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Slow Onset Climate Change Impacts

Global Trends and the Role of Science-Policy Partnerships

Denise Margaret Matias

Slow onset climate change impacts: global trends and the role of science-policy partnerships

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Abstract

Climate change is often associated with extreme rapid onset events such as intense typhoons (also known as hurricanes or cyclones) or heavy precipitation, but it also manifests in slow onset events, such as sea level rise or ocean acidification, whose rate of impact is gradual and appears less destructive than that of extreme events. Yet, the UNFCCC found that the negative impacts of slow onset events are already affecting developing countries and there is an urgent need to manage the risks, despite the slow pace of the process. This discussion paper reviews publications on slow onset events in order to understand how global research is responding to this urgency. By looking at geographical, disciplinary, and thematic trends in research, it concludes that research on slow onset events is increasing. However, most of the currently published research has been conducted in and focused on North America and Europe. With developing countries most at risk, it is recommended that more research efforts be focused on them. In addition, risk-management measures for slow onset events are yet to be established; transdisciplinary cooperation between civil society, researchers, and policymakers can be instrumental in creating an enabling environment for such measures.

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Bonn, October 2017 Denise Margaret Matias

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Abbreviations

α	Level of statistical significance
X^2	Pearson's chi-squared test
IPCC	Intergovernmental Panel on Climate Change
p	p-value or probability value
PAR	Pressure and Release Model
RH	Risk-Hazard Model
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

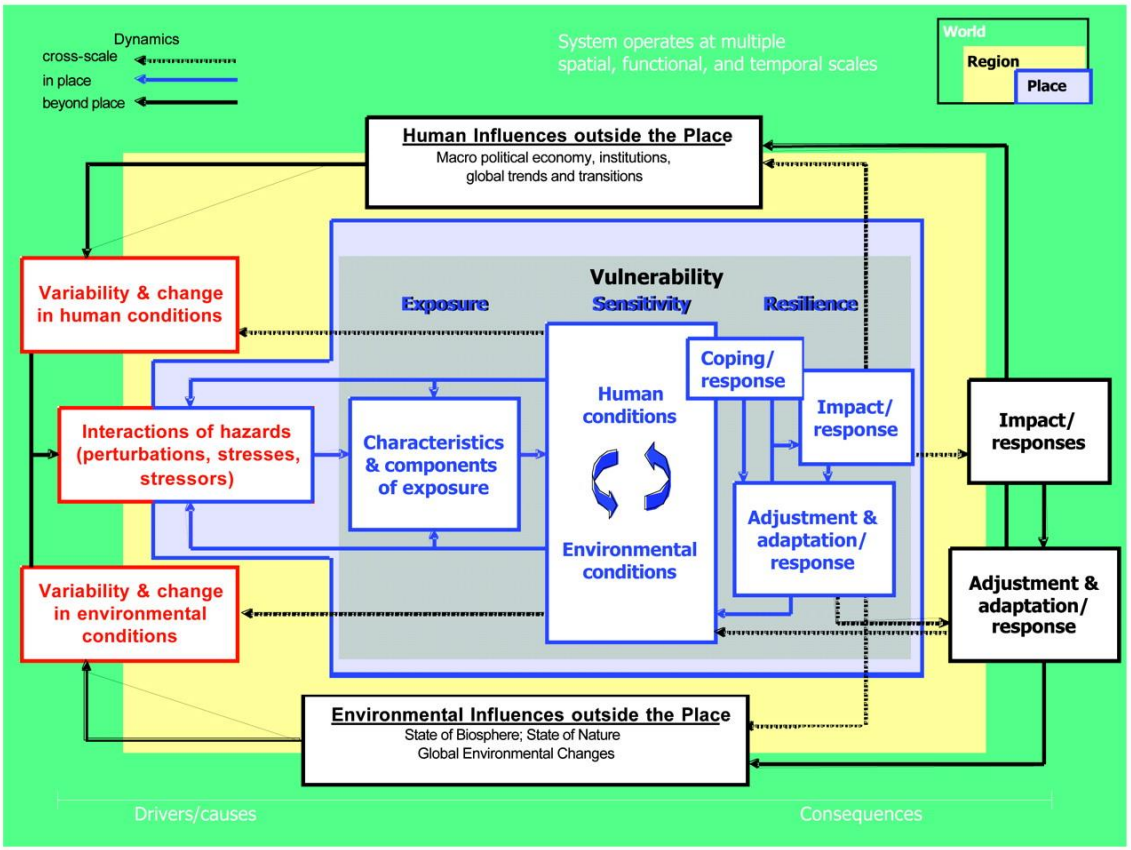
The reality of climate change is often associated with extreme rapid onset events such as intense typhoons or heavy precipitation, whose sudden impacts attract widespread attention, but climate change also manifests in slow onset events such as sea level rise or ocean acidification, whose rate of impact is slower and appears less destructive than that of extreme events. The Cancun Agreements (Decision 1/CP. 16) identified slow onset events as "including sea level rise, increasing temperatures, ocean acidification, glacial retreat and related impacts, salinisation, land and forest degradation, loss of biodiversity and desertification." Slow onset events span a broad range of systems. If their associated risks are not managed, this may lead to the social-ecological thresholds or tipping points of systems being crossed, and may pose severe challenges to adaptation (IPCC, 2012).

