REVIEW OF CLIMATE CHANGE RISKS AND VULNERABILITIES

Marius Cosmin BOIANGIU
Bucharest University of Economic Sciences, 010374, Romania
mariuscosmos@yahoo.com

Abstract
The proper acknowledgement and understanding of climate change induced risks and vulnerabilities are critical in the development of mitigation and adaptation policies. The paper summarizes and reviews the most important risks and vulnerabilities as assessed by the latest report of the Intergovernmental Panel on Climate Change (IPCC), the leading international authority on evaluating scientific data and information on climate change. It concludes that while mitigation efforts should continue at even higher pace, adaptation measures based on sound scientific research should be stepped up.

Key words: *climate change, risks, vulnerabilities, adaptation, IPCC*

JEL Classification: *Q54; Q56; Q57*

I. INTRODUCTION

The activation of the world's countries, non-governmental organizations and research community in investigating and fighting climate change began in the early 1990s with the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988, and the United Nations Framework Convention on Climate Change (UNFCCC) in 1992.

At its creation, the UNFCCC's objective was to stabilize greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference in the climate system. The text of the convention states that such a level should be reached within a time frame enough to allow ecosystems to adapt to climate change naturally, to ensure that food production is not threatened and to enable economic development to be made in a sustainable manner (United Nations 1992).

The conclusions of the most recent report of the IPCC, which has become the main scientific reference for climate change policymaking, are that "*greenhouse gas emissions will cause even more heating and long-term changes in all components of the climate system, increasing the likelihood of severe, persistent and irreversible effects on humans and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions that, together with adaptation, can limit the risks of climate change"* (IPCC 2014).

As the climate system has been shown to have a high sensitivity to human activity, which can be accentuated by natural positive feedback mechanisms, projections for the evolution of climate change have to consider different forecasting scenarios for future actions and the development of human society: population size and lifestyles, economic activity, technological progress, energy production and use, global climate and environmental policies etc.

In order to fit the predictions of climate change as closely as possible, the IPCC examined about 300 basic scenarios that do not include additional efforts to reduce GHG emissions and 900 mitigation scenarios, which provide for emission reductions in various forms. All scenarios were uniformized based on the estimated CO_2-equivalent[6] by 2100. It was considered that the global average temperature - the main indicator of climate change - is mostly determined by cumulative GHG emissions.

In 2015, the annual average CO_2-equivalent of all GHGs and climate force agents (including aerosols with cooling effect) reached 445ppm, representing an increase of nearly 4 ppm compared to 2014 and 35 ppm compared to 2005. Of this, the annual average carbon dioxide concentration reached 403 ppm in 2016, an increase of more than 45% compared to pre-industrial levels (EEA 2018). For reference, a concentration of 450 ppm CO_2-equivalent to an increase in the global average temperature of 2°C above the pre-industrial level.

The IPCC has selected four significant evolutionary scenarios of CO_2-equivalent concentrations in the atmosphere by the end of the century, called Representative Concentration Pathways (RCP): one with a drastic reduction in estimated emissions (RCP2.6), two intermediate scenarios (RCP4.5 and RCP 6.0) and a scenario with high GHG emissions in this century without additional mitigation measures emissions (RCP8.5). Each scenario is identified based on the estimated supplemental radiative forcing by 2100: 2.6, 4.5, respectively 6.0 and 8.5 W/m^2.

RCPs are only *possible* paths of positive GHG-induced forcings that are not necessarily congruent with the emissions evolution courses because they do not quantify the uncertainties surrounding natural interactions between the components of the climate system and, in particular, the amplifying or inhibiting effect of feedback mechanisms. This means that a lower emissions scenario may still lead to a higher variation in CO_2-equivalent concentrations and vice-versa, a higher emission pathway may ultimately lead to a lower concentration.

