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Assessing the Risks of Climate Change[1]

Policy Brief
by the Scientific Advisory Board
of the UN Secretary-General

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[1] For this policy brief, we draw extensively on King et al., 2015, The World Bank, 2012 and also on WEF, 2016.

Key Recommendations

I. Consider that in a 4oC or warmer world, there might be absolute limits to adaptation (e. g., to sea level change of several meters over the long time, to high temperature and humidity exceeding the physiological limit to heat stress, among many others) and impacts would disproportionally affect the world's poor. Even on a 2oC world, parts of the Planet will experience high degrees of warming and risks associated to that.

II. The risks of climate change should be assessed in the same way as risks to public health (or national security): start from an understanding of what we wish to avoid and focus on the best available information to identify worst-case scenarios in relation to long term changes and short term events, and consider low probability, catastrophic impact events.

III. Assessments of specific, local, sectorial, national or global risks of climate change should be repeated regularly and consistently based on a consistent set of indicators of risk; engage at the beginning of the process a wide range of experts (scientists, policy makers, political leaders, decision makers) and track how expert opinion changes over time; and should be reported to the highest decision making authority.

IV. The Paris Agreement global consensus to limit temperature rise to 2oC and even further "to pursue efforts to limit the temperature increase to 1.5oC above pre-industrial" is the only consistent response to risk reduction to preserve a safe climate for the Planet's future. A global carbon roadmap is needed aligning science, technology and policy measures and behavioral changes to reduce emissions at the pace needed for Earth system stability.

1. Introduction

Climate change can be framed as an issue of resilience and risk management. Policy-makers need a full assessment of the risk that climate change poses in order to decide on the prioritization of climate change mitigation and adaptation strategies. The majority of research into the impacts of climate change examines the impacts under the lower degrees of warming, such as the 2oC limit intended under the UN Framework Convention on Climate Change (UNFCCC), and not at the impacts and risks posed by high degrees of climate change that could occur. For instance, as noted in the IPCC AR5 WG2 Summary for Policymakers, ‘relatively few studies have considered impacts on cropping systems for scenarios where global mean temperatures increase by 4°C or more’.

And even those, expressed in the statistical language used by the Intergovernmental Panel on Climate Change, convey serious, but gradual changes in the future.

The impact of high degrees of climate change, which entail potential planetary catastrophes, but whose probability – at least in the short-term – is low (e.g., less than 10%) tends to get overlooked by scientists and, therefore, by policy-makers as well. Politicians and decision-makers usually need a full assessment of the risk posed by climate change before deciding priorities of mitigation and adaptation, and easily ignore risks associated with extreme warming which inherently have higher scientific uncertainty levels but pose greater risk and threat to resiliency.

Addressing the extremes and risks associated with those extremes seems obvious – and it is to those in the business and insurance industries. We are also happy to pay dearly for insurance for our homes that may never be used, because we know the risk and cost of a fire or flood in our home. The approach to risk-taking spell out characteristics of that approach but also the opposite and literature demonstrates that in some cases humans often do not make rational decisions, i.e. failure to evacuate during a hurricane.

In contrast, when it comes to risks to human health the approach of maximum risk aversion is clearly seen. Take, for instance, the case of recent virus epidemic outbreaks and how health organizations responded to it. In particular, the World Health Organization (WHO) issued a highest level international health emergency warning on the risk of zika virus to pregnant women on very scarce scientific evidence on the relationship of zika virus infection and fetuses' brain malformation. After the warning come out, scientific studies established with uncertainty that about 1% to 4% of pregnant women who had zika virus infection within the first 3 months of pregnancy would develop fetuses' brain malformation and that was sufficient for WHO to reiterate strongly the international health emergency warning.

We need to use similar rational reasoning when it comes to assessing the risk of dangerous climate change and acting upon it. Science tells strongly that carbon dioxide concentrations should be lower than 350 parts per million if humankind is to be on the safe operating space, and we're currently over 400 parts per million (ppm) and have reached an equivalent of 480 ppm when all GHG are considered. We already know that we're facing increasing risks of severe, unpredictable climate impacts, and yet the reductions to our emissions trajectory have been far too modest, or even negative. Our home is almost on fire and we are still reluctant to buy the insurance.

