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ORIGINAL PAPER

Governing Climate Change Risks: Implications for Mitigation and Adaptation

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Abstract This article analyzed climate change risks from the perspective of contemporary environmental risks and how they have been internalized by policy. In order to do so, the main characteristics of this type of risk were analyzed based on the contributions from social theory authors on contemporary environmental risks. Next, the implications of these characteristics for the production of policy responses to climate change risks were discussed. The two main types of policy responses to climate change in the literature were presented: mitigation and adaptation. Finally, their interaction, differences and possibilities for synergy were analyzed. Understanding climate change as a contemporary environmental risk, the way it was presented in this article, implies a radical change in the development bases of society, since greenhouse gases emissions from human activities contribute to the aggravation of global warming. Climate change challenges the traditional ways of governing in many ways, since climate change policy should involve the questioning of the current processes of development. Profound changes in ways of thinking and established political action are needed.

Keywords Climate change risks · Contemporary environmental risks · Mitigation · Adaptation · Climate governance

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1 Introduction

The warning has been made: the Earth's average temperature may not increase more than 2 °C compared to the preindustrial levels by the end of this century or changes in the climate system will occur completely out of control. Still, global emissions of carbon dioxide, responsible for aggravating global warming, have increased their concentration in the atmosphere in record numbers during the last 800,000 years, reaching 400 parts per million in 2013 (IEA 2013). Climate change is characterized, therefore, as one of the greatest global challenges of the twenty-first century.

Scientists of all areas share the concern that our planet is in the exceeding process of hazardous biophysical barriers regarding the climate system (Lenton et al. 2008; Kriegler et al. 2009; Scheffer et al. 2009; Rockström et al. 2009). The transgression of these limits should increase the risk of irreversible climate change such as: the loss of major ice sheets, accelerated sea level rise and abrupt changes in forest and agricultural systems.

Natural science scientific researches are fundamental for a more comprehensive understanding of these processes. However, the results of a global survey of the International Human Dimensions Programme on Global Environmental Change (IHDP) showed that the human dimensions of the global environmental changes, and among them climate change, are also important, but severely underestimated (IHDP 2011). Furthermore, institutions, organizations and institutional arrangements through which people manage their relationships with the natural environment and global biogeochemical systems prove to be inadequate and poorly understood (Biermann et al. 2010). The better understanding of social and political dimensions of climate change could contribute to the pursuit of minimizing the impacts of global environmental changes.

This article analyzes climate change risks from the perspective of contemporary environmental risks and how they have been internalized by policy. In order to do so, the main characteristics of this type of risk are analyzed based on the contributions from social theory authors on contemporary environmental risks such as: Beck (1992, 1995, 2000a, b, 2009), Giddens (1990, 2000, 2009) and others. Next, the production of policy responses to climate change risks is discussed. The two main types of policy responses to climate change in the literature are presented: mitigation and adaptation. Finally, their interaction, differences and possibilities for synergy are analyzed.

2 Climate Change Risks and Contemporary Environmental Risks

Risk indicates the possibility that an undesirable state of reality or adverse effects may occur as a result of human activities or natural events (Kates et al. 1985). This definition suggests causal connections between actions or events. Thus, the risks need to be perceived in the causal articulations of conditions with actions and actions with effects. Therefore, the risks require a form of specific knowledge of the causal links between particular conditions, specific actions (decisions) and possible

consequences, since the conditions, actions and risk effects are spatially and temporally fragmented. So, the risk definition contains three elements: the results that have an impact on what people value; the uncertainty (the possibility of occurrence) and a formula to combine these two elements (Adam et al. 2000; Renn 2008). Beck (2008) adds that the risk is also a socially constructed phenomenon, and some people have a greater ability to define risk than others. This will be explored later.

Contemporary societies face risks of various kinds, such as: natural, environmental, industrial, technological, economic, geopolitical and social (Veyret 2007). This article works with environmental risks in order to better understand the social and political dimensions of global environmental changes, specifically what involves climate change. Regarding the methodological aspects, the proposed analysis is done from Ulrich Beck's perspective of risk (1992, 1995, 2000a, b, 2009, 2010), also worked by Giddens (1990, 2000, 2009), among other authors, since it adds important elements for understanding the environmental crisis in advanced modernity, by identifying new risks and their many social implications in contrast to the institutional, political and legal epistemological limits of the established social order. It also signals possible ways to reorient the treatment of these new environmental issues and their relations with the market, the state and civil society (Ferreira et al. 2012). The main ideas that characterize these risks and their relation to climate issues are important to be understood so it is possible to move forward in the analysis of how societies have responded to these risks in terms of political strategies and public policies.