On a policy level, extreme weather events have influenced countries to prioritise adaptation as well as mitigation (e.g. EEA, 2014; RP, 2012). Even research has focused on extreme weather events, with far more publications turning up in a literature search on the topic compared to slow onset events.[1] However, this does not imply that slow onset events are less important than extreme weather events. On the contrary, the findings of a UNFCCC technical paper on slow onset events shows that "there are synergistic interactions between rapid onset and slow onset events that increase the risk of loss and damage", which underlines the importance of concurrently addressing slow onset and extreme climate change impacts (UNFCCC, 2012). The UNFCCC technical paper also found that the negative effects of slow onset events were already affecting developing countries, with the resulting loss and damage likely to increase significantly. Given this increasing urgency, this paper contributes to analysing current trends in research on slow onset climate change impacts, and identifying gaps where additional cooperation and research efforts should be directed.

The IPCC provides a broad overview of current knowledge on climate change, but as the field of climate change research dynamically evolves, new literature-review approaches are needed to identify and characterise persistent and emergent gaps in knowledge (Ford, Berrang-Ford, & Paterson, 2011). This discussion paper reports on a review conducted in order to understand how global research has responded to the increasing urgency associated with slow onset climate change impacts. To this end, the paper pursues three objectives: (1) to identify global trends in research on slow onset climate change impacts; (2) to analyse research trends through the risk-hazard (RH) or pressure-and-release (PAR) models; and (3) to characterise risk-management measures through the lens of the vulnerability framework in sustainability science proposed by Turner et al. (2003) (Figure 1).

1 A literature search on Google Scholar during mid-October 2017 using search terms "Extreme climate change" returned results of 2,540,000 compared to 1,120,000 for "Slow climate change" or 171,000 for the search terms slow onset events climate change (without search operators " ").

Figure 1: Framework for analysing vulnerability in sustainability science



Source: Turner et al., 2003

1.1 The frameworks

This review draws on a body of literature that explicitly deals with slow onset events. This paper takes a critical look at the thematic, geographical, and disciplinary trends in published research to inform science-policy work on slow onset events. Three particular frameworks support this analysis: the RH model, the PAR model, and the vulnerability framework devised by Turner et al. (2003).

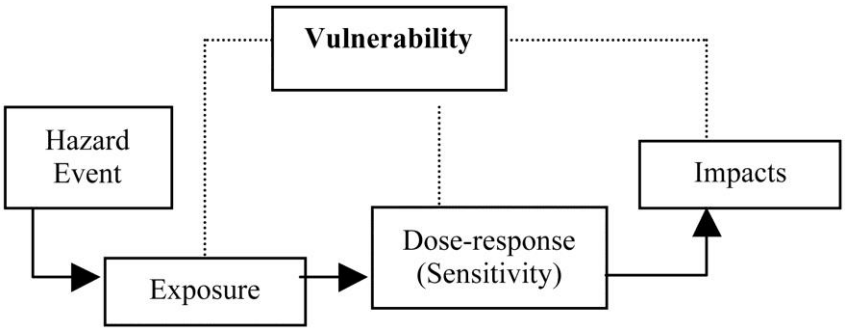
The RH model (Figure 2) analyses climate change impacts as a function of exposure and sensitivity to a hazard event. Vulnerability is mostly shaped by exposure and sensitivity, corresponding to a focus on biophysical risks. Nonetheless, the RH model has been found by Turner et al. (2003) to be lacking in (a) the ways in which the systems in question affect the impacts of the hazard; (b) the differences in subsystems and components that shape the impacts; and (c) the role of socio-political structures in shaping exposure and sensitivity.