Therefore, it is the goal of this policy brief to emphasize the need to assess direct and systemic risks at high degrees of climate change and the extremes at those higher levels and the means for developing a risk-based approach to communicating the risks of climate change to policy makers and to the public. It is framed along the principles of risk analysis in terms of probability of high impact events for high degrees of warming, particularly those affecting human wellbeing and livelihoods.

2. Background

While the international community uses two degrees as the rule-of-thumb threshold for "dangerous" warming, some major climate impacts are already locked-in, particularly for low-lying and island nations. But against this optimistic backdrop, greenhouse gas emissions have continued to rise. What happens if we overshoot the 2°C target for limiting global warming? And also considering the large regional variations of warming expected (e.g., the Artic is warming at a rate twice as high as the global average). With each passing year the scale of the task looms ever larger. As temperatures rise, so do the risks.

COP21 advanced considerably on many fronts and particularly by setting a goal of keeping warming well below 2°C, and for the pursuit to limit the warming to 1.5°C. This decision is a clear recognition of the climate risks of keeping the "safety guardrail" at 2°C. This goal demands a global effort to reduce global emissions much earlier than a 2°C target would allow, reducing the carbon space and requiring stringent decarbonization of the global economy and close to zero net emissions by mid-century.

Rising temperatures have consequences for food, water, and energy security, ecosystems, infrastructure, human health and international/national security. And the higher the temperature, the greater the risk those climate change impacts will be serious and damaging and even irreversible and catastrophic. One of the most direct impacts society feels from more high increase temperatures is the increased risk to heat waves, and the greater frequency and intensity of extreme weather.

The IPCC AR5 uses four pathways (RCPs 2.6 W/m^2, 4.5 W/m^2, 6.0 W/m^2 and 8.5 W/m^2) (IPCC, 2013) to illustrate how greenhouse gases could evolve this century. In 2100, the RCP 4.5 scenario should allow the global temperature to level out at about 1.4°C to 3.1°C above pre-industrial levels. *Yet even accepting this level of risk would require a strong commitment to mitigation, and at 3°C the risks* of strong sea level rise from Antarctic and Arctic sea ice melting, and the loss of marine ecosystems, such as coral reefs *are already very high.* Natural ecosystems are also set to suffer under higher temperatures. In the IPCC's AR5 most extreme scenario (RCP 8.5) *temperatures exceed 4°C by 2100 and unless emissions cease altogether, temperatures will continue to rise long past the end of the century.* In RCP 8.5, projections for 2150 show an increase of 6°C. This may be a worst-case scenario, and it is very difficult to envision what a 2°C world will look like, let alone 4°C or 6°C. Yet as the IPCC AR5 Report notes, under any of these scenarios there is a risk of triggering large, abrupt or irreversible changes in the climate system and associated ecosystems.

In summary, the recent IPCC report concluded that "*global climate change risks are high to very high with global mean temperature increase of 4°C or more above preindustrial levels in all reasons for concern, and include severe and widespread impacts on unique and threatened systems, substantial species extinction, large risks to global and regional food security, and the combination of high temperature and humidity compromising normal human activities, including growing food or working outdoors in some areas for parts of the year*" (IPCC, 2014).

3. The principles of risk assessment[2] applied to climate change

The risks of most concern in risk assessment are usually those with the greatest impact, especially when there is potential for irreversible consequences. Climate change fits the definition of a risk ('*an uncertain, generally adverse consequence of an event or activity with respect to something that humans value*'), because it is likely to affect human interests in a negative way, and because many of its consequences are uncertain. We have to ask the questions "*What is it that we wish to avoid?*" and "*How likely is that?*" And we have to attempt to identify the biggest risks, especially thresholds and tipping points at which impacts become irreversible.

Generally, risk assessment practitioners such as those in the insurance industry are not tolerant at all of false-negatives – they minimize the likelihood of assuming that a risk will not occur. They are particularly concerned with events of low probability and very high impact, such as (in the climate context) an increase in temperature of above 2°C predicted to occur with only 10% probability. By contrast, the IPCC defines '*likely*' as 66-90% probability, and '*unlikely*' as 10-33% probability. In order to avoid such false negative errors, the risk associated with a 10% probability would be virtually unacceptable. Translating scientific uncertainty to a risk assessment is necessary for decision-makers. And taking into account the range of regional temperature increases for a given global average temperature increase is needed even when considering lower global temperature increases.