Contemporary environmental risks are characterized as consequences of the development process of industrial society and are directly influenced by the increasingly intense globalization process (Beck 1992, 2009; Beck et al. 1994). This proposition can be applied to climate change: apparently innocuous gases, such as methane and carbon dioxide, are released as development products (through agricultural industrialization, increased energy consumption and economic growth) and alter the composition of the atmosphere with potentially drastic incalculable consequences to ecosystems and societies (Bulkeley 2001). Scientific and technological advances can help to generate more risks. Thus, the side effects of industrial production are characterized as a deep institutional crisis of industrial society itself.

Their close relationship with the future and the "misfortunes" is another feature of contemporary risks, which is often associated with future possibilities. The risks make present something that does not exist yet, that is, future events that may occur and cause threats. In this case, a consequence of this relationship with the future is the uncertainty, since it is not possible to know exactly what the world will be like in 20, 30 or 40 years. However, it is possible to mention probabilities and scenarios (Giddens 2009). In the case of climate change, the uncertainties regarding this issue have decreased with the increasing consolidation of climate scientific research in the world. The consequences of climate change are well documented, and there is more information and better understanding of future risks and impacts.

Despite many efforts to develop climate scenarios, risks and changes to every part of the planet, they still carry uncertainties and are available only to larger scales. It is still difficult to predict what might happen in more detail on a local scale. Uncertainties in climate modeling are present: in the future emissions of

greenhouse gases (GHG) and aerosols; volcanic and solar activity that affect the radiative forcing of the climate system; in direct effects of the increased CO_2 atmospheric concentration in plants and their behavior effect in the future climate; in the global climate sensitivity and regional patterns future climate projections simulated by the models; and in the natural climate variability. Some of this variability is the result of internal disturbances of the climate system (not forced by GHG), and the other would be associated with air pollution and release of GHG resulting from human activities (Marengo 2006; Ambrizzi and Lacerda 2012).

Hence, scientific knowledge about risks is largely characterized by sophisticated and accurate scientific calculations rather than by lay evaluation. However, they can also contain mistakes. The scientific risk assessment is permeated by uncertainty and may be partial (Murphy 2012).

Also in this issue, Beck (1992, 2000) estimates that the development of science and technology cannot fully predict and control the risks that they have contributed to create and once they are discovered, they tend to be irreversible. This is the case of climate change. Regarding the irreversibility of these risks, there are many studies that explore the transgression of the critical limits of the climate dynamics, from which there is no turning back. Even with the stabilization of GHG concentrations, the increasing in temperature and sea level will continue for centuries due to the timescales associated with climate processes and feedbacks.

Contemporary environmental risks are also characterized by "escaping" perception, situated in the sphere of physical and chemical formulas, keeping up "invisible." They are based on causal interpretations and at first they only exist because of knowledge about them. So, they can be changed, expanded, dramatized or minimized within the knowledge and, hence, are open to definition and social construction (Beck 1992, 2009). In the case of climate change, the understanding of the processes by which GHG affect climate systems, modeling and monitoring of future changes in global weather patterns are all dependent on scientific understanding.

As a result, the risks have two key dimensions: the real one and the one constituted by the perception and social construction (Beck 2000). The reality of the risks emerges from the impacts that are rooted in continuous industrial and scientific production. Perception and social construction are related to the knowledge about the risks, which are linked to the history and cultural symbols. This means that knowledge about complex issues includes symbolic and normative dimensions and that the statements about the risks are filtered through the interaction of the existing structures of meaning, of the social networks in which people are inserted, the media and other communication channels (Lockie and Measham 2012). These filters contribute to the attenuation or amplification of specific statements about the risks in the public discourse. And in these situations, they have a significant role, based on elements such as the magnitude, distribution and temporal structure of risk, trust and mistrust in the institutions that make claims about the risks and the complexity of cause and effect relations.

One problem in such cases is the spatial and temporal gap between actions and their impacts, i.e., the difficulty in understanding some symptoms of impacts and invisible effects of specific actions. Climate change is an illustration of this temporal

disconnection, because the responsibility shares of human activities for aggravating global warming have been discussed for a long time. In this perspective, the risks may be irrelevant or localized within their impact unless humans observe and communicate them to others (Luhmann 1979). Thus, the risk experience is not only the experience of physical damage but is the result of processes by which groups and individuals learn to obtain or create interpretations risk (Kasperson et al. 2003). In the case of climate change, the scientific reports produced by the Intergovernmental Panel on Climate Change—IPCC (1990, 1995, 2001, 2007, 2013)—contributed to the knowledge about their risks and their amplification in the public discourse.