[6] Indicator of GHG concentration in the atmosphere measured in ppm (parts per million)

In all these scenarios, however, the surface temperature of the Earth is estimated to increase until the end of the 21st century. Under these circumstances, the IPCC believes that heat waves are likely to be more frequent and longer, extreme precipitation will become more intense and more frequent in many regions of the world, and the oceans will continue to warm up and grow.

RCP2.6 is the only scenario that keeps the global temperature below 2°C above the pre-industrial level as aimed by the Paris Agreement, the current global level international treaty for mitigating climate change.

Average changes in surface temperature for the period 2016-2035 compared to baseline period 1986-2005 are similar for all four RPCs and will probably range from 0.3°C to 0.7°C. Global average temperature increase of the surface until the end of the 21^{st} century (period 2081-2100) is likely to be in the range of 0.3°C - 1.7°C for the RCP2.6, 1.1°C -2.6 °C for RCP4.5, 1.4°C - 3.1°C for RCP6.0 and 2.6°C - 4.8°C for RCP8.5. The Arctic region will continue to warm faster than the global average (IPCC 2014).

Given the high responsiveness of the climate system to the variations in human activity, assessing the future impacts of climate change will depend heavily on the path to be followed by society by the end of this century but also on the inherent unpredictability of nature and uncertainties still existing at scientific level in understanding the complex mechanisms in this process. It is obvious however that the current trends will continue for a certain period and potentially will be accelerated.

II. RISKS AND VULNERABILITIES OF CLIMATE CHANGE

Risks to nature, society and the economies can be grouped according to their direct or indirect impact, length and magnitude. In general, all socio-economic areas will be affected, as will all the regions and subregions of the globe, but not all of them will be affected equally. By example tropical regions are expected to suffer more than those in temperate areas. Not only adverse effects are expected, but also beneficial in some sub-regions or sectors, although the aggregate negative impact is expected to overcome in medium to longer term any short-term positive effect

In the Fifth Assessment Report (AR5) of the IPCC (IPCC 2014), global climate change risks are viewed as manifesting through a series of integrative characteristics, which are a supplemental cause for concern but also frame the limits from which climate system changes become dangerous and overcome the adaptability of ecosystems, society and world economies:

the uniqueness of systems at high impact; for example, many species and systems (such as coral reef systems or Arctic ice systems) have limited adaptation capacities and are subject to increased risks with each 1C global warming;

extreme weather events such as heat waves, extreme floods and rainfall, which are becoming more and more likely as additional heating;

the uneven distribution of risks, which are higher for communities and disadvantaged people at any level of development; the uneven distribution mainly affects the risks linked to agricultural production and the availability of water resources, which are already under the influence of regional climate change impacts;

the cumulation and aggregation of negative impacts that can affect both the Earth's biodiversity and the world economy on a large scale;

large-scale singular events that creates potentially irreversible and very damaging regimes for physical, biological or human systems, such as the complete loss of Greenland's ice sheet, the melting of the Arctic ice or the shutdown of the North Atlantic circulation system.

The IPCC identifies three major categories that will be affected by the impacts of climate change, depending on the types of risk and vulnerabilities existing on a global scale:

systems and natural and managed resources, and their uses, such as:
freshwater resources; t
terrestrial and land water systems;
coastal and low-lying systems;
ocean systems;
food security and food production systems;
human habitats, industry and infrastructure:
urban areas;
rural areas;
economic sectors and services;
human health, well-being and security, including aspects such as vital needs and poverty.

The following is a compilation of the principal risks and vulnerabilities in each of the categories and subcategories identified by the intergovernmental group, based mainly on the data and conclusions of the AR5 (IPCC 2014). At the same time, in view of its drafting methodology the IPCC report of 2014 reflects the existing international scientific consensus on climate change risks until the next report is drawn up in 2022. This review retains only the information which was presented with a medium degree of confidence and up.

