of the fate of the emissions ensuring that these land areas counteract the effects of industrial activities in one country or another (Smaglik, , 2000). Moreover, although it is said that all managed and unmanaged ecosystems should be considered terrestrial sinks, all countries should focus their efforts to adopt decisive measures to reduce carbon emissions to the atmosphere. These types of measures should be adopted by industrialized countries, rather than supporting projects to reduce greenhouse gas emissions in developing countries rather than in their own (Smaglik, 2000). It is for this reason that these considerations lead to the conclusion that sinks are not a panacea and that there are steps to take, such as reducing emissions that have not yet been enforced due to various interests.

4. Biological Uncertainties of Climate Change

The multitude of relations established between anthropogenic and natural factors and their influence on ecological processes associated with one or more organization levels, attributes to the study of climate change an inescapable difficulty. The effects of changes in land use, the fragmentation of habitats, the increase in nitrogen deposition, the introduction of non-native species and their interactions on the environment are difficult to quantify separate from the effects generated exclusively by climate change.

If we focus on the pressures that climate change can generate on ecosystems, we find that this is a significant additional pressure on terrestrial ecosystems, already seriously affected at present by pollution, over-exploitation and land fragmentation. The Intergovernmental Panel on Climate Change already warned in the fourth report (IPCC, 2007) that on average, 33% of the current forest area will be affected due to changes in the frequency and intensity of fires, water distribution and wildlife diversity (Dale, 2001). Scott *et al*. (2000) and Mouillot *et al*. (2002).

The effects on terrestrial ecosystems vary from one region to another. So subtropical dry forests in Zimbabwe could diminish around 45%. In Mexico it is expected the expansion of dry forests, while the coverage of humid montane tropical forests is likely to be reduced. In tropical regions are also expected changes in the structure and composition of forest stands, due to their sensitivity to changes in water availability and soil moisture. In boreal and temperate forests temperature rise could extend the temporal growth and reproduction ranges, favoring its poleward expansion, but in turn increasing the frequency of fires and pest outbreaks.

An increase of one degree Celsius can cause significant changes in the composition and distribution of certain plant populations and, according to the IPCC, trees we associate with mature forests (slow-growing species) are expected to be replaced by quick-growing trees and shrubs associated with disturbed areas. It is also expected for the vegetation distribution to move to higher elevations at a rate of 8-10m per decade so some species limited to mountain tops could become extinct. Other studies show that the distribution margins of some species of birds and butterflies have also moved further north and to higher altitudes (e.g., 18.9 km on average for British birds as Thomas and Lennon, 1999 and 2nd in latitude for the *Euphydryas editha* butterfly as Parmesan, 1996).

Globally, the effects can be very serious. In the USA it is estimated that a rise of just one foot (0.3048 meters) in sea level would eliminate 17 to 43% of its wetlands (EPA, 2002).

Arid and semi-arid areas seem to be the most vulnerable to rainfall reduction, as experienced by the great Lake Chad with its dramatic surface decrease since the sixties of the past century. Wetlands in high latitudes are particularly vulnerable to global warming and a change is foreseen in its distribution northwards. In the Iberian Peninsula, summers will be drier and will endanger habitats such as Doñana. Coastal systems will be affected due to the rise of sea level and water temperature, and also to the increased risk of storms. Thus, the low-lying coasts of western and central Africa are exposed to the risk of erosion and flooding and a fraction of the Nile Delta could be lost. In Europe some coastal areas are under the mean sea level and many are vulnerable to storm surges, and in the low-lying coasts and estuaries of Latin America, rising sea levels could reduce the shoreline and much of its biodiversity.

It is expected a significant loss of ice in the Arctic, which would increase flooding in other geographical locations and transform the landscape greatly. In Antarctica the expected changes are smaller, but could prompt the poleward displacement of some species, and many other ice-dependent species could be disadvantaged in both polar areas. Alterations in a few degrees on the sea temperature may also have important trophic disorders. In the Galapagos Islands, during the El Niño phenomenon of 1997-1998, the water surface temperature increased and a great number of filtering organisms died as a result of the decrease in plankton in which they fed on, altering the food web.

In addition, the disappearance of many species as a consequence of the climate change will have a major impact on agricultural ecosystems for which they provide sevices such as soil fertility, pollination, and the fight against diverse pests. Agricultural systems in poor countries will be the most affected, bringing about consequences for the global food certainty.

5. Conclusions

Where after, we can draw the following conclusions:

First Conclusion: the effects of global warming sound remote, but the disorders are on our side. The nature around us changes. Birds, plants and insects behave differently. This is the everyday climate change and is already producing great biophysical and socioeconomic disorders. To ease that change trying to harm as little as possible the social and economic fabric of the world is one of the biggest challenges humanity faces.

Second Conclusion: The cost of fighting global warming will be very high. Reducing CO2 emissions is extremely expensive due to the dependence on fossil fuels. But the cost of not addressing this reduction is assumed to be greater in the long term, both socially and economically.

Third Conclusion: There is a high degree of confidence that neither adaptation nor mitigation alone can avoid all climate change impacts. Adaptation and mitigation can complement each other and together can significantly reduce the risks of climate change.

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