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Loss and damage: Defining slow onset events

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The Earth is slow to warm. Even if all emissions were halted immediately, historical emissions would cause warming, and impacts, for years to come. Current committed warming will bring about extreme weather events – droughts, floods, extreme heat waves – as well as impacts manifested as ***slow-onset*** *changes and* ***state shifts*** *in climate. With current levels of committed warming we also face the risk of passing* ***tipping points*** *of important climate system elements[1] that may trigger a process of abrupt and non-linear climate change.[2] In this brief we describe in more detail such slow-onset processes and the* ***loss and damage*** *they may cause, in particular to human lives and livelihoods. We also consider the emerging governance challenges under the UNFCCC of managing long-term threats associated with slow-onset processes, state shifts, and tipping points.*

Introduction

With Decision 1/CP.16, Parties agreed to consider slow-onset events in the work programme on loss and damage. Decision 1/CP.16 includes a footnote that lists categories of impact that negotiators considered to be "slow onset events": sea level rise, increasing temperatures, ocean acidification, glacial retreat and related impacts, salinization, land and forest degradation, loss of biodiversity and desertification.

These slow-onset "events" – more appropriately termed slow-onset ***processes***, ***hazards***, or ***impacts*** – are an important element in the conversation on loss and damage, distinct from extreme events. The losses that result from slow-onset processes will affect many more people than extreme events over a long period of time. Because they are persistent and develop over time, they are not amenable to many of the approaches currently under consideration for addressing extreme events, such as index-based insurance.

Moreover, because these "events" progress and increase in impact over time, "adaptation" is a decreasingly viable option. As temperatures and sea levels rise, territory will become uninhabitable and unproductive. Soil moisture levels will decrease to the point that cultivation of crops is no longer viable in entire regions. Groundwater sources in coastal areas will become too saline to provide drinking water for people living there. Adaptation will become impossible on low-lying islands and in the most arid regions, leading to permanent loss of lands, livelihoods, and cultural resources.

Slow-onset events will have significant and wide-ranging impacts on people's lives and livelihoods and are irreversible in our lifetimes if temperatures continue to rise.

In this briefing we take each of these categories of slow-onset processes and impacts in turn to more visually elaborate the ***loss and damage*** that may result from them, with reference to useful background studies as appropriate. We focus our examples on impacts directly related to lives and livelihoods. The reader should keep in mind that direct impacts on lives and livelihoods are more tangibly translated into economic terms. However, as we have written about previously, impacts on cultures, ecosystems, and territories that cannot be

[1] The Atlantic thermohaline circulation, West Antarctic ice sheet, Greenland ice sheet, Amazon rainforest, boreal forests, West African monsoon, Indian summer monsoon, and El Niño/Southern Oscillation. See Lenton, T.M. et al. 2008. Tipping elements in the Earth's climate system. *Proceedings of the National Academy of Sciences* 105: 1786-1793.
[2] Lenton, T.M. 2011. Early warning of climate tipping points. *Nature Climate Change* 1: 201-209.

easily valued in monetary terms (non-economic impacts) must also be integrated into considerations of "loss and damage."

We finish the brief with a discussion of elements that must be considered by Parties, as they continue their work on loss and damage, which are necessary to begin to address the emerging long-term challenges posed by slow-onset processes, permanent phase shifts, and tipping elements.

Sea level rise

As temperatures rise, the water in the world's oceans and seas will expand. Glaciers and ice caps will melt. Both these processes lead to an inexorable, albeit uneven, increase in the level of the seas and reconfiguration of coastal areas.

Sea level rise will lead directly to ***loss of both territory and productive land***. Moreover, with increasing sea levels, aquifers and soils will become contaminated with salt, leading both to a ***loss of ability to produce food*** in saline conditions and ***loss of freshwater for drinking***. (see also the discussion below on salinization)

- "Salinity along the Bangladesh coast has already encroached over 100km inland into domestic ponds, groundwater supplies and agricultural land, through the various estuaries and water inlets intertwined with major rivers."[3]
- With the sea level rise predicted for the Mediterranean, "10% of Egypt's population (an estimated 6 million people) would be affected and 12%–15% of the agricultural land of the Nile Delta could be lost. Even if direct inundation is prevented, rising sea levels will change the freshwater-saline interface, rendering some of the fertile coastal agricultural areas increasingly difficult to cultivate."[4]
- The government of Guyana is contemplating drastic measures to maintain food production and food security in the face of rising seas: shifting its rice production areas inland. "Almost all rice is cultivated on the northeast stretch of coast, which is increasingly affected by flooding."[5]

Sea level rise will also lead to ***loss of critical marine ecosystems*** for food production such as mangroves and coral reefs, which serve as fish nurseries and habitat, with consequent impacts on fish populations and fisheries resources that provide food and livelihoods.