A. Natural and managed systems and resources and their uses:

According to Jiménez et al. (2014), the risks related to **freshwater sources** will increase significantly with increasing GHG concentrations. For each additional degree of global warming, about 7% of the world's population will be at risk of reducing their renewable water resources by nearly 20%. Climate change will significantly reduce renewable surface water and groundwater resources in most dry subtropical regions. This will increase water competition in agriculture, ecosystems, settlements, industry and energy production, affecting in many regions the security of water, energy and food supply. On the contrary, water resources are projected to grow at high latitudes.

Under the RCP8.5 scenario (where emissions will continue to rise significantly), it will increase the frequency of weather droughts (less rainfall) and agricultural droughts (less soil humidity) in regions that are currently arid until the end of the 21st century. It is possible that in these regions will increase the frequency of hydrological droughts over short periods (less surface water and groundwater). Using simulations of changes in drought severity index Burke et al. (2008) predicts a general downward trend in humidity in certain regions over the century, particularly in the Amazon region, the United States, North Africa, southern Europe and East Asia. According to these predictions, the percentage of areas marked by "severe" droughts will increase from 10% at the beginning of the century to 40% at the end of the century.

Climate change will negatively influence freshwater ecosystems by changing water flows and water quality. They also reduce the quality of raw water, which will present a risk to the quality of drinking water even with conventional treatment. The risks are generated by: the increase of temperature; increase of sediments, nutrients and pollutants because of heavier precipitations; strong dilution of pollutants because of droughts; perturbations of water- treatment installations because of floods. There are few data available showing that soil erosion and sediment loads change significantly due to climate change. However, it is anticipated that temperatures and precipitation increases will alter soil erosion and sediment accumulation, although the magnitude of these changes is uncertain and depends on the seasonality of precipitation, land cover and soil management practices (Jiménez et al. 2014).

Terrestrial and land water systems will continue to be under stress due in the second half of the century, especially under the high average concentrations scenarios (RCP6.0 and RCP8.5), according to Settele et al. 2014. In the first half of the century, threats from direct human intervention, such as land use and land use change, pollution and water supply, will prevail. The impact will be stronger for terrestrial and aquatic ecosystems at high altitudes, for which any scenario of heating that exceeds the minimum RCP2.6 version will lead to major changes in species distribution and ecosystem functioning.

Settele et al. (2014) reveal that increases of water temperature will lead to changes in the distribution of freshwater species of problems of water quality, particularly in systems face a high anthropogenic nutrient loading. Alteration of rainfall patterns will substantially alter the significant ecological characteristics of the flow patterns of many rivers and wetlands, and will exacerbate the impact of water use in developed river basins.

Populations of species that will not keep up with the climate shifts will find themselves in areas of unfavourable climate and in the impossibility to reach areas with suitable climate. Animal species from flat areas are particularly vulnerable because they have to disperse over greater distances than species in mountainous regions to keep pace with climate change. Species with low dispersing capacity will be also particularly vulnerable for example plants (especially trees), small mammals and amphibians.

In general, a net loss of biodiversity is expected. Many terrestrial and freshwater species will be at risk of extinction both directly due to climate change and indirectly due to the interaction of climate change with other pressures on biodiversity, such as habitat modification, overexploitation of resources, pollution and invasive species.

Natural carbon storage provided by terrestrial ecosystems will be partially cancelled by the carbon emissions due to the transforming of natural ecosystems (mainly forests) into farmland and pastures, and ecosystem degradation. Carbon stored in the terrestrial biosphere is vulnerable to losses in the opposite direction, towards the atmosphere due to direct and indirect effects of climate change, deforestation and degradation. The net transfer of CO_2 from the atmosphere to land-based systems is estimated to diminish on the course of the 21st century. Increases in the frequency or intensity of ecosystem disruptions such as droughts, wind storms, fires and pest eruptions will become more attributable to climate change.

Measures to adapt or mitigate climate change can also have negative consequences for terrestrial and freshwater ecosystems. For example, measures to counteract the variability in water supply, such as building more dams and increasing water extraction, will in many cases worsen the direct negative effects of climate change. Similarly, carbon sequestration measures by planting fast-growing tree species in places where they did not grow or the conversion of uncultivated or undegraded areas into bioenergy crops will lead to negative impacts on ecosystems and biodiversity (Settele et al. 2014).