Vulnerability in the PAR model (Figure 3) is shaped by underlying causes that make exposure unsafe and lead systems to face disasters. The PAR model emphasises the differences in vulnerability of different exposure units, such as ethnicity and social class (Turner et al. 2003). The PAR model thus addresses the shortcomings of the RH model, but in turn falls short in not incorporating the vulnerability of biophysical systems. Consequently, the PAR model and

the RH model may complement each other, but fail by themselves to comprehensively grasp the vulnerability of coupled human-environment systems.

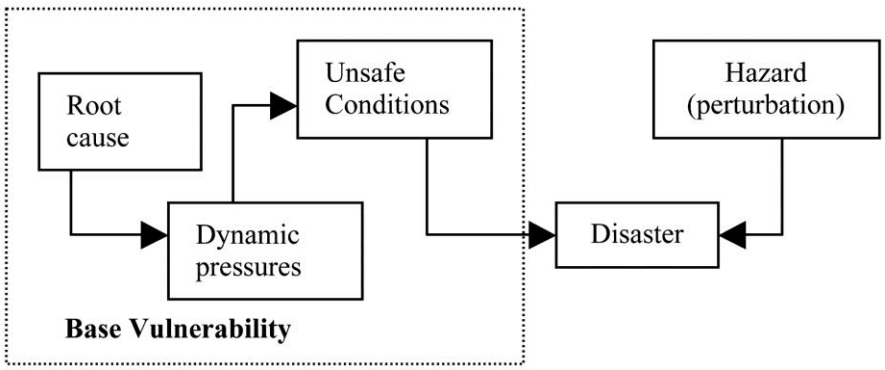
The vulnerability framework (Turner et al., 2003) is largely predicated on the condition and dynamics of the coupled human-environment system exposed to hazards. It can be seen as combining the strengths of the RH and PAR models: RH models seek to understand the impact of a hazard as a function of exposure and sensitivity of the system, while PAR models seek to understand the conditions that make exposure unsafe (Turner et al., 2003). The RH model (Figure 2) focuses on biophysical risks, while the PAR model (Figure 3) mostly emphasises the social contexts of exposure. The vulnerability framework for sustainability science unites both the RH and PAR model by differentiating the coping capacities of biophysical and social systems. It also resonates with the IPCC Fourth Assessment Report, which describes vulnerability as a function of exposure, sensitivity, and adaptive capacity (IPCC, 2007; Cardona et al., 2012). This was further expanded in the contribution of Working Group II to the IPCC Fifth Assessment Report, in which vulnerability, together with hazard and exposure, are described as shaping impacts or risks of climate change (Oppenheimer, Campos, Warren, Birkmann, Luber, O'Neill, & Takahashi, 2014).