Sea level rise will ***damage protective barriers, such as embankments and mangroves, and resources*** important for local coastal-based tourist economies, including coral reefs, beaches, and port facilities.

Increasing temperatures

Whilst it is clear that global temperatures are rising and that this is a background condition for all considerations of climate change impacts, there are also specific impacts that will result from the slow increase of temperature that should be considered in the context of "loss and damage." These include impacts on lives and livelihoods.

As temperatures increase, cropping and pasture regions will become unproductive due to loss of soil moisture – again an example of ***loss of productive land***. As soil moisture evaporates more quickly with higher temperatures, even if rainfall patterns remain constant cropping seasons can shorten to the point that even short season crops cannot be grown.[6]

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[3] Khan, A.E. and M.I. Islam. 2011. Water salinity and maternal health. 5 June. http://www.thedailystar.net/newDesign/news-details.php?nid=188591

[4] Sowers, J., A. Vengosh, and E. Weinthal. 2010. Climate change, water resources, and the politics of adaptation in the Middle East and North Africa. *Climatic Change* DOI 10.1007/s10584-010-9835-4

[5] http://www.trust.org/alertnet/news/guyana-tries-out-rice-cultivation-on-savannah

[6] Dai, A. 2010. Drought under global warming: a review. *WIREs Climate Change* DOI: 10.1002/wcc.81. Dai warns that with climate-change related drying, a very large population could "be severely affected in the coming decades over the whole United States, southern Europe, Southeast Asia, Brazil, Chile, Australia, and most of Africa.

- In Sri Lanka, during the recent delay in the summer monsoon, the lack of rain was worsened by rising temperatures. "According to the annual report of the Sri Lanka Central Bank, average temperatures have increased by about 0.45 Celsius in Sri Lanka over the last two decades. Rising temperatures mean that whatever water is available in dry-zone areas like the Parakarama Samudraya evaporates quickly."[7]
- Long-term drought in the northern states of Mexico has devastated cattle herds and crops. Experts expect the drying in this region to continue; models indicate that *extreme* drought will be the *normal* condition in southern Mexico by the end of the century.[8] In this situation, the word "drought" – usually meant to indicate a *temporary* drying away from a wetter normal condition – becomes over time inappropriate. Indeed the slow drying over time, at least partly related to increase in temperature, leads to a permanent shift in the regional climate. A permanent shift in the climate would mean thousands of farmers losing use of their lands and their livelihoods.

Not only will mean temperatures continue to increase, but also temperature extremes. ***Areas will be lost for human habitation*** as temperature extremes become too dangerous for human and animal life.

Animals become less productive in high heat, with ***damage to yields, food production, and farmer livelihoods.*** For example, the United States' dairy industry has seen milk yields plummet this year in the extreme heat suffered in the Midwest during its summer season.[9]

Ocean acidification

As carbon dioxide dissolves in oceans, the acidity of the oceans increases, with impacts on a wide range of marine life, and there is a reduction in carbonate available to marine organisms to construct their shells. "Studies have shown that a more acidic environment has a dramatic effect on some calcifying species, including oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton."[10] "It is anticipated that future ocean acidification will affect adult and juvenile coral growth and recruitment, coralline red algae growth, reef structural integrity and potentially even the density of bio-eroding grazers and predators."[11]

As atmospheric carbon dioxide levels increase, scientists anticipate further acidification of the oceans. The rate at which this will happen is yet unclear, as there are many processes yet to be understood linked in the ocean chemical soup that may slow or speed the rate of acidification.