The perception of climate change risks is increasing among key stakeholders. A 2015 survey with 750 stakeholders from business, NGO, academy, etc. indicated that they ranked failure of climate change mitigation and adaptation as the most impactful global risk and ranked that third in terms of likelihood for the next 10 years (WEF 2016).

We must consider the biggest risks and the possibility of adaptation capacities failing in a 4°C or higher warming world. Therefore, it is critical for our analysis to identify limits to adaptation or thresholds not to be transgressed.

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[2] Principles of risk assessment (King et al., 2015):
Assess risks in relation to objectives, or interests. Start from an understanding of what it is that we wish to avoid; then assess its likelihood; Identify biggest risks. Focus on finding out more about worst-case scenarios in relation to long-term changes, as well as short-term events; Consider the full range of probabilities, bearing in mind that a very low probability may correspond to a very high risk, if the impact is catastrophic; Use the best available information, whether this is proven science, or expert judgment. A best estimate is usually better than no estimate at all; Take a holistic view. Assess systemic risks, as well as direct risks. Assess risks across the full range of space and time affected by the relevant decisions; Be explicit about value judgments. Recognize that they are essentially subjective, and present them transparently so that they can be subject to public debate.

4. Selected examples of risks of higher degrees of warming

Currently, our carbon dioxide emission patterns are taking us to 3oC to 7oC of global warming with regional temperature extremes as high as 10oC. As time goes by, and if we fail to mitigate (reduce emissions), the likelihood of high degrees of warming increases. Even if we limit total emissions to about 1,000 billion tonnes of CO2-eq, the "safe carbon budget" established by the IPCC on its Fifth Assessment Report, there is still a 30 percent chance of global warming exceeding the 2oC threshold. The safer guardrail for not exceeding 1.5oC is even more stringent: limit total emissions to less than 500 billion tonnes of CO2-eq by mid-century and remove CO2 from the atmosphere further on (negative emissions). The voluntary pledges put forth by countries for COP21 would mean at least 2.7°C warming (2.7°C-3.5°C range). If we factor in the uncertainties in the behavior of the carbon cycle feedbacks—likely reduction of unknown magnitude of the carbon sink by the ocean and terrestrial biota as the planet warms– the warming by 2100 could be more than one degree higher than the IPCC AR5 estimates. Additionally, for a given global temperature increase, the corresponding land temperature increase will be far greater. Lastly, on one extreme tail of the distribution of high emission pathways, we have to consider that temperature increases of over 8°C or even 10°C cannot be excluded over the long term and the very high risks they entail are the ones mostly in need of risk analysis.

Next, we present a few illustrations of risks to sectors and ecosystems. The purpose is not to provide an exhaustive scientific review, but rather to illustrate some of the biggest risks as examples of low probability, very high impact risks, implying irreversibility and limits to adaptation.

5. Sea level rise and impact on coastal cities

There are over 400 million people living in 136 coastal cities with population exceeding one million people. Consider the likelihood of catastrophic sea level rise due to the collapse of the Greenland and West Antarctic Ice Sheets. Those ice sheets store the equivalent of seven to ten meters of sea level rise. They have collapsed in the past under a 2oC warming, and this can happen again due to several feedback mechanisms. It is uncertain when a collapse may take place since it may evolve over centuries to millennia, but is very likely to happen if the planet warms up by 2-3°C. That much sea level rise would completely re-draw coastlines and would push hundreds of millions from their homes. There may be limits to adaptation. For instance, for the Thames Estuary, 5 m of mean sea level rise was identified as an absolute limit for sea wall raising and tidal barrier construction.

6. Ocean biodiversity (warming and ocean acidification)

A global warming of 4°C or more by 2100 would correspond to a CO_2 concentration above 800 ppm and an increase of about 150 percent in acidity of the ocean. The already observed and projected rates of change in ocean acidity over the next century appear to be unparalleled in Earth's history. The regional extinction of entire coral reef ecosystems, which has already started, could be completed well before the 4°C is reached. This extinction would have profound consequences not only for the dependent coral reef species but also for the people who depend on them for food, income, tourism, and shoreline protection. Their depletion would represent a major loss to Earth's biological heritage (The World Bank, 2012) and would be irreversible for a very long period.