Figure 2: Risk-Hazard Model



Source: Turner et al., 2003

Figure 3: PAR model



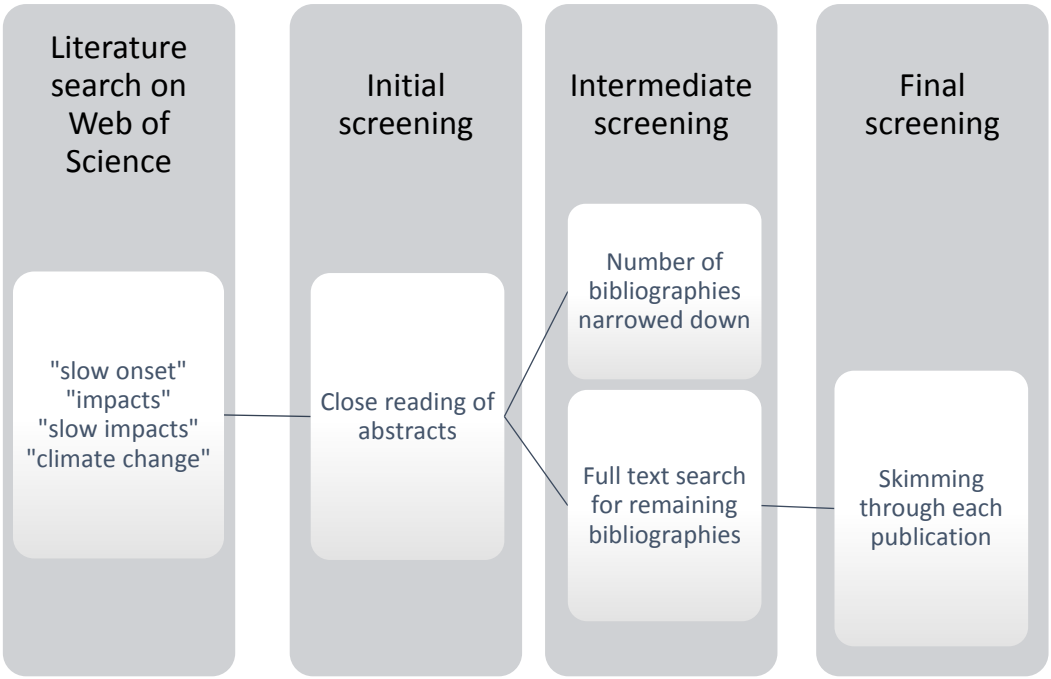
Source: Turner et al., 2003

The following section describes the approach for identifying and analysing literature and presents the qualitative and quantitative approaches employed to pursue this paper's objectives. These objectives are addressed in the results section. In the discussion section, this paper highlights the increasing publications on slow onset events during the last decade and its implications for science-policy work. In conclusion, this review highlights the opportunities for further research on slow onset events and provides recommendations on how research can proceed in an interdisciplinary and transdisciplinary manner to better inform the science-policy interface.

2 Methodology

Following the review framework of Newig and Frisch (2009), a literature search was conducted in Web of Science using the search terms "slow onset", "impacts", "slow impacts" and "climate change". The literature search was conducted on articles published in the English language from the year 1945 until May 2017. The resulting number of bibliographies was 352, excluding proceedings and news. An initial screening through close reading of the abstracts was conducted to check whether the bibliographies were relevant to the topic of slow onset climate change impacts. The number of bibliographies to be reviewed was narrowed down to 179 bibliographies for articles that mostly tackle slow progress of the UNFCCC, slow adoption of mitigation and adaptation measures, or slowing down the process of climate change. After a full text search of these bibliographies, this number was further narrowed down to 157 publications.

Figure 4: Review methodology



Source: Author

Each publication was reviewed and coded, based on several criteria (Table 1). In order to understand global trends in research on slow onset events and address our first objective,

basic information about each publication was identified. This included year of publication, country of institutional affiliation of first authors and country of study. The type and disciplinary focus of the paper were also identified. Descriptive statistics on these metrics, as well as the papers' tables and figures, were generated from R software version 3.4.1 and its packages bipartite, ggplot2, and sjPlot. Inferential statistics were calculated through Stata 14.2. In order to analyse research trends and address our second objective, the approach towards slow onset events discussed in the publications was classified, based on the RH and PAR models. The vulnerability framework (Turner et al., 2003) was used in characterising the risk-management measures provided by several publications, thereby addressing our third objective.

Table 1: Criteria for reviewing publications

Journal information	Information on slow onset events	Analytical information
Year of publication	Main system impacted by slow onset event 1) atmosphere 2) terrestrial 3) freshwater 4) saltwater	Internal and external factors contributing to slow onset event
Country of institution of first author	Type of slow onset event	Driver of vulnerability
Disciplinary focus	Occurrence (i.e. projected or actual)	Risk-management measures
Geographical region of study	Impacts on humans or species	
Scale of the study		