Acidification will have significant, direct impacts on lives and livelihoods, as fish-dependent communities will be affected in numerous ways:

- "Many of the most sensitive species are directly or indirectly of great cultural, economic, or ecological importance for example, warm-water corals that reduce coastal erosion and provide habitat for many other species."[12]
- "These organisms are a human food source (e.g., molluscs), provide food for fish (e.g., pteropods are eaten by salmon) and create ecosystems and refuges for fish (e.g., coral reefs)."[13]

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[7] http://www.trust.org/alertnet/news/erratic-rainfall-in-sri-lanka-hitting-rice-crop-power-production

[8] Wehner, M. et al. 2011. Projections of future drought in the continental United States and Mexico. *Journal of Hydrometeorology* DOI: 10.1175/2011JHM1351.1.

[9] LaCrosse Tribune. 2012. Extreme heat cuts milk production."17 July. http://lacrossetribune.com/news/local/state-and-regional/extreme-heat-cuts-milk-production/article_9bee7bca-d030-11e1-8cc8-0019bb2963f4.html

[10] http://www.pmel.noaa.gov/co2/story/Ocean+Acidification

[11] United Nations Environment Programme (UNEP). 2010. UNEP Emerging Issues: Environmental Consequences of Ocean Acidification: A Threat to Food Security. Nairobi, Kenya: UNEP.

[12] European Project on Ocean Acidification. 2012. "Messages for Rio+20." http://epoca-project.eu/index.php/what-do-we-do/outreach/rug/oa-aoe.html

[13] United Nations Environment Programme (UNEP). 2010. UNEP Emerging Issues: Environmental Consequences of Ocean Acidification: A Threat to Food Security. Nairobi, Kenya: UNEP.

- "Significant reef loss would, therefore, impact marine biodiversity, threaten the survival of coastal communities through reduced food sources and reduce the capacity of nearby coastlines to buffer the impact of sea level rise, including increased storm surges."[14]

Ocean acidification will lead to a direct ***loss of fisheries*** resources. ***Loss and/or damage of coral reef ecosystems*** will lead to greater storm impacts, ***damage to tourist economies*** and ***loss of livelihoods*** based on tourism and fisheries.

Glacial retreat and related impacts

Glacier retreat is related to increasing temperatures, though local climates (both with respect to temperature and precipitation) will dictate the speed at which particular glaciers melt. Glaciers in South America are disappearing particularly quickly, including in Peru's Cordillera Blanca. "Where scientists once believed that they had 10 to 20 years to adapt to reduced runoff, that time is now up," according to Michel Baraer of McGill University in Canada. "For almost all the watersheds we have studied, we have good evidence that we have passed peak water. … This means that the millions of people in the region who depend on the water for electricity, agriculture and drinking water could soon face serious problems because of reduced water supplies."[15]

According to the most recent assessment of the IPCC, glaciers in the Himalaya are receding more quickly than anywhere else in the world.[16]

For millions of persons, glacial retreat will mean ***loss of essential water resources*** for drinking water, irrigation and electricity production.

Salinization

Salinization is the increase in salinity of soil or water. Sea level rise is expected to lead to increasing salinity of coastal aquifers due to intrusion. Salinization can be exacerbated with a decrease in precipitation, as less recharge of aquifers with freshwater will allow more seawater to infiltrate into the aquifer. "Further intrusion due to the rise of sea level combined with less fresh water recharge into these coastal aquifers will enhance inland encroachment of seawater and intensify other salinization phenomena,"[17] such as the salinization of lands as sea waters penetrate inland.

"Increased salinity has severe consequences on agricultural productivity, with the multiple effects of surface water, groundwater and soil quality change combining to reduce crop yields. Climate change is expected to exacerbate this situation, with projections by CEGIS [Center for Environmental and Geographic Information Services] suggesting that the '5 ppt' isohaline line could shift as far north as 90km inland due to sea- level rise by the 2070s."[18]

As noted above in the section on sea level rise, salinization of croplands and aquifers will lead to ***loss of productive land, the ability to produce food and loss of potable drinking water.***

[14] United Nations Environment Programme (UNEP). 2010. UNEP Emerging Issues: Environmental Consequences of Ocean Acidification: A Threat to Food Security. Nairobi, Kenya: UNEP.
[15] McGill University. 2012. Retreating glaciers threaten water supplies. *ScienceDaily*, 12 January.
[16] Cruz, R.V., et al. 2007. Asia. In Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. Cambridge, UK: Cambridge University Press.
[17] Sowers, J., A. Vengosh, E. Weinthal. 2010. Climate change, water resources, and the politics of adaptation in the Middle East and North Africa. *Climatic Change* DOI 10.1007/s10584-010-9835-4
[18] International Organization for Migration (IOM). 2010. Assessing the evidence: environment, climate change and migration in Bangladesh. Dhaka, Bangladesh: IOM.

