NOTES FOR THE AGENDA OF CLIMATE CHANGE RESEARCH IN MEXICO

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ABSTRACT

Climate change is a challenge to the academic communities and is an issue at the frontier for very diverse scientific disciplines. Climate change, by itself, necessarily implies changes in the social, economic and cultural policy paradigms. This area of study requires the creation of an agenda of academic research which contributes to the transition from the decoupling of economic growth in emissions of greenhouse gases.

Keywords: *Climate change, climate model, multidisciplinary scientific agenda*

Climate change is a scientifically proven fact and every year data supporting the existence of this phenomenon caused by human activities are added. Therefore, it is necessary that research on the issue is maintained. In this context, climate change has the challenge to build and consolidate its own methodologies, but also promote the realization of multidisciplinary research.

Therefore, climate change research must transcend the realm of the novel and fashionable to become, in the medium and long term, in the central area of economic growth and social development of Mexico. Research in climate change must not only pursue investigations that are replicated elsewhere in the world, but it should seek to become an academic frontier that serves, in itself, as a strategy of social adaptation.

WHAT IS CLIMATE CHANGE?

Climate change can be defined as an imbalance of energy in the atmosphere. This imbalance has been caused by global warming, which in turn has been caused by the excessive concentration of greenhouse gases discharged into the atmosphere since the Industrial Revolution of the nineteenth century.

The greenhouse effect itself is not something that can be seen as negative for the planet, in fact thanks that the atmosphere can fulfill the function of retaining heat and humidity is what, among other things, has allowed this planet to have life. This statement makes sense when you consider that without the presence of the greenhouse effect the actual average temperature of the world would be at least 18 ° C below zero. Thanks to the thermodynamic stability of the atmosphere the temperature differential is 33 ° C as the usual average global temperature is 15 ° C. (Garduño, 2004, p. 28)

While the atmosphere meets many different functions, in the present case, however, we have to focus on the already mentioned ability to concentrate energy because through it temperature, moisture amounts , and rainfall are regulated; so the atmosphere is a determining factor of the weather and climate.

One of the key elements in this global concern for the atmosphere is derived from the timing of climate change affecting the world. It this sense, it is necessary to say that the planet has already undergone changes of its climate in the past, but they were developed and consolidated over a very long time and usually identified with climate transitions in different geological eras. This area of analysis of climate changes in the past, can be documented with various techniques such as the analysis of lake sediments on the banks of rivers and lakes, permafrost, the rings of trees and many other tools of this kind. This area of research is called paleoclimatology and is part of the research agenda of climate change.(Lozano, 2004, pp. 65-76)

In other words, in the natural history of the planet, climate change has been a constant. The difference between natural climate change and climate change spoken about today, according to data we have, is that this new phase of warming has been caused by human activity that have focused on increasing the levels of welfare and development of nations and peoples. The timing of the start of the so-called Industrial Revolution leads directly to the middle of the nineteenth century. This means that in just 150 years on average mankind has induced a change of climate which naturally would have taken the planet thousands of years generate.

In this very short period of time, what mankind has done to the atmosphere is induce a change in the natural balance of its components in an unnatural way; that is, that there has been an excessive concentration of gases with global warming potential whereby the regular dismissal of surplus energy into space is prevented and they are trapped in the Earth's atmosphere,

increasing the temperature of the planet. Therefore, there is a direct correlation between the greater amounts of such greenhouse gases in the atmosphere with the rise in global average temperature.

This is why Paul Crutzen, in the middle of an academic debate, suggested the idea of considering the period we live as the Anthropocene. This contribution is moving in the paradigm that climate changes are characterized as transitional stages between very long geological eras and that what exists today has been a result of the change in the energy balance of the atmosphere, so much so that the change is unstoppable given life scenarios that do not have, at least at this time, much certainty. Paul Crutzer formally wrote this dissertation in 2000 and since then has managed a research branch that is slowly increasing. In an of itself, the Anthropocene analysis should be considered as one of the themes of the current scientific agenda not only in the context of climate change. (Crutzen and Stoermer (2000), Duarte Quesada, Carlos M. (Ed) (2006); Di Donato, Monica (2009); Vilches and Gil (2009), Gonzalez, Jose A. and Carlos Montes (2010); Schwagerl, Christian (2011), Fernandez Duran, Jorge (2011), Irwin, Ruth (2011) and Syvistki, James (2012).