To Yearley (2009), the social construction of climate change risks is perceived in three aspects. First, it is given by the projection on the future behavior of a huge complex system on which knowledge is not complete and is being built. The social construction of climate change risks also occurs because these risks depend on the assumptions that the people, the government and corporations will make. This is because social systems are directly related to the various mechanisms of climate change. People's behaviors, consumers and other stakeholders will affect climate change risks and will also be affected by them. The third aspect is related to the design and establishment of institutions within which climate risks projections are legitimately generated. This is characterized by a negotiation process with interests at stake.

The social construction dimension of risk is closely linked to the notion of risk perception. It deals with the psychological and emotional factors that strongly impact the behavior and that need to be considered in the development of risk management strategies (Slovic 2000). Decisions are affected by the perceptions of who takes them. As a result, climate change risks perception of policy makers influences government responses to the problem (Alber and Kern 2008).

Contemporary environmental risks are characterized by threats that arise for all humanity and occur globally as implicit result of the industrialization process (Beck 1992, 2009). Regarding climate change, experiences and sources of risk are distant in space and time, expanding the "web" of social and natural relations of their cause, effect and responsibility (Gandy 1999). The most historically responsible countries for GHG emissions (sources of risk) are not the only ones affected by the impacts of climate change. Despite the "boomerang effect" of this type of risk (Beck 1992), suggesting that the developed countries will also be affected by them, through changes in weather patterns and impacts that are associated with them, climate change risks unequally affect populations. They are most felt by the most vulnerable populations. The unequal dynamics of this type of risk make the understanding and analysis of local vulnerabilities central elements of analysis (Beck 2009).

As a consequence, contemporary environmental risks are both local and global (Adam et al. 2000). Environmental risks have no boundaries; they are universalized by the air, wind, water, food chains, ecosystems and all possible biogeophysical interrelations. In regard to climate change, the global dimension of risk refers to the instability of the climate system that affects the planet as a whole, while the local dimension refers to the consequences and impacts that are felt in specific places.

Some regions benefiting from the increase in global average temperature is also possible, such as the coldest inhabited areas of the planet, which can increase their cultivable areas.

This local and global simultaneity of risk is related to the "delocalization" of contemporary environmental risks. This means that their causes and consequences are not limited to one geographical location or space, causing them to be "omnipresent" (Beck 2008). The delocalization takes place at three levels: spatial, temporal and social. At the spatial level, in the case of climate change risks, they are not confined to borders, with no limits for them. In relation to the temporal level, risks have a long "latency period," so that their effect over time cannot be fully determined or limited. On the social level, the attribution of the causes and consequences of risks is not possible with any degree of reliability due to the complexity of the problems and the duration of the chain effects.

These risks are also characterized by "non-compensability," i.e., the idea that accidents may occur as long as, because they can be compensated, is not possible. This happens because of the difficulty of science and technology in controlling the consequences and dangers of climate change. Thus, the logic of compensation is replaced by the preventive and precautionary principle (Beck 2008). Since the changes in the climate system are real and dealing with their consequences is a great challenge, it is not prudent to allow these risks to materialize, because there can be no way to compensate them.

Finally, climate change risks can be materialized in the form of natural events such as: heavy rainfall, droughts, hurricanes and other events related to weather and climate. The consequences of these events are considered environmental disasters (such as: floods, landslides, contamination of water bodies, lightning and others) when they affect human populations causing displaced groups of people, deaths, injuries and economic losses. Giddens (2000) distinguishes between two types of risk: the "external," experienced as coming from outside, tradition or nature (for example, crop failures, floods, plagues and famine, among others) and "manufactured" risk, created by the very impact of our growing knowledge about the world. Although the author classifies climate change as manufactured risk, the risks of climate change manifest themselves in the form of external risks. Thus, it is difficult to distinguish climate change risks from natural processes/risks, considering the way they manifest.

In addition, Beck (2010) makes a distinction between climate risks and climate disasters: climate risks are the anticipation of these future disasters, in order to prevent them. This "present" future of climate risk is real; while the "future" future of climate disasters, on the other hand, is still unreal (Beck 2010: 259). In this sense, climate change risks are related to present-oriented future, aiming at present actions changes, especially by the governments, which play an important role in establishing an appropriate regulatory framework to respond to these risks.