Land and forest degradation

The UN Convention to Combat Desertification (UNCCD) defines land degradation as a "reduction or loss, in arid, semi-arid, and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical, and biological or economic properties of soil; and (iii) long-term loss of natural vegetation."[19] "Land degradation is caused by multiple forces, including extreme weather conditions particularly drought, … and extreme weather events such as droughts and coastal surges which salinate land."[20]

The slow onset of degradation due to climate change is clearly related to processes described in earlier sections – salinization and increasing temperatures – which have an impact on physical, chemical and biological properties of the soil. Climate change will also affect natural vegetation through extinction of many plant species.[21] "Forage quality in pastures and rangelands generally declines with increasing carbon dioxide concentration because of the effects on plant nitrogen and protein content, reducing the land's ability to supply adequate livestock feed."[22]

Losses and damage associated with land degradation include "undermining of food production, famine, increased social costs, decline in the quantity and quality of fresh water supplies, increased poverty and political instability, reduction in the land's resilience to natural climate variability and decreased soil productivity."[23]

Forests across the globe are being transformed as a result of climate change. Related to the decrease in soil moisture from increasing temperatures, climate change makes forests drier. This drying increases the likelihood and severity of forest fires.[24] Forest-dependent populations risk ***loss of territory and livelihoods*** as forests burn or are degraded through changes in species composition.

Loss of biodiversity

"Many plant and animal species are unlikely to survive climate change."[25] Figures vary, but a 2004 assessment estimated that 15-37% of species from a sample of 1,103 terrestrial animals and plants would be extinct due to climate changes anticipated by 2050.

Humans are dependent on the natural world for sustenance. Ecosystems and their plant and animal inhabitants support our communities, economies, cultures and spiritual lives in myriad ways, too varied and numerous to address in a short briefing. The ***loss of countless species*** will impoverish our lives, ***damaging ecosystems***, and threaten the stability of those systems upon which we depend.

Desertification

The UN Convention to Combat Desertification defines desertification as " land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities." The sections above on land degradation, increasing temperature and salinization are relevant to consideration of loss and damage due to desertification.

The World Meteorological Organization explains that "climate change might exacerbate land degradation through alteration of spatial and temporal patterns in temperature, rainfall, solar radiation, and winds. … It is

[19] World Meteorological Organization (WMO). 2005. Climate and land degradation. Geneva, Switzerland: WMO.
[20] http://www.who.int/globalchange/ecosystems/desert/en/index.html
[21] Thomas, C.D. et al. 2004. Extinction risk from climate change. *Nature* 427**:** 145–148; Pounds, J.A. 2004. Ecology: clouded futures. *Nature* 427**:** 107–109.
[22] http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/climate-change-impacts-by-sector/agriculture#key5
[23] World Meteorological Organization (WMO). 2005. Climate and land degradation. Geneva, Switzerland: WMO.
[24] http://wwf.panda.org/about_our_earth/about_forests/deforestation/forestdegradation/
[25] http://www.nature.com/nature/links/040108/040108-1.html

predicted that there will be a 17 per cent increase in the world area of desert land due to the climate change expected, with a doubling of atmospheric CO_2 content.[26]

Loss and damage impacts of desertification include ***loss of territory*** and ***loss of productive land***, leading to ***loss of livelihood options***. When productive lands are lost, migration becomes the primary option.

Missing items in the list of slow-onset hazards: permanent state shifts and tipping points

In the discussion above on increasing temperatures and the concomitant reduction in soil moisture levels, we noted that these processes are predicted to lead to a likely permanent situation of extreme drought in southern Mexico. Long-term extreme droughts shift to states of permanent aridity. As temperatures increase and soil moisture levels decline around the world, these changing conditions result from climatological shifts, which then bring about shifts in ecosystems as well as the productive uses of those ecosystems.