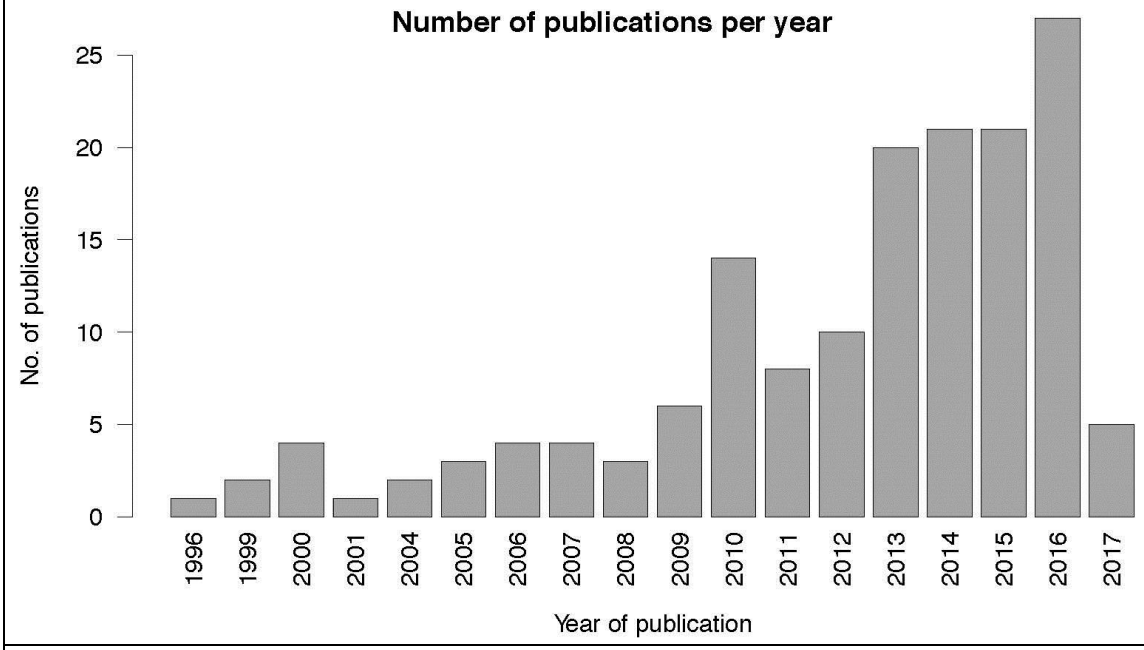
Source: Author

3 Results

3.1 Trends in slow onset events research

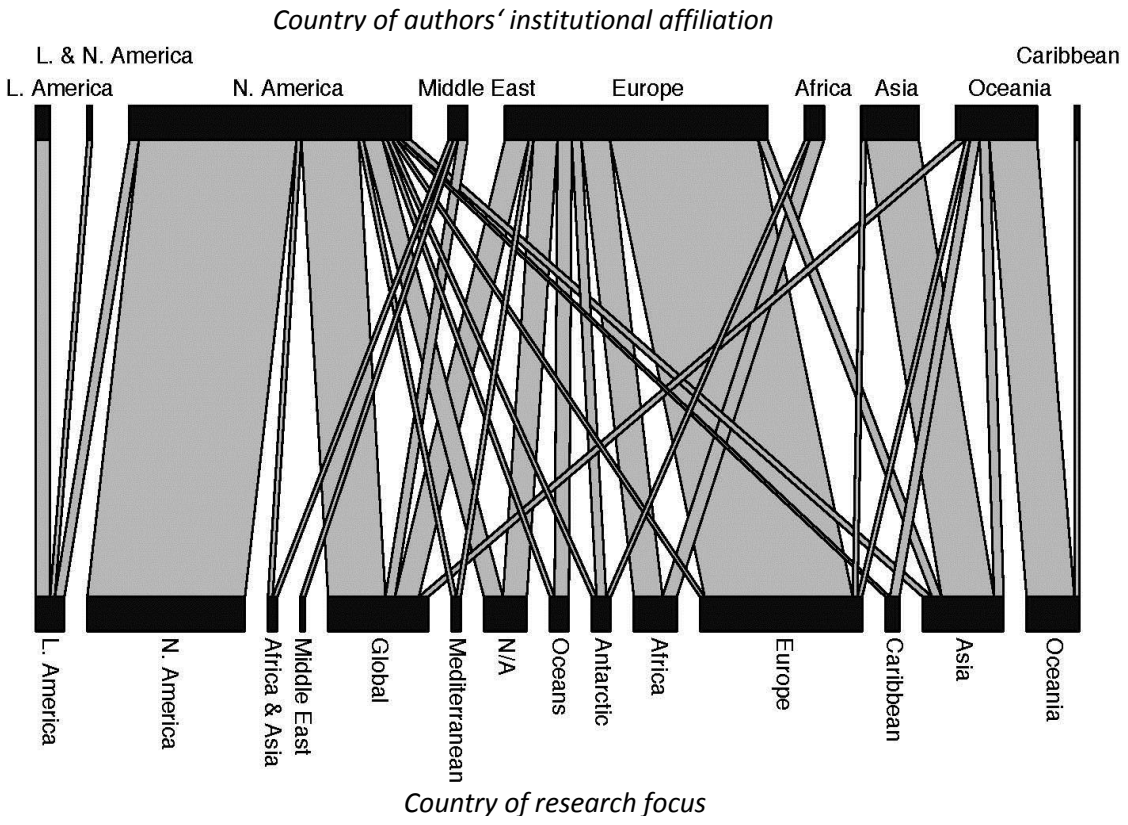
The number of publications on slow onset events increased between 1996 and 2016. Looking at Figure 4, there were deviations in some years (e.g. 2011 and 2012) but there is a general trend of increase in publications on slow onset events. To determine the statistical significance ($\alpha = 0.01$) of the increasing number of publications per year, a Mann-Kendall test and Spearman's rank correlation were conducted. The tests resulted in a Kendall's tau-b of 0.783 with a significance probability (p) = 0.000 (rounded to three significant digits) and a Spearman's rho of 0.896 with a p = 0.000 (rounded to three significant digits). These statistical results show that there is a monotonic trend of increase in publications on slow onset events throughout the years.