The perspective of environmental risks based on the characteristics presented here differs from the risk perspective of other areas of knowledge, such as geography. In this case, risks "result from the association between natural hazards and risks from natural processes exacerbated by human activity and territory occupation" (Veyret 2007: 63).

Contemporary environmental risks, including climate change risks, characterize the global risk society (Beck 2009). As such, society becomes reflexive in three stages: first, when it becomes an issue itself; second, when the perceived globality of risks produced by civilization itself boosts the revitalization of national policies and the development of international cooperation institutions, and third, when policy loses its defined contours, allowing the formation of global and direct "subpolitics." Late modern society became a risk society when it started to increasingly engage in debating, preventing and managing the risks that it itself produced. The risks faced by humanity can be avoided by political action taken on behalf of endangered humanity (Beck 2008). Next, we examine the responses that have been given to these risks.

3 Responding to Climate Change Risks: Climate Change Political Strategies

Responses to climate change are increasingly non-optional. They are not only expected from enthusiasts, industrialized countries or major GHG emitters. For such a complex problem like climate change, solutions are equally complex, involving several fields of human activities, and different stakeholders and segments of society, such as: multilateral agencies, state governments, companies, associations, pressure groups and society in general, in order to clarify the causes of these risks and determine the conditions for their confrontation. Civil society, research institutions, universities, private sector and other stakeholders play an important role in the production of responses to the climate crisis. This article does not provide an analysis of climate governance, resulting from the interactions among the government, private sector, political parties, civil society organizations and others. Instead, it stands out the governments' role in the production of policy responses to climate change risks.

In addition to playing a key role in defining regulation, institutions, appropriate rules and modes of climate governance, governments are fundamental stakeholders in the production of responses to climate change for several reasons. First, government policies and incentives are important to enable financial investments of the private sector necessary to mitigate and adapt to climate change. In addition, with the increased frequency and severity of extreme weather events, governments are forced to improve their "insurance" function. Climate change exacerbates security problems, demanding the renegotiation of the border between public and private insurance systems. Governments may be pressured to become insurers by more people and more damages.

Second, governments also have an important role in investment on knowledge and learning platforms, especially regarding adaptation. Investments on research and development and more effective spaces for technological innovation are central in order to tackle climate change. It also requires information on the climate system at different levels and the exchange of experiences among governments, promoting policy learning.

Third, governments have the responsibility to guide the private sector, facilitate community action, establish decentralization in decision making, and adaptation and mitigation actions. In addition to the guidance, governments must play a reinforcement function, i.e., to ensure that goals and objectives are achieved through the emphasis on regulation, taxation, long-term planning and communication.

The climate issue has characteristics related to contemporary environmental risks discussed here, which imply challenges for policy responses to the problem. One of the biggest challenges lies at the development foundations of societies, regarding the dependence on GHG in industrial and agricultural activities for over 200 years. The transformation of production and consumption patterns in order to reduce emissions and adaptation to climate change requires radical changes in current practices.

Although there is a great understanding of the processes related to climate change and their implications for societies, many uncertainties still remain, especially with regard to sensitivity and stability of the climate system. GHG emissions from the burning of fossil fuels have increased since the Industrial Revolution and the climate system evolves over decades, centuries and millennia (Meadowcroft 2009). Such long-term issues do not fit well into the daily or weekly rhythm of everyday politics and into a 4-year electoral cycle, as in most countries.

All these factors contribute to make climate issue a difficult management problem. Table 1 presents the features related to climate change risks, underlying issues arising from them and the political challenges they pose.

The temporal issue related to climate change is linked to the issue of planning and, in this sense, the time of the problem, the time of policy making and the time of the impacts and consequences of the problem often do not converge. Climate issues force government planning for more than 4 years, which is usual in most countries. In addition to providing discomfort to policy makers, there is the difficulty of planning on what is still unpredictable, in some cases. To address climate change risks, policy needs a long-term perspective in terms of planning.

As a consequence, the main challenge that arises is how to establish policies to address climate change, when the future is uncertain and how to limit these risks, since there is no previous experience about them. They cannot be fully assessed until it is too late and expected dangers materialize. This challenge follows the "Giddens" paradox' (Giddens 2009), which states that once the dangers posed by global warming are not tangible, immediate or visible in the course of everyday life, many tie their hands and do nothing concrete about them. However, waiting until they become visible and tangible in order to take strong action may be too late. Thus, the difficulty of establishing climate change policy lies in the incorporation of uncertainties into specific regulatory instruments.