State shifts are qualitative changes in the state of a system. Such changes are often, though not always, irreversible. While most often we think of state shifts in biological or climatological terms, we can also consider socio-economic state shifts, brought about when land is no longer able to produce food, to provide fodder for animals, or when fisheries no longer provide enough fish for the fishing communities dependent on them.

These permanent shifts in state can happen slowly or rapidly. The drying described above will result from a slow shift in the temperature and precipitation regime. Major tipping elements in the earth system, such as the annual West African and Indian summer monsoons, the El Niño Southern Oscillation, or the Amazon rainforest could be pushed towards tipping points that would bring about more rapid state shifts with impacts felt at the global level.[27]

Managing and addressing long-term challenges associated with slow-onset processes

Parties will need to undertake further work under the Convention to enhance the understanding of slow-onset processes, the types of loss and damage associated with various types of slow-onset impacts, and how these impacts might be addressed in multiple contexts. Below we discuss several specific issues that require further systematic consideration under the Convention, based on the work already achieved under the work programme on loss and damage and our analysis.

The work undertaken so far in the work programme on loss and damage has made clear that addressing loss and damage will require international-level action and additional efforts and institutions to systematically consider and address the needs of developing countries. Both economic and non-economic loss and damage must be addressed. The mandate of the work programme requires Parties to look at both approaches for dealing with climate change-related extreme weather events and slow-onset hazards, including sea level rise, increasing temperatures, ocean acidification and glacial melt. Up to the moment, the work programme has given little consideration to the issues raised by slow-onset processes and impacts. This gap must be recognized in the work moving forward under the Convention after COP18.

The complexity of slow-onset events and the need to enhance our understanding, coordination and cooperation in assessing and addressing their impacts points to the need for special consideration both under the governance mechanisms of the UNFCCC and within other regional and multilateral institutions. Elements that must be considered by the UNFCCC and other bodies include:

- **Specialized support for addressing impacts from slow-onset processes:** As noted throughout the brief, slow-onset events will require action and measures to address loss as well as to remediate and rehabilitate damage – to livelihoods, to both natural and managed ecosystems, and other productive

[26] World Meteorological Organization (WMO). 2005. Climate and land degradation. Geneva, Switzerland: WMO.
[27] Lenton, T.M. et al. 2008. Tipping elements in the Earth's climate system. *Proceedings of the National Academy of Sciences* 105: 1786-1793.

resources. Parallels might be sought with the governance system for addressing impacts of extreme events, where disaster risk reduction and humanitarian intervention build the proactive and reactive response to a disaster. The level of funding that might be required to prevent, manage, and compensate for loss and damage related to slow-onset impacts varies greatly country to country and between regions and is highly uncertain. This uncertainty only highlights the importance of appropriate consideration in the context of finance. The precautionary principle underscores the need to support and implement proactive approaches to manage slow-onset climate hazards.

- **Migration:** The needs of climate migrants require appropriate consideration. Existing international frameworks dealing with issues of displacement and migration will need to be expanded to handle movement resulting from the pressures imposed by slow-onset processes. Many people will be forced to move from areas affected by permanent changes to the ecosystems and other resources on which they depend for their lives and livelihoods. Adequate provisions will need to be designed in collaboration with relevant international institutions to consider how to address the issue of migration, displacement, and population distribution. The COP has the capacity to make recommendations to other international bodies along these lines.
- **Financial shocks and lost development opportunities:** The potential for large-scale economic disruption brought on by slow-onset climate change hazards will require significant coordination of international trade and investment flows. Addressing loss and damage resulting from slow-onset processes, in the context of sustainable development, will require different approaches than those used to address financial shocks resulting from extreme events. For example, slow-onset impacts may permanently diminish the tourism industry in many developing countries due to the loss of ecosystems, animal and plant diversity, and other tourist-attracting resources (for example, rainforests, coral reefs and glaciers). Such issues need to be part of the consideration of slow-onset impacts.
- **Identification of tipping points:** Further work to understand slow-onset hazards should include a goal to enhance our understanding of tipping elements and tipping points, and possible early warning mechanisms for the potential triggering of key tipping elements, both ecological as well as societal. Based on this enhanced understanding, Parties would recommend appropriate actions.