Figure 5: Increase in publications



Source: Author

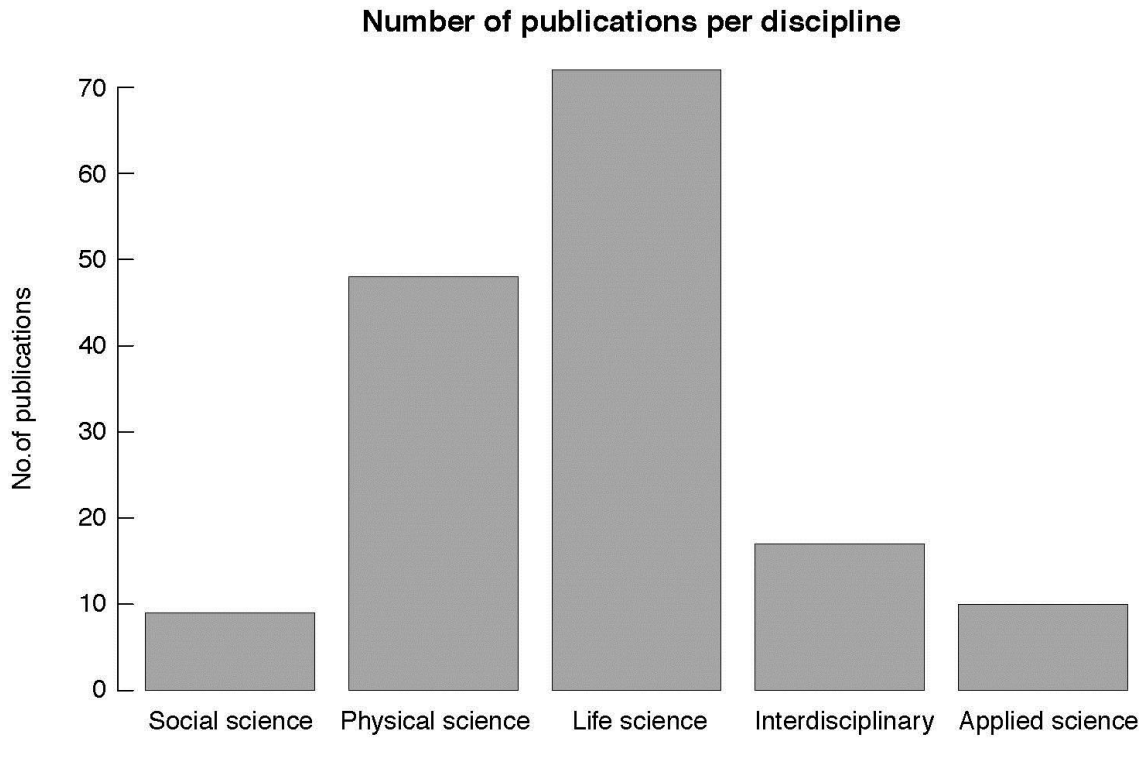
Figure 6: Research focus in and authorship from the Northern Hemisphere