Considering the current signs of extreme weather events, one might think that uncertainty about future climate has two sides: one that the changes may be less severe than climate science has estimated; two that climate science is underestimating all of these events and the changes will be even more severe. Based on the characteristics of climate change risks presented in the previous session, it does not seem prudent for policy makers to wait until these risks become concrete hazards and disasters without doing anything to change that.

Table 1 Political challenges related to climate change risks. *Source*: Elaborated by the author, based on Beck (1992), Giddens (2009) and Meadowcroft (2009)

Structural feature	Underlying issues	Political challenges
Temporality based on long term	Gradual changes in atmospheric composition and increased evidence of climate change induced by human activities	Emission reduction benefits will be perceived in the future, but the economic costs happen in the present
	Current emission reduction effects will take decades to reflect into the climate system	Existing political institutions based on 4 years of electoral cycles, in most countries, and development plans and budgets on annual basis
	Global warming continues for more than a century even with the stabilization of atmospheric GHG concentrations	Tendency to deal with more immediate issues
		Lack of representation of future generations and the non-human natural world in the decision-making process
Global implications	Emissions from anywhere affect the global climate	Tendency to wait for others' actions, since local and national actions seem useless and impose immediate costs
	Emissions have very different absolute and per capita levels among countries, and vary over time	Need for the political authorities to coordinate action at all different levels (local, state, national, regional, international, global)
	Expected effects of climate change vary considerably from region to region	
	Threats that arise for all mankind	Lack of connection between internationalized supply chains and national regulatory systems
	Damages caused to the climate system may be irreversible	
Extent and social perception	Fundamental changes needed for many consumption and production activities	How to guide a deliberate transformation of production and consumption patterns
	Need for a revolution in the energy production and consumption and changes in transportation, manufacturing, construction, agriculture, forestry, land use and urban zoning	Dependence on technological and development existing trajectories
		Acquired rights that resist change
		Shock between climate policy needs and large-scale state economic intervention
	Implications for population growth and development	Established administrative structures that fragment policy in different sectors, related to climate change
	Climate change risks are often invisible to the senses; their perception depends on scientific knowledge	
Scientific uncertainty	Uncertain trajectory of future GHG emissions	Uncertainty used as excuse to delay government action and by those who fear that their material interests are affected by mitigation
	Uncertainty of current emissions effects on global temperature	
	Uncertainty of temperature impacts on regional and local climate	Uncertainty range and lack of knowledge interfere in deterministic calculation of cost/benefits
	Radical discontinuities potential	
	Uncertainty of impacts on ecosystems	Uncertainty and lack of knowledge interfere in traditional risk assessment
	Dynamic science presents new results, diagnoses and predictions that have helped to reduce uncertainty	Difficulty in establishing policy responses in the face of uncertainty

Table 1 continued

Structural feature	Underlying issues	Political challenges
Distribution and equity links	Different countries and regions will be affected in different ways	Disagreement regarding responsibility for the problem and sharing mitigation and adaptation costs
	Different countries and regions have different historical and current emissions standards	Disagreement on relevant criteria in determining the division of charges
	The international system and national policies are characterized by profound social and economic inequalities	Difficulty in determining the costs that this generation shall pay to reduce risks of future generations
		Uneven distribution of dependence on fossil fuels and their reserves

In addition, Beck (2010) warns that the overuse of the climate policy concept eventually "castrates" it since it ignores the fact that climate policy is not just about the weather, but about the transformation of basic concepts and institutions established during the development of industrial society. Climate policy should be about changes in development patterns, which are at the heart of the climate change crisis.

In any case, political action at the international, national and local levels will have a decisive effect on setting limits to global warming through the emissions reduction (mitigation) and adapting to what is already underway. This is explored next.

4 Governing Climate Change Risks

Risks can be changed by modifying the initial activity or event or by minimizing its impacts (Renn 2008). In the case of climate change, societies can reduce GHG emissions (mitigation), thereby decreasing the rate and magnitude of change and they can adapt to its impacts. These responses can and should be complementary, as shown next.

4.1 Climate Change Mitigation

After identifying the main activities that contribute to climate change, some alternatives have been proposed in order to minimize them, such as the replacement of fossil fuels with biofuels, the use of energy from renewable sources, proper management in agriculture and farming, carbon market and mainly, changes in the patterns of production and consumption, waste reduction and energy efficiency. This kind of action goes toward mitigating the problem, that is, promoting the reduction and stabilization of GHG emissions. Mitigation includes all human activities aimed at reducing emissions or increasing GHG sinks (IPCC 2001).