Wong.et al. (2014) describe that **coastal and low-lying systems** are particularly vulnerable to three factors: level, temperature and the acidity of the oceans. Changes in coastal areas cannot yet be attributed to climate change, as many are the result of direct human intervention. However coastal areas will be affected at a later stage by the increase in water levels due to oceans' latency in reaction to the increase in average temperature. The negative effects that will be felt include erosion, flooding or sinking of coastal areas.

According to Wong.et al. (2014), increased acidity will be higher in areas where eutrophication or nutrient-rich deep-water upwelling is already a problem. This will have negative effects on many calcifying organisms. Warming and acidification will lead to coral bleaching and mortality, and decrease their constructive capacity, making the coral reefs some of the most vulnerable marine ecosystem, with few options for adaptation. At the same time, Zondervan et al. (2001) and Zhang and Cao (2016) highlight the negative feedback effect on the increase in atmospheric CO_2 concentration by increasing the organic calcification mechanisms and increasing carbon absorption in the oceans.

The population and economic assets exposed to coastal risks as well as human pressures on coastal ecosystems will increase significantly over the coming decades as a result of population growth, economic development and urbanization (Wong et al. 2014). According to the report, humans were the main determinants of changes in coastal aquifers, lagoons, estuaries, deltas and wetlands, and the anthropogenic pressures on coastal ecosystems and is expected to increase. This is due to excessive nutrients from the introduction, change and reducing sediment drain schemes.

At the same time, in the absence of adaptation measures, hundreds of millions of people will be affected by coastal floods and will be displaced by land loss by 2100; most affected are in the east, south-east and south of Asia. In these regions developing countries such as Bangladesh or Vietnam as well as small islands are expected to face very high impacts as well as damage and adaptation costs worth few percent of GDP. Moreover, developing countries and small islands in the tropics, dependent on coastal tourism, will be affected directly not only by future sea level rise and associated extreme events, but also indirectly by coral bleaching and ocean acidification, and by the associated reduction of incomes (Wong et al. 2014).

Human society depends to a large extent on the benefits **of ocean systems,** which in turn are very sensitive to climate change. The potential impacts of climate change will be particularly on: production of food in the seas and oceans (fisheries and aquaculture), the procurement of natural resources from the oceans, nutrient recycling, global climate regulation, including oxygen production and carbon sequestration, extreme weather phenomena as well as other cultural, aesthetic or supportive benefits. Climatic variations over several decades associated with temporary warming periods of 1ºC at regional level have led to the fundamental restructuring of ecosystems and to large socio-economic implications (Pörtner et al. 2014).

The report reveals that increases of average water temperatures and the incidence of extreme values alter natural habitats and cause changes in the size and distribution of oceanic populations, local extinctions, and expansions or migrations of animal species to more climate appropriate latitudes. The highest vulnerability is found for polar fauna, due to the narrow range of temperatures required for survival and/or adaptation, and for tropical species in danger of overcoming their upper thermal ranges. It is expected that the ocean-wide changes in ecosystem properties will continue. Irreversible and widespread changes in the spatial distribution of the species and the seasonal calendar of their activities (feeding, growth, development, behaviour and productivity) will have implications for species composition as well as derived goods and services.

In the mid-21st century, spatial changes in the distribution of marine species will result in an increase in the wealth of species at medium and high latitudes and a decrease in tropical latitudes, resulting in a global redistribution of the catch potential for fish and invertebrates, implications for food security. Also, movements of species, which will seek to optimize the temperature regime with increase warming are designed to lead to high latitude invasions and high local extinction rates in tropical and semi-enclosed seas. This will lead to an increase in fishing yields in some high latitude regions by 2055 (compared to 2005), a redistribution at average latitudes but a decrease in the tropics and the Antarctic area (Pörtner et al. 2014).