EVIDENCE OF CLIMATE CHANGE

The correlation of an increase in greenhouse gases-rise in global temperature is relatively new in the study of the atmosphere (features and functions) and can be traced back to early last century. Three authors can be considered as the pioneers of this area of research. For the first case we can find Svante Arrhenius is the document entitled “Über die Wärmeabsorption Kohlensäure Durch und die auf Ihren Einfluss Erdoberfläche der Temperatur.” but it did not become popular until 1908 when the document was

published in English. (Arrhenius, S. 1901, 1908). After him was Guy Stewart Callendar who published an article called "The artificial production of carbon dioxide and Its influence on climate" (Callendar, 1938). Within this aspect of the pioneers in this area of research we close with Roger Revelle who in 1957 published "Carbon dioxide exchange between atmosphere and ocean and the question of an increase of atmospheric CO2 during the past decades" (Revelle and Suess, 1957).

From that moment, there has been developed an area of research that has been promoted by various academic institutions and bodies belonging to the United Nations (UN). This aspect of scientific and instrumental research can be traced to the results of the World Climate Conference that was organized by the World Meteorological Organization in 1979. The result of that meeting was that the scientific community came out with the task of verifying the existence of climate change, because they already had suspicions that human activities could be causing a mismatch in thermal system in the world (IISD, 2009, p.1).

In that sense thing to note it is that the Intergovernmental Panel on Climate Change (IPCC) jointly created by the Nations for the Environment Program and the already mentioned World Meteorological Organization in the year 1988 Toronto, Canada, which understands the weather, in a restricted sense, as the average weather and more rigorously, as a "statistical description of the weather in terms of the mean and variability of relevant quantities over periods that may range from months to thousands or millions of years. The usual averaging period is 30 years "(IPCC, 2007, p. 78).

Based on the narrow definition of climate, the IPCC understands climate change as a change of state of identifiable climate (for example, using statistical tests) by changes in the mean and / or the variability of its properties, which persists for long periods of time, typically decades or longer. Climate change may be due to natural internal processes or *external forces*, or to persistent

anthropogenic changes in the composition of the *atmosphere* or *land use*. (IPCC, 2007, p. 77).

Based on the definition of climate that the IPCC uses and taking it as a starting point for the research agenda in its task of checking the existence of climate change (a task that has been indicted by the IPCC since its inception to date) then it can be understood that what happened was that the scientific community had, necessarily, to do a search of historical data for both temperature and precipitation to prove or disprove the hypothesis.

In fact the proving of this problem, with 90% confidence (Conde, 2010, p.17), was announced to the world in 2007 with the publication of the Fourth Assessment Report of the IPCC and that certainty has been extended with the appearance of the Fifth Assessment Report of the same organism.

Today, the existence of climate change has not been refuted, and it can even be said that every year confirms its existence as the World Meteorological Organization report published annually by the State of World Climate. The report corresponding to the year 2014 has emphasized that all the years since 2000 are in the range of the hottest 20 years, "14 of the 15 warmest years since records have been taken during the XXI century [...] are maintained, demonstrating, that "global warming is caused by human activity." (WMO, 2015, p. 2)

However, the global concern of climate change not only lies in the fact that the likely adverse impacts that climate change would generate in the world and which has opened a spiral of uncertainty for taking political decisions in the matter. Another element of concern to the academic community dedicated to the analysis of climate change has to do with the timing of the effects caused in the climate system caused by increased concentrations of greenhouse gases.

The premise of these long-term scenarios are simple: if the world's societies implement mitigation and emissions are stabilized by the end of this century, the stabilizing of the global

temperature would still take several centuries to regulate and regulation of sea level would take at least a millennium.

As already stated, the existence of climate change has a high level of scientific consensus. It is that understanding that the correlation of emissions-climate change has sought to be reversed or at least disengaged. What has been proposed is that countries stop looking for increased levels of welfare and economic development, but rather that economic activities disengage from the emission of greenhouse type gasses, for which emissions reduction has acquired a central role in the issue of climate change.

With regard to the increase in temperature, it has been placed by the *international climate diplomacy* in the range of 2 ° C but this threshold must be based on a significant fact: from "1880 to 2012 the average global temperature has increased 0.85 ° C "(IPCC, 2014, p.2)

ACADEMIC CHALLENGES OF CLIMATE CHANGE IN THE WORLD

If climate change is directly related to the form and the ways in which societies around the world have obtained their standards of economic growth and social development, then it becomes clear that societies must change their paradigms. It is, in other words, to imagine a kind of world that is different and in which the existence of the human species is assured in the best possible terms, not only to the current dwellers on the planet, but also for future generations.