For some time, climate policy was synonymous of energy policy. This is due to the fact that the power supply in the world is largely dominated by fossil fuels, the main source of anthropogenic GHG emissions. This was also reflected in the IPCC Second Assessment Report (1995), which showed a strong inclination to tackle climate change through mitigation, especially through the pursuit of energy options. In addition to the energy sector, other sectors are also involved in the mitigation of climate change, such as: transport, construction, industry, agriculture, land use, forestry and waste.

Economic, institutional and technological factors influence the mitigation capacity that can promote mitigation actions. Among the economic factors, there are: income, reduction and opportunity costs. The effectiveness of government regulation, clear market rules, skilled workforce and public awareness constitutes the institutional parameters. Finally, the technological factor is related to the ability to absorb existing technologies or to develop new innovative technologies that enable GHG emission reduction.

In order to achieve climate stabilization, stabilizing and reducing GHG emissions are necessary. There is no uncertainty involving what has to be done in this case. However, there are many challenges and difficulties involving mitigation. Among the main barriers to implement mitigation policies are the emission reduction costs and the political will. There are other factors that also affect mitigation policies, such as: the experts and non-experts relations; risk perception; regulators-industry relations; the power and influence of interest groups and historical culture. Mitigation actions are directly related to economic development issues since they imply changes in development bases of industrial society.

4.2 Climate Change Adaptation

The adaptation in the context of climate change refers to any adaptation or adjustment that occurs in natural or human systems in response to actual or expected climate change impacts, aiming to deal with the consequences, moderate damages or exploit beneficial opportunities. Adaptation may reduce vulnerability in the short and long term (Adger et al. 2003; Klein et al. 2005).

Vulnerability refers to a greater or lesser susceptibility of people, places, infrastructure and ecosystems to suffer some kind of harm, understood as an intrinsic quality of human and natural systems that expresses the ability or inability to respond to the risks (Acselrad 2006), characterized by external events that can be occasional or structural, such as climate variability and extreme weather events. Three important elements permeate the notion of vulnerability: the degree of exposure to risk; the susceptibility to risk and the adaptive capacity to face the materialization of the risk (Moser 1998; De Sherbinin et al. 2007). Vulnerable people, social groups, or places, would be the most exposed to dangerous situations, more sensitive to these situations and less capable of responding and recovering.

Adaptation actions have multiple drivers, such as economic development and poverty reduction, and are incorporated into the broader development and sectoral planning initiatives, both regional and local, such as: water resources management, coastal management and risk and disaster reduction strategies.

For some authors (Adger et al. 2003), all societies are fundamentally adaptive and there were many situations in the past when societies have adapted to changes in climate and similar risks. However, some sectors are more sensitive and some groups in society are more vulnerable to climate change risks than others. Other authors (Burton 2010) argue that adaptation to the daily weather has occurred over time in different ways, under different aspects; however, the adaptation to climate change is a different issue. In addition, all societies need to improve their adaptive ability to face present and future climate change.

Adaptation to climate change weakly became part of the public agenda with the United Nations Framework Convention on Climate Change in 1992, in Rio de Janeiro. Since the focus of the convention was GHG emissions, it emphasized pollution control and mitigation; therefore, less attention was given to adaptation. Furthermore, adaptation strategies need a reliable scientific basis to be developed. Because of this, many policy makers tend to wait until they are actually affected by extreme weather events in order to take action. However, even with the developments of climate science, disaster losses have risen globally, showing that natural risk management efforts, human resettlement, disaster risk reduction and adaptation to climate change have not been successful and still need effective measures and investment policies. Adaptation strategies need to be proactive, i.e., not toward coping with the changes after they occur, but trying as much as possible to avoid them to actually occur.

Some ideas about adaptation have undergone major changes, such as the initial notion that mitigation is global and adaptation is local. It is recognized that adaptation needs national and international cooperation to be successful, since adaptation is local but also regional, national and global. Adaptation is also multi-sectoral, involving all sectors of national adaptation strategies. Also, climate variability and extreme weather used to be considered in terms of events, from which the social systems should recover and return to normal. Now, the sequences of these events are considered, such as continuous series of drought, flooding or cyclones, instead of just isolated droughts and storms. This perspective shift provides a focus on systemic risks and risk reduction rather than just disaster management. Disasters used to be considered as humanitarian concerns and were handled one at a time. Now, the idea that disaster recurrence is predictable and they are a common and shared responsibility is predominant (Burton 2010).