The European Environment Agency confirms the observations on the increasingly frequent occurrence of sub-tropical species in European waters and the withdrawal towards north of sub-Arctic species (EEA 2016). The consequences of these changes will be to increase socio-economic vulnerability in poorly developed countries, especially those in tropical regions, and to increase disparities in food security between developed and developing countries.

As regards the way **food security and food production systems** are affected by climate change, Porter et al. (2014) note that the negative impact on agriculture and food production is already evident in many regions of the world. However, due to the regional variability of climate change, there is also a positive trend in some regions of high latitude areas. Major crops (wheat, rice and maize) in tropical and temperate regions will be negatively impacted, starting with temperature increases of 2°C and above and without taking compensatory adjustment measures, although other regions may benefit. At the same time, climate change will progressively increase the interannual variability of crop yields in many regions of the world.

Data quoted by Porter et al. shows a high negative sensitivity of crop yield at extreme day temperatures above 30 ˚ C, depending on the crop (Schlenker and Roberts 2009). The IPCC report also confirms the stimulating effect of increasing CO_2 concentrations but also the harmful effect of high levels of tropospheric ozone (O_3), although CO_2 and O_3 crop interactions, average and extreme temperatures, availability of water and nitrogen must continue to be researched. Climate change and raised CO_2 concentrations will increase distribution and competitiveness of invasive weed and will change the geographical distribution of diseases and pests, while it is still unclear the effect on the intensity of their pressure on crops.

In principle, according to Porter et al. (2014), all aspects of food security will be potentially affected by climate change, including access to food and its uses, and price stability. Food security risks will be generally higher in regions at low latitudes. Changes in temperature and rainfall, without considering the effects of CO_2 emissions, will drive up food prices worldwide by 2050, with a growth estimated at between 3 and 84%. Change projections that include CO_2 and O_3 influene and ignore the impact of pests and diseases indicate that overall increases in price is more likely, with a series of impacts ranging from -30% to +45% by 2050.

The report also indicates that adaptation of fisheries, aquaculture and animal production potential will be enhanced by adopting multisectoral strategies to minimize the negative impact of climate change. Adaptation measures for fisheries and aquaculture should include stocks management measures to maintain ecosystems in a state resistant to change, and the development of early warning systems for extreme events. Adaption for livestock systems should focus on adjusting management to available resources, using better-adapted breeds for the shifting climate and eliminating obstacles to adaptation, such as improving farms access to credit.

B.Human habitats, infrastructure and industry:

Urban areas are some of the largest generators of GHG emissions, but they also host a large proportion of the world's population and economic assets at risk of climate change. AR5 (Porter et al 2014) shows that rapid growth and accelerated growth of large urban settlements in low and middle-income countries have been accompanied by rapid growth in urban communities, many of whom live in informal settlements.

All these large urban habitats are extremely vulnerable to extreme climate and weather-related (e.g. hurricanes, sand storms, droughts, forest fires etc.). A number of climate induced risks and threats for urban areas will intensify: increasing sea levels, heat stress, extreme rainfall, inland and coastal floods, landslides, droughts and increased aridity, water supply difficulties, air pollution etc. All these will have an increasingly negative impact on health, standards of living, human assets and economies at regional and national levels.

Climate change will have a profound impact on a wide range of systems infrastructure (power and water supply, sewerage and drainage of the water, transport and telecommunications links etc.), services (including health and emergency), constructions or ecosystemic services. Climate change will boost the effect of social, economic and environmental factors that already challenge individual well-being and household welfare in urban areas. At the same time, adaptation to climate change will provide cities that take such measures with competitive economic advantages by reducing the associated risks to local communities and companies.

In order to better manage the risks of climate change in urban areas, it is necessary to further develop the management of disaster threats. Porter et al. 2014 also reveals that urban areas face constraints across the world obtaining and distributing financial and other resources needed for adaptation. In most cities with low and middle income, delays in infrastructure development, the lack of appropriate mandates and of financial and human resources severely constrain actions for adaptation, which creates additional long-term vulnerabilities.