In this case, science must provide politicians and decision makers from around the world, as much as possible, the most detailed scientific information on future scenarios that are expected while testing options to the solutions of such problems.

In that sense the most current research agenda is being coordinated by the IPCC. This information was released in its Fifth Assessment Report and has the same structure of the four reports submitted previously: for example, group I is dedicated to increasing knowledge of the scientific basis of climate change, group II is focused on the analysis impacts, threats and adaptation strategies and also features an analysis by continental regions, small island states, the polar regions and open oceans. Finally the working group III is devoted to the analysis of mitigation strategies, but also includes analysis of political criteria decision making in a context of uncertainty and potential funding sources.

The topics reviewed by each of the working groups of the Report were:

Topics of Working Group 1

- Observations: atmosphere and surface, the oceans and cryosphere.
- Information for paleo climatic archives
- Carbon and other biochemical cycles
- Clouds and Aerosols
- Radiative anthropogenic and natural forcing
- Evaluation of climate models
- The detection and attribution of climate change: from the global to the regional
- Climate change in the short term: projections and predictability
- Long-term climate change: projections, commitments and irreversibility
- Sea level changes
- Climate phenomenon and their relevance for future climate change at regional levels

Topics of Working Group 2

Part A: global and sectoral aspects

- Bases for making decisions

Natural resources and systems as an object of management and uses

- Freshwater resources
- Terrestrial and inland water systems
- Coastal systems and low-lying areas
- Oceanic systems
- Systems of food production and food security

Human Settlements, Infrastructure & Industry

- Urban areas
- Rural areas
- Key economic sectors and services

Human health, welfare and safety

- Human health
- Human security
- Life & poverty averages

Adaptation

- Needs and options for adaptation
- Planning and execution of adaptation
- Opportunities of adaptation, restrictions and limits
- The economy of adaptation

Multi-Sectoral impacts, risks, vulnerabilities and opportunities

- Detection and recognizing of observed effects
- Emergent risks and key vulnerabilities

- Resilient climate pathways: adaptation, mitigation or sustainable development

Part B: Regional Aspects

- Regional context
- Africa
- Europe
- Asia
- Australasia
- North America
- Central and South America
- Polar Regions
- Small Islands
- Open oceans

Topics of Working Group 3

Highlighted issues

- Report on political answers implemented in climate change policies under risk management and uncertainty
- Concepts and social, economic or ethical methods
- Sustainable development and equity

Ways to mitigate climate change

- Drivers, trends and mitigation
- The evaluation of transformative pathways
- Energy systems
- Buildings
- Industry
- Agriculture, forestry and other land uses
- Human settlements, infrastructure and territorial planning

Assessment of policies, institutions and finance

- International cooperation: agreements and instruments
- Regional Development and Cooperation
- Policies and national and subnational institutions
- Investment and Finance (Crossover issues)

THE CHALLENGE OF GLOBAL CLIMATE FINANCING AS A RESEARCH TOPIC

At the moment there is no cost estimate consistent enough about how much climate change costs, for example Nicholas Stern said that this phenomenon is "tantamount to lose between 5% and 20% of annual global GDP each year." (Stern, 2007, XV) and on the other hand, the UN Framework Convention on Climate Change (UNFCCC) has indicated that only to mitigate "global additional investment and financial flows between 200 and 210 billion would be required in 2030 "(UNFCCC, 2007, 6) while regarding adaptation the Convention itself has not been able to give an estimate.

Still, climate finance has been occurring since the Framework Convention on Climate Change was established, through the Global Environment Facility and various financial instruments and funds to date. In that sense, this type of financing may be included in the green economy because of "low carbon emissions, efficient use of resources and is socially inclusive" (UNEP, 2011, p. 18)

Climate finance is one that seeks to "reduce emissions and enhance sinks of greenhouse gases , and their goal is to reduce vulnerability and maintain and increase the resilience of human and ecological systems to the negative impacts of climate change." (UNFCCC, 2014, p. 19) but is immersed in a global social and

economic context of free market which is why the environmental benefits of reduced emissions have been placed into debates that go beyond what environmental and benefits of its implementation, so in the context of global academic discussion there can be found discussions dealing about what and how to finance the transition to decarbonized economies (Clapp, Ellis, Benn and Corfee-Morlot, 2012). The role of rapid financing mechanisms have also been reviewed (Nakooda S., et al., 2013), and what kind of institutions should be involved in climate change financing to maintain the principle of a mixed economy and the prevailing global free market from the 80s of the twentieth century has also discussed. (Smallridge D., et al., 2012)

Given this complexity of analysis, and considering that there are over 20 financial funds to which countries can go to and say that, as a research topic, the overall financing strategy is "messy and complicated, with multiple funds, each of which has its own objectives, internal logic and ways of functioning "(ECLAC, 2015, p. 8) which shows that academics can help shape how it should be and make climate finance at global, regional and national scales.