Source: Author

Most of the publications reviewed had focused their research mostly on Europe and North America, with some undertaken on a global basis and some on Asia and Oceania (see Figure 5). There were very few research studies on Africa and Latin America. The majority of the authors originate from institutions based in Europe and North America, with the authors conducting research in their own regions as well as in other regions such as Asia, Latin America, and Oceania. Authors from Latin America conducted research only in their own region, with authors from Asia, Africa, and the Middle East following a similar trend, except for one study conducted elsewhere. When these publications were grouped according to disciplinary focus, the majority of the publications belong to the life sciences (e.g. botany, marine science, ornithology, ecology, and palaeontology), followed by the physical sciences (e.g. atmospheric science, chemistry, climatology, geology, geomorphology, meteorology, and geography). Some studies were interdisciplinary and a few belonged to the applied sciences (engineering and medicine) and social sciences (e.g. economics, history, law, and human geography). Most of the publications reviewed used field experiments, modelling, and spatial analysis methods. Only two publications used qualitative methodologies in the form of focus-group discussions and key-informant interviews.

Figure 7: Disciplinary fields of publications on slow onset events



Source: Author

3.2 Frameworks for understanding trends in slow onset events research

The majority of the publications (59%) are consistent with the RH framework, focusing on exposure and sensitivity and its resulting impacts. A small number of the publications (14%), through a focus on adaptive capacity, mostly resonate with the PAR framework. The other publications did not discuss any drivers of vulnerability, nor were they consistent with

either the RH or PAR frameworks. Most of the publications (97%) discussed impacts of slow onset events, with a majority (70%) of these publications discussing impacts on species and the rest on humans. The impacts on humans revolve around health and wellbeing, including financial and food security. The impacts on species have common themes: species distribution shifts, changes in phenology or reproductive physiology, and decline or extinction. A small number of publications (26%) discuss both actual and projected impacts. Actual impacts are discussed by close to half of the publications (45%) and projected impacts feature in a little over a quarter of the publications (30%).

Pearson's Chi-squared (X^2) tests were conducted to check whether there were statistically significant relationships between impacts of slow onset events on humans and species and the different drivers of vulnerability. The X^2 tests returned statistically significant results ($\alpha = 0.01$) at $p = 0.000$ (rounded to three significant digits) with $X^2 = 39.355$ with 14 degrees of freedom for impacts on humans and $p = 0.000$ (rounded to three significant digits) with $X^2 = 40.0435$ with seven degrees of freedom for impacts on species. Adaptive capacity was the biggest contributor to the X^2 in the case of impacts on humans, while exposure and sensitivity were the biggest contributors to the X^2 in the case of impacts on species.

3.3 Characteristics of slow onset events and interactions of hazards

Most of the publications (66%) featured slow onset events impacting the atmospheric system. Other publications focused on impacts of slow onset events in saltwater, terrestrial and, to a limited extent, freshwater systems. A small percentage (15%) of the publications tackled slow onset events in multiple systems. The majority of the publications (76%) described impacts brought about by increasing temperatures, in combination with other slow onset events such as forest degradation, glacial melt, sea level rise, ocean acidification, decline in biodiversity, and drought. The magnitude of the impacts can be influenced by the internal factors inherent to the system, or external factors that are additional stressors to the system (Füssel, 2006). Internal factors differ from one system to another, but the external factors can be similar from one system to the next. In the publications reviewed, natural resource extraction and exploitation, pollution, land use change, industrialisation, and *force majeure*, among others, were identified as external factors exacerbating impacts of slow onset climate change events. More than half of the publications (59%) provided recommendations, which mostly reflect their disciplinary focus.

4 Discussion

The results show how research is increasingly paying attention to slow onset events. The impacts of slow onset events manifest in multiple systems and in various forms. These are also shaped by the internal characteristics of the different systems and external confounding factors: longstanding stressors such as pollution or overexploitation of natural resources. The interaction of these factors with slow onset events shows the complexity of managing the associated risks. Slow onset events per se are foreseeable phenomena, but when they interact with external stressors, there is no certainty about the outcomes. In the following subsections, the results are discussed and analysed based on the potential of research efforts

to contribute to the management of slow onset climate change events. Furthermore, suggestions are made on how this potential can be realised.

4.1 Geographical trends of research on slow onset climate change events

The results of the review show that research on slow onset climate change events was mostly conducted on the impact of these events in North America and Europe by authors who come from these two regions. This trend goes against the urgency of one of the key findings of the UNFCCC technical paper on slow onset events, whereby "the negative effects of slow onset events are already affecting developing countries and the resulting loss and damage associated with slow onset events is likely to increase significantly, even assuming that appropriate mitigation and adaptation action is undertaken" (UNFCCC, 2012). This lack of research on the impact of slow onset climate change events in so-called developing countries is problematic. In particular, it leads to missed opportunities for these countries to develop appropriate adaptation measures as early as possible. Since the impacts of slow onset events are closely tied to other development issues, such as biodiversity conservation or sustainable development, failure to manage slow onset climate change risks can offset current development gains. This research imbalance also deprives climate policy of a much-needed evidence base it can consult for its decisions.