Also, **rural areas,** which include about 50% of the total population of the world and over 70% of the poor people in the developing world, will be increasingly exposed to climate risks, but in different proportions, depending on the region and a series of local economic, social and land-use factors (Dasgupta et al. 2014).

The IPCC report points out that rural populations in developing countries and not only are already subject to climate-neutral pressures, such as reduced investment in agriculture, problems with resources, regulation policies, land regimes, income dislocations resulting from changes in market processes and product circulation at international level, environmental degradation etc. In contrast, the trend in developed countries is to move to different rural development models, including multi-use of rural areas and multisectoral approaches, cooperation of diverse actors, and shifts to investment financing rather than subsidies. For all these reasons, the impact of climate change on rural economic life and interconnections at regional level is difficult to separate.

Impacts on rural areas that can be attributed directly to climate change include drought, storms, floods and other extreme events that affect public infrastructure and health but the major effects of climate change in rural areas will be felt in water supply, food security and farm incomes (Dasgupta et al. 2014). To cope with the domestic production temporary shocks that will be felt by some regions or countries due to climatic events, it will be necessary to adapt and improve international agricultural trade. Strengthening agricultural markets, improving the predictability and reliability of the world trading system and investments in additional supply capacity for small farms could lead to a reduction in market volatility and adequate management of the food deficits caused by climate change.

Dasgupta et al (2014) emphasizes that climate change mitigation measures such as increasing the supply of renewable energy, encouraging the cultivation of biofuels or compensations for reducing emissions from deforestation and forest degradation will have a significant indirect impact on some rural areas, both positively by increasing lucrative opportunities, but also negatively by intensifying conflict their limited resources.

In terms of **key economic sectors and services**, the direct impact of climate change will be relatively small compared to the influence of other factors such as demographic change, technological progress, regulatory framework and governance, the lifestyle of society etc. (Arent et al. 2014).

The report indicates that the gradual alteration of different climatic characteristics (temperature, precipitation, wind, cloud and etc.) and changes in frequency and intensity of extreme weather events will progressively affect the operation of energy producing units. Risks related to availability and cooling of water will be the main concern for thermal and nuclear power plants. Several options are available to cope with reduced water availability, but at a high cost, and therefore the reduction in thermal conversion efficiency remains the main concern. Also, climate change may affect the integrity and reliability of pipelines and electricity networks, which will require changes to the standards of design, construction and operation.

Risks to water and water supply infrastructure include floods, but also water scarcity and cross-sectoral water competition. Floods can have major economic costs, both in terms of the impact (capital destruction, production disruptions) and in adaptation (construction of defence systems, investment protection). Water scarcity and increased competition between institutional, economic or social factors on water may mean that this important resource will not be available in a sufficient quantity and quality for certain uses or locations. Transport infrastructure, despite the fact that there is still no conclusive evidence of how it will be affected by climate change, will remain vulnerable to the increased incidence of extreme events as well as changes in meteorological indicators (extreme temperatures, strong winds etc.) located outside design value registers.

AR5 shows that one of the most affected sectors will be the insurance system. More frequent and/or intense disasters it as estimated for certain regions or types of threats, will increase the loss and variability of losses for insurance systems. They will have difficulties in providing affordable risk coverage and at the same time to secure more risk-based capital, especially in low-income and medium-income countries.

Climate change will significantly affect the health sector through increasing the frequency, intensity and extent of extreme weather events and rising demand for services and health facilities, including public health programs, activities, disease prevention, personal care, infrastructure and consumables related to the treatment of infectious diseases or climatic events related to temperature.

The way global warming will directly affect productivity and economic growth is still little understood at the scientific level. Estimates of aggregate economic losses for the past 20 years range from 0.2% to 2% of revenue. Losses will increase as temperatures rise, but estimates of the incremental impact of carbon dioxide emissions range in significantly large register, from a few dollars to several hundred per tonne of carbon emissions (Arent et al. 2014). More recent studies such as Pretis et al. (2018) shows that GDP per capita projections have high uncertainty with an average GDP capita estimated about 5% lower at the end of the century for a 2°C average warming compared to 1.5°C. The correlation between climate induced reductions of GDP growth per capita and national incomes is significant, with low-income countries recording greater losses.