7. Human Health (physiological limits to heat stress)

Of course people do adapt to climate change, and will need to adapt even more than today. What is a plausible worst case for heat stress due to climate change this century and beyond? There is only so much heat that a human can tolerate. Human physiology operates within limits, and a 7°C global warming would make it difficult to find adaptation solutions. Heat waves would become so extreme that they would be fatal to anyone without reliable air-conditioning, even healthy people resting in the shade. The human body cannot endure wet-bulb temperatures[3] higher than 35°C for more than a few hours. Urban heat inland effects and other environmental stressors make this limit to adaptation even more plausible for many megacities towards the end of the century and in the 22nd century.

8. Conclusions

Far from being 'in the tails of the distribution', disruptive changes to our natural ecosystems and to our industrial ecosystems are now almost inevitable. No nation will be immune to the impacts of climate change. However, the distribution of impacts is likely to be inherently unequal, regionally dependent, and tilted against many of the world's poorest people, who have the least economic, institutional, scientific, and technical capacity to cope and adapt (The World Bank, 2012).

Climate change needs to be understood by policy-makers as an issue of risk reduction management since uncertainty justifies action rather than inaction, in line with the precautionary approach espoused in the UNFCCC. Risk assessments must be routinely issued and need to be regularly updated, and be strongly communicated to governments and economic sectors. Meanwhile, minimizing risks means putting much more clout into stringent and urgent mitigation policies because we need insurance against the odds of catastrophe.

The greatest risks of climate change arise when thresholds are crossed: what had been gradual becomes sudden; what had been inconvenient becomes intolerable. The greatest reductions in risk will be won in the same way. Gradual, incremental measures will not be enough: we must seek out non-linear, discontinuous, disruptive transformational change (King et al., 2015). This transformational change will also require increased social unacceptability of the possibility of a fossil future.

[3] Wet-bulb temperature is defined as the air temperature when the air is saturated of water vapor (100% relative humidity).

References:

IPCC, 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324.

IPCC, 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.[

King, Schrag, Dadi, Ye and Ghosh, 2015. Climate Change: a Risk Assessment. Available from http://www.csap.cam.ac.uk/media/uploads/files/1/climate-change--a-risk-assessment-v11.pdf.

The World Bank, 2012. Turn Down the Heat: Why a 4 C Warmer World Must be Avoided. A report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. November 2012, Washington, D.C., USA. Available from www.class-central.com/mooc/1328/coursera-turn-down-the-heat-why-a-4-c-warmer-world-must-be-avoided.

World Economic Forum, 2016. The Global Risks Report 2016 -11th Edition. Available at wef.ch/risks2016.

For reference: Key risks (IPCC-AR5-WG2-SPM)

The key risks that follow, all of which are identified with high confidence, span sectors and regions. Each of these key risks contributes to one or more RFCs (Reasons For Concern) (IPCC, 2014).

i. Risk of death, injury, ill-health, or disrupted livelihoods in low-lying coastal zones and small island developing states and other small islands, due to storm surges, coastal flooding, and sea-level rise.

ii. Risk of severe ill-health and disrupted livelihoods for large urban populations due to inland flooding in some regions.

iii. Systemic risks due to extreme weather events leading to breakdown of infrastructure networks and critical services such as electricity, water supply, and health and emergency services.

iv. Risk of mortality and morbidity during periods of extreme heat, particularly for vulnerable urban populations and those working outdoors in urban or rural areas.

v. Risk of food insecurity and the breakdown of food systems linked to warming, drought, flooding, and precipitation variability and extremes, particularly for poorer populations in urban and rural settings.

vi. Risk of loss of rural livelihoods and income due to insufficient access to drinking and irrigation water and reduced agricultural productivity, particularly for farmers and pastoralists with minimal capital in semi-arid regions.

vii. Risk of loss of marine and coastal ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for coastal livelihoods, especially for fishing communities in the tropics and the Arctic.

viii. Risk of loss of terrestrial and inland water ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for livelihoods.