4.2 The need for trans- and interdisciplinarity in slow onset climate change research

Silos not only extend to geographical focus, but also to the disciplinary origins of research on slow onset climate change events. Most of the research was conducted by those in life and physical sciences. The social sciences had the least to contribute to slow onset climate change research. Several authors have explored the role of the social sciences in climate change research (e.g. Pidgeon & Fischhoff, 2011; Victor, 2015) and they emphasise the potential contribution of the discipline to climate change solutions because "actual impacts that will arise [from climate change] clearly depend on how people will respond" (Yearley, 2009). Slow onset events provide more room than rapid onset events to prepare appropriate responses and, should behavioural changes be needed, the social sciences can advise on the dynamics and development of such. Surprisingly, there is little social science scholarship on slow onset events so far; perhaps this is due to the perceived lack of urgency in this facet of climate change (Alonso, 2017).

However, it is clear that no single discipline holds the best solution to climate change, and continuous criticism of the dominance of natural sciences in climate change research (e.g. Victor, 2015) may only deepen the disconnect and disciplinary silos. Working in a trans- and interdisciplinary manner is not only mutually beneficial for the natural and social sciences, but it may even facilitate identification of good solutions to slow onset climate change. This is not new; integrated science platforms such as Future Earth provide opportunities for interdisciplinary interaction (Denis & Moser, 2015). The cooperation only needs to be nurtured and transformed into transdisciplinary collaboration with other sectors, such as civil society and policy makers.

4.3 Transdisciplinarity and science-policy partnerships in slow onset climate change research

Slow onset climate events, due to their slow occurrence, are not considered disasters comparable to extreme rapid onset events. Apart from being perceived as non-urgent, slow onset climate events rarely qualify for disaster relief or payouts from established risk-management instruments such as climate risk insurance. Other financial instruments, such as catastrophe bonds or weather derivatives, are not suitable for slow onset events because they do not involve a triggering event (UNFCCC, 2012). In addition, there are other losses to consider, which have values that are not commonly measured in purely economic terms (Serdeczny,Waters, & Chan, 2016; Serdeczny, Bauer, & Huq, 2017).

The impacts of slow onset events are not readily detected, rendering them almost invisible to policymakers. Transforming interdisciplinary cooperation to transdisciplinary collaborations can facilitate better responses to slow onset events. For example, Alonso (2017) emphasised that the adaptation and disaster risk-reduction communities complement each other when it comes to addressing slow onset events. The multiple dimensions of transdisciplinarity provide enough guidance on how civil society, science, and policymakers can work together (see Bergmann et al., 2012). Knowledge co-production among these different sectors may hold the key to faster uptake of solutions to slow onset climate change events.

5 Conclusion

Compared to climate-related extreme events, there are fewer publications on slow onset events. Nonetheless, scholarship on slow onset events has increased in the past decade, indicating that the research community is now also paying greater attention to these events. Despite this, much work needs to be done in conducting research in regions where the negative impacts of slow onset events are already occurring. The results of this review show that most slow onset event research has been conducted by researchers in North America and Europe, and has focused on the impact of slow onset events in these regions, when most negative effects of slow onset events are already affecting developing countries. Moreover, most of the research on slow onset events has so far been conducted by scholars from the life sciences and physical sciences. While a few publications have been written in an interdisciplinary manner, the social sciences and applied sciences still lag behind. As the impacts of slow onset events touch upon the different determinants of vulnerability (exposure, sensitivity, and adaptive capacity), no single discipline can address slow onset events comprehensively. Rather than criticising the dominance of the natural sciences in climate change research, efforts should be strengthened to advance pertinent scholarship in an inter- and transdisciplinary manner. As slow onset events do not manifest as catastrophic natural events that precipitate immediate losses, they miss out on established risk-management measures like climate-risk insurance or catastrophe bonds. There is, therefore, an urgent need for civil society, researchers, and policymakers to cooperate and to create an enabling environment that can help in managing the impacts of slow onset events.

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