C. Human health, well-being and security

Smith et al. (2014) reveals that human health is directly sensitive to changes in temperature, rainfall patterns and extreme events such as heat waves, floods or drought. Indirectly, health can be affected by environmental disturbances caused by climate change (such as changing the types of disease vectors) or by social responses to climate change (such as population migration). Temperature variability is a risk factor *per se* that includes the impact of rising average temperatures on heat-related deaths and injuries. By the middle of the century, existing public health problems will be exacerbated, and existing diseases, such as food and water-borne infections will expand their area to regions where they are not currently present.

The report concludes that if climate change continues as envisaged in the RCP scenarios major hazards to human health will manifest through: greater risk of injury, illness and death caused by more intense heat waves and more frequent fires; increased risk of malnutrition as a result of lower food production in poor regions; decrease of work capacity and low labour productivity of vulnerable populations; increased risks of food-borne pathogens (norovirus, hepatitis A virus, salmonella, escherichia coli etc.), water-borne microbial diseases (cholera, typhoid fever and paratyphoid or bacillary dysentery) and vector-transmitted diseases (malaria, yellow fever, dengue fever, Lyme disease etc.)

In terms of **human security**, migration and increased risks of violent conflict will be the main threats from climate change (Adger et al. 2014). The report notes that migration flows are sensitive to changes in the availability of resources and ecosystem services delivery. Major extreme weather events in the past have led to significant population movements and changes in the incidence of extreme events will increase the risks of such movements. The models, scenarios and observations available suggest that coastal flooding and the permafrost melt, in particular, can lead to the migration of whole populations and resettlement in other regions. Migrants themselves may be vulnerable to the impact of climate change in destination areas, especially in urban areas in developing countries.

Climate change will lead to new international security challenges for states and will increasingly affect security conditions and national security policies. The physical aspects of climate change, such as sea level rise, extreme events and hydrological disturbances will be major challenges for vital transport, water and energy infrastructure. Some countries will face major challenges to their territorial integrity, such as small island states and other countries highly vulnerable to increasing sea levels. Also, some cross-border effects of climate change, such as changes sea ice layer (for example in the Arctic), water used in common or the migration of fish stocks have the potential to increase rivalry and tensions between states. Factors that increase the risk of inter-state and intrastate violent conflicts, such as extreme poverty, economic depression, weak public institutions and failed states, collapsed social systems etc. can be amplified by climate change and environmental variability (Adger et al. 2014).

Olsson et al. (2014) describe potentially significant effects on life conditions and the occurrence of poverty, showing that climate change will worsen the existing poverty conditions, exacerbate inequalities and create both new vulnerabilities and opportunities for individuals and communities across the globe. Climate change will exacerbate multidimensional poverty in most developing countries, especially in mountainous or low-lying countries. Climate change will also create new poverty pockets in countries where there are development disparities.

III. CONCLUSION

All these effects on natural and human systems are direct impacts of climate change. However, most of the consequences for society and the global economy will come from the indirect impact, manifested by multiple interactions and in some cases extremely complex factors, cascading influences, positive or negative feedbacks as well as the costs associated with mitigation efforts.

The mitigation goal of international agreements is to limit the increase in average global temperatures to a level that is not irreversibly harmful to nature and humanity. In the medium and long-term it is impossible to foresee the indirect impacts of climate change because of the very high variability and complexity of factors. Neither the net cost of mitigation in relation to the expected benefits can be properly estimated given the uncertainty regarding policy options for emission reductions and the difficulty of quantifying technological advances and their costs.