Some part of the literature has discussed the links between adaptation and social and economic development, especially from the perspective of adaptive capacity to climate change in countries and communities (Smith et al. 2003; Folke et al. 2005; Klein et al. 2005; Adger et al. 2007; Satterthwaite et al. 2007; Posey 2009). Adaptive capacity involves governance, human and financial resources, institutions, infrastructure and technology, among other factors. Therefore, adaptive capacity is different in each location and is affected by multiple climatic and non-climatic variables. This discussion highlights the importance of political development and natural risk management for adaptation. It also shows that adaptation is not only relevant in the context of climate change, but is an ongoing process to reduce vulnerability to natural climate variability and climate change induced by human activities. The literature about adaptation, social equity and environmental integrity

has worked with the concept of sustainable adaptation, which also depends on the context, varies among communities, places and over time and needs to integrate local knowledge in their responses. Sustainable adaptation strategies need to establish specific links between vulnerability and poverty.

One of the main difficulties in implementing adaptation policies is related to the high costs to address current and short-term climate change risks. According to the evaluation of Ayers (2009), official financing mechanisms under the UNFCCC are not sufficient to meet the needs.

4.3 Mitigation and Adaptation: Differences and Synergies

The dichotomy between adaptation and mitigation is built mainly in the minds of politicians and scientists and is reinforced by the different ways in which knowledge is traditionally produced and the different approaches and strategies. At the institutional level, the difficulty of integrating adaptation and mitigation strategies in existing and new sectoral policies reinforced this dichotomy (Tompkins and Adger 2005; Biesbroek et al. 2009). The complex institutional arrangements to include climate change in sustainable development policies have hindered the identification of synergies and balance between adaptation and mitigation.

Mitigation and adaptation have some differences, especially regarding time and space scales. For instance, the benefits of mitigation actions implemented today will only be realized in decades due to GHG permanence in the atmosphere, while adaptation actions have immediate effects and benefits when reduce vulnerability to climate variability. Although mitigation actions are implemented at the local or regional level, the benefits are global, while adaptation usually operates on the scale of the affected system, which is local.

The policy strategies and stakeholders involved in mitigation and adaptation also feature other difference between these types of response to climate change. Mitigation involves the energy and transport sectors and, in some cases, land use change and agriculture. These sectors are most commonly linked to planning issues and to the formulation of national policies and involve medium and long-term investment decisions. Adaptation involves the most impacted sectors by climate change, such as: agriculture, tourism, health, water supply, coastal management and nature conservation. In this case, the involved stakeholders range from individual farmers to national planning agencies.

Determining the benefits of mitigation and adaptation actions is another significant difference. All mitigation actions, no matter how diverse they are, will be used to reduce GHG emissions and, considering global benefits, it is irrelevant where in the world these actions will take place. The benefits of adaptation can be measured in terms of financial loss, saved human lives and natural and cultural losses avoided. Table 2 shows the main features and differences between mitigation and adaptation actions.

The issue of climate policy is no longer whether to mitigate climate change or to adapt to it. Since the impacts of climate change are already being felt by natural and human systems, adaptation becomes a necessity. However, relying solely on adaptation can lead to climate change of such magnitude that effective adaptation

Table 2 Main differences between mitigation and adaptation actions. *Source*: Elaborated by the author (based on Klein et al. 2005; IPCC 2007)

Features	Mitigation	Adaptation
Objectives	Involves reducing GHG emissions	Involves reducing vulnerability to the impacts of climate change
	Related to the transition to a low carbon economy	Related to planning issues in general, with emphasis on urban issues
Time	Involves GHG reduction goals to be achieved in a given period of time	Involves specific actions that can be taken in the short, medium or long term
	Effects and benefits are perceived in long term	Effects and benefits are perceived in short-term
Space	Effects and benefits are global	Effects and benefits are local and/or regional
Stakeholders and policies	Mainly energy, transport, land use change and agriculture policies	Mainly agriculture, tourism, health, water supply, coastal management, urban planning and nature conservation policies
	Involves national planning agencies	Involves from individual farmers to national planning agencies

will be possible only to a very high social and economic cost. So, the successful implementation of climate policy is linked to the way they are integrated, that is, the integration of mitigation and adaptation strategies and also the relationship between them, among sectoral policies, among other levels of government and among relevant stakeholders. Thus, it is understood that both mitigation and adaptation are essential to reduce climate change risks.