THE CHALLENGES OF CLIMATE CHANGE FOR THE MEXICAN SCIENTIFIC COMMUNITY

Climate change provides an opportunity to do things other than how they have been done so far. So the first thing to be known is what kind of themes will echo in the Mexican scientific community. Secondly, what kind of scientists should be incorporated in this task and finally, what is the importance of such research for the future of Mexico.

In the first instance it is necessary for the scientific community to incorporate the research agenda of the IPCC and suits the needs of Mexico. That is, if the world is looking not only

to improve climate information, the scenarios should be that it permeates every aspect of national scientific research. Not only is necessary to tropicalize the topics of the IPCC, but rather see the reality and climate scenarios for Mexico in a regionalized way. (Conde et al, 2010) Nor is it that the Mexican scientific communities only make a large inventory of research that has already been done in Mexico. It has to do with making climate science form part of the world vanguard on the subject.

In Mexico, the issue of climate change should serve to also answer broader questions and they would have to do with security and integrity of individuals in the context of climate change, when, how and at what cost would the endogenous boost in technological innovation be which allows the country to promote a renewal of its industrial park, using alternative energies developed by Mexican researchers.

We must necessarily enter the global academic debate on low carbon emissions, green economy and green growth to understand what paths they must follow in the coming years on climate change. The economic dimension should venture into the analysis of international cooperation and existing mechanisms for funding to date and the role they will play the Green Climate Fund in the financial architecture for climate change, which will begin operating starting in 2020.

In the context of climate change, the development of the Fifth Assessment Report of the IPCC, Mexico was placed in the region of North America with the United States and Canada. There is the fact that the North American Free Trade Agreement is still in effect, but in the context of international climate talks Mexico does not negotiate with its trading partners of the regional bloc placed by the IPCC. Since both Canadians and Americans are part of Annex I of the Kyoto Protocol (although the United States has not ratified it and Canada has ceased to belong to the instrument) in the climate negotiations, Mexico is part of Environmental Integrity Group (made up by the Repu-

blic of Korea, Monaco, Liechtenstein, Switzerland and Mexico) and therefore no longer negotiates alongside the Latin American regional bloc. Mexico in an international context is not part of the working groups of the American continent. This fact by itself is one of the issues that are part of the research agenda of our country in the context of climate change.

In the Fifth Assessment Report of the IPCC, there are specific accusations against the Mexican case and that in itself involves areas of research to the scientific community. These themes are:

- The weather in North America has changed and some changes are socially relevant that have been attributed to anthropogenic causes (very high confidence). The recent climate changes and extreme single events show both impacts from the tensions and exposed climate-related system vulnerabilities (Very high confidence).
- Many pressures on climate carry risks, particularly those related to intense heat, heavy rainfall, and reduction in snow cover increase its frequency and/or severity in North America in the coming decades (Very high confidence).
- Hydric resources are already stressed in many parts of North America, as a result of causes unrelated to climate change, and is expected that they get even further stressed due to climate change (high confidence).
- Effects have been observed in the modification of the temperature or climactic variability in the yields of the principal crops (high confidence). Projected increases in temperature, reductions in rainfall in some regions, and increased frequency of extreme events can be translated into the reduction in net productivity in the main crops in North America at the end of the XXI century without adaptation, although the rate of reduction varies according to the scenario and model, and in some regions, especially in the north can be benefits (Very high confidence).

- They have been observed effects on human health because of extreme climate phenomena, although the relative trends on climate change and the attribution have not been confirmed to date.
- Observed impacts in livelihoods, economic activities, infrastructure and access to services in urban and rural settlements of North America have been attributed to a rise in sea level, changes in temperature and rainfall, and the occurrences of extreme events like heatwaves, drought, and storms (High confidence).
- Much of the infrastructure in North America is currently vulnerable to extreme climate events and, if investments are not made to strengthen them, they will be even more vulnerable to climate change (Medium confidence).
- Most of the sectors of the economy in North America have been affected by and have responded to extreme meteorological conditions including hurricanes, floods and heavy rains (High confidence). (IPCC, 2014, pp. 1443-1445).