However, given the perceived threats of global warming and the possible effect of natural positive feedbacks, it appears more and more evident that mitigation efforts should continue at an even higher pace. Increased anthropogenic emissions are mainly the result of population growth and the economy, but with the adoption of regulations and technologies aimed at developing low-GHG societies and economies, it is possible to decouple socioeconomic development from emissions all over the world. At the same time it appears critical to step up adaptation measures to counter the pressures and risks associated with climate change in short and medium term and lay the foundations for long-term natural and human resilience.

Adaptation measures are invariably specific at regional and sub-regional level due to different biophysical and socio-economic characteristics, but the transfer of knowledge and good practices can bring closer geographically distant regions and diverse socio-economic contexts.

Any adaptation measure should start from a scientifically sound assessment of impacts and vulnerabilities based on three indicators: exposure to a certain impact, sensitivity and adaptive capacity of systems. At the same time scientific research is still to match the depth and complexity of many of the aggravating factors related to climate change.

IV. REFERENCES

1. Adger, W.N. et al., 2014, Human security, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, IPCC 2014, Field, C.B. et al. (eds.), Cambridge University Press, p. 755-791
2. Arent, D.J. et al., 2014, Key economic sectors and services, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, IPCC 2014, Field, C.B. et al. (eds.), Cambridge University Press, p. 659-708
3. Dasgupta, P. et al., 2014, Rural areas, in Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, IPCC 2014, Field, C.B. et al. (eds.), Cambridge University Press p. 613-657
4. EEA (European Environment Agency), 2016, Distribution shifts of marine species, https://www.eea.europa.eu/data-and-maps/indicators/northward-movement-of-marine-species-2/assessment
5. IPCC, 2014, Summary for Policymakers, in Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, [Edenhofer, O., R. et al. (eds.).] Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
6. Jiménez Cisneros, B.E. et al, 2014: Freshwater resources, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, IPCC 2014, Field, C.B. et al. (eds.), Cambridge University Press, p. 229-269
7. Olsson, L. et al., 2014, Livelihoods and poverty, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, IPCC 2014, Field, C.B. et al. (eds.), Cambridge University Press, p. 793-832
8. Porter, J.R. et al., 2014, Food security and food production systems, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, IPCC 2014, Field, C.B. et al. (eds.), Cambridge University Press, p. 485-533
9. Pörtner, H.-O. et al., 2014, Ocean systems, în Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, IPCC 2014, Field, C.B. et al. (eds.), Cambridge University Press, p. 411-484
10. Pretis, F. et al., 2018, Uncertain impacts on economic growth when stabilizing global temperatures at 1.5°C or 2°C warming, Philosophical Transactions of the Royal Society A Theme issue 'The Paris Agreement: understanding the physical and social challenges for a warming world of 1.5°C above pre-industrial levels', Mitchell, D. et al. (eds), volume 376, issue 2119
11. Revi, A. et al., 2014 Urban areas, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. IPCC 2014, Field, C.B. et al. (eds.), Cambridge University Press, p. 535-612
12. Schlenker, W. and Roberts, M.J., 2009, Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change, Proceedings of the National Academy of Sciences of the United States of America, 106(37), 15594-15598
13. Settele, J., R. et al., 2014, Terrestrial and inland water systems, in Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. IPCC 2014, Field, C.B. et al (eds.), Cambridge University Press, p. 271-359
14. United Nations, 1992, United Nations Framework Convention on Climate Change, Article 2, https://unfccc.int/resource/docs/convkp/conveng.pdf
15. Wong, P.P. et al., 2014, Coastal systems and low-lying areas, in Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. IPCC 2014, Field, C.B. et al. (eds.), Cambridge University Press, p. 361-409
16. Zhang, H. și Cao, L., 2016, Simulated effect of calcification feedback on atmospheric CO2 and ocean acidification, Scientific Reports volume 6, Article number: 20284 (2016)
17. Zondervan, I. et al., 2001, Decreasing marine biogenic calcification: A negative feedback on rising atmospheric pCO2, Global Biogeochemical Cycles Volume 15, Issue 2 https://doi.org/10.1029/2000GB001321