This scenario is very recent because throughout the history of climate policy, GHG mitigation was the focus of policies, science and media. This reflected the concern that a greater focus on adaptation would weaken the willingness of society to mitigate climate change and also meant the belief that natural selection and market forces would bring adaptation without the need for political intervention. At that point, according to Biesbroek et al. (2009), proponents of adaptation strategies were seen as defeatist and fatalistic and linked to strategies of "doing nothing."

In all IPCC assessment reports, mitigation and adaptation actions were stated as necessary responses to climate change. However, as the first reports highlighted the high GHG emissions, the reactions were more related to their reduction. According to O'Brien et al. (2010), climate change was built as an environmental problem that could be solved by reducing emissions and with little attention to social, political, cultural and ethical dimensions. So, with the climate policy mainly focused on energy policy, adaptation was not a concern.

However, since the third IPCC report (2001) established that human beings are—at least partly—responsible for climate change and that some impacts can no longer be avoided, academic and political attention to adaptation sharply increased. The fact that the climate system will continue to suffer changes even after GHG emissions reduction also contributed to more attention on adaptation. In addition, failure to reduce GHG emissions in the required magnitude in order to avoid dangerous climate change also helped the promotion of adaptation actions. The

2012 IPCC report focused its efforts on showing that adaptation to extreme events that are already inevitable is required.

However, in this report, the IPCC (2012) states that adaptation and mitigation can complement each other and together can significantly reduce climate change risks. The potential for the development of synergies between mitigation and adaptation has become a recent focus of climate policy research. Climate policy is expanded when considering a wide range of options for carbon sequestration in vegetation, oceans and geological formations and reducing the vulnerability of sectors and communities to the impacts of climate change. It is noticed that climate policy plays the role of facilitating the integration and successful implementation of mitigation and adaptation in sectoral and development policies.

Therefore, climate policy has evolved to share a great interface with sustainable development. Currently, climate policy has the role of not only controlling the atmospheric GHG concentrations, but also of reducing the adverse impacts of climate change, and also of dealing with development and equity issues.

The need to combine short-term actions to support long-term strategies has driven policymakers to integrate mitigation and adaptation policies in new and existing policies and strategies in order to make more efficient and effective use of financial and human resources, instead of formulating different climate policies for each sector.

5 Concluding Remarks

Climate change sets up an unprecedented challenge to contemporary societies. Respond or not to the risks arising from climate change will greatly influence the future life on Earth. This article addressed the climate change risks, characterized as contemporary environmental risks, products of the development process, influenced by the globalization process, closely related to the future and uncertainties, often unpredictable, inevitable and incalculable and often cause irreversible damages. They are invisible to the senses and threaten all humanity. Thus, they differ from natural risks. However, part of the climate risks materializes as natural risks (floods, landslides, cyclones, etc.), implying different kinds of policy responses.

Despite the uncertainties that permeate climate change risks, there are many certainties. And the uncertainties cannot "suffocate" policy responses. The ways to mitigate climate change are well known and require radical changes in the development patterns of contemporary societies. Uncertainties are more related to what, in fact, adapt to.

Without visualization techniques, symbolic forms and mass media, the risks are nothing at all (Beck 2008). This is the why the dimension of construction and social perception of climate change risks is so important. Responses to these risks will be given based on this.

And in this direction, the role of governments was discussed. Also, the political implications of climate change risks were analyzed, as well as their challenges such as: the aspects related to the long-term temporality; the global implications of the problem; the extent and social perception; the scientific uncertainties; distribution

and equality links. Risks are the result of multi-level processes, problems that arise from the organization and structure of society, reflecting the choices of how societies are organized and their development choices. Climate change consists, therefore, of a multilevel challenge, related to both local and global scales.

Finally, we discussed the evolution of climate policy in its two key aspects: mitigation and adaptation. Climate policy was initially based on energy policy. However, this has changed with the failure of these policies, since GHG emissions have not decreased as expected, and with the need to adapt to extreme weather events, already inevitable. Current climate policy involves the synergy between adaptation and mitigation and is linked to sustainable development.

Understanding climate change as a contemporary environmental risk, the way it was presented in the article, implies a radical change in the development bases of society, since it is the GHG emissions from human activities that are contributing to the aggravation of global warming. Climate change challenges the traditional ways of governing in many ways, since climate change policy should involve the questioning of the current processes of development. Profound changes in ways of thinking and established political action are needed.

This article provided theoretical elements that can be used to analyze empirical cases of policy responses to climate change. In addition, it proposes the reflection whether the risk perspective presented here is present in the policy responses to climate change worldwide and whether these responses are sufficient to address the climate crisis.

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