To do this type of investigation it is required to maintain the base of scientists that are already making climate change research, but it is essential that the volume of scientists dedicated to this task increases. This group of specialized researchers in atmospheric sciences can put as a goal working to give a strong impetus to the investigation of the atmosphere and its interactions and even create its own model of future climate.

It is also required to encourage the participation of social scientists to help them analyze the current social conditions of Mexicans and understand how social actors, both individually and collectively, interact before the manifestations of natural climate variability and climate change because this cannot be done through climate models.

In the context of climate change, and because of the likely adverse impacts, it is necessary that the scientific communities

of Mexico learn to work in a multidisciplinary way, but leave behind the participation schemes in which the work is divided and only meet at the end to integrate a final version of a research report. In that sense, it is necessary to create mechanisms of communication and interaction among researchers that have it as a language and process of encoding the issue of climate change.

Climate change must begin to look like a science amalgam, in which various scientific disciplines can raise the possible scenarios in which they will have to generate their processes of social development and economic growth.

Due to its geographical location and its biodiversity, Mexico has been listed as vulnerable to the impacts of climate change (Gay *et al*., 1995; Gay *et al* 1996;. Gay, 2000) therefore climate science and scientists dedicated to this issue must begin to play a more important role in creating the policy options to help the country to be sustainable, despite the adverse climate scenarios. In that sense, the study of climate change should be seen as a strategic element for the future development of Mexico.

The impacts associated with climate change, are expected in the agricultural, water, and coastal sectors, more storms and a severe climate, ecosystems and biodiversity, as well as damages to strategic infrastructure which is necessary to reduce the vulnerability of the population and productive sectors and increase their resilience and strength of the strategic infrastructure ", as well as conserve, restore and manage sustainably ecosystems ensuring environmental services for adaptation and mitigation of climate change. In other words, the research agenda on the issue is guaranteed to exist for a long time.

In this same area of academics there have been made new assessments of impacts on biodiversity (Trejo *et al*, 2011;. Gómez Díaz, JD *et al*., 2011) thermal stress in human populations (Tejeda-Martínez A. *et al*.. , 2011) agricultural productivity (Monterroso Rivas AI *et al*., 2011) fisheries (Martinez Arroyo, A. *et al*., 2011) studies of comfort according to temperature-humidity

index (Hernández A. *et al*., 2011) and water resources (Sanchez-Torres Esqueda, G. *et al*., 2011).

Some areas of research interest can be taken from the *National Climate Change Strategy. Vision 10-20-40* as the document considers that climate change represents a great opportunity to conserve and sustainably use natural capital, leverage the huge potential for developing clean energy, correct inefficiencies in the use of energy, create jobs with a green economy, promote sustainable territorial development, increase competitiveness and improve public health and quality of life of the population (SEMARNAT, 2013, p. 9).

This same diagnosis calls for the analysis of climate change with the downscaling at the municipal level. The Government of Mexico, the Special Climate Change Program 2014-2018 identifies 1,385 municipalities vulnerable to various climatic events such as floods, landslides, agricultural drought, decreased precipitation and temperature performance, heat waves and disease transmission (Government of the Republic, 2014) in this case, not only does it deal with climate issues, but how to combat poverty, because from the point of view of governmental logic poverty is the main factor of social vulnerability associated with the impacts of future climate change.

CONCLUSIONS

For many, climate change is a hot topic, from the field of research it is a fascinating subject because it allows the possibility of entering areas that are at the frontier of knowledge. However, climate change, as a scientifically proven fact, is much more than just that, since it has to do with the future of humanity and under what conditions the social and political communities around the world will have to live.

In the case of Mexico, it is necessary to promote research on climate change (monodisciplinary as well as multi and interdisciplinary ways) in order for the results of these investigations to generate alternative actions to implement in the short and medium term both in the field of mitigation and adaptation to the social problem.

Climate science in Mexico must be seen as an investment for the future of the country. This requires funds to diversify funding and the breaking of paradigms that have separated scientific communities. That is, we should think about the social adaptation of our country to the challenge of climate change, and can begin by doing such simple innovations such as those previously mentioned. The future of Mexico requires the formation of climate experts, but also a focused investment in research so that in the shortest possible time there can be generated plausible options to be implemented nationwide. Investing in climate science is an investment in the future of Mexico.

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