UNIVERSITY OF NATURAL RESOURCES AND LIFE SCIENCES, VIENNA
INSTITUTE FOR DEVELOPMENT RESEARCH

UNIVERSITY OF COPENHAGEN
FACULTY OF SCIENCE

MASTER THESIS

‘Loss and Damage’ in the IPCC Special Report on 1.5°C A qualitative content analysis

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Vienna, May 2020

ABSTRACT

Sea level rise drowning islands in the Pacific, heatwaves sweeping over parts of Asia and Africa, and extreme weather events wreaking havoc across the globe. Even if we limit global warming to 1.5°C, regions around the world will still face drastic changes to their environment. Scientists refer to Loss and Damage (L&D) as the residual impacts of climate change that the world will experience due to the slow pace of mitigation measures, limited or inadequate adaptation, and the overstepping of adaptation limits. Being a relatively new concept, L&D remains undefined and understated in the global arena of climate politics. The aim of this thesis is to examine the extent of L&D arising under two different climate change mitigation scenarios: a 1.5 °C and a 2 °C increase in global mean temperatures at the end of the century, compared to pre-industrial levels. The thesis draws on the Special Report on Global Warming of 1.5°C (SR1.5) by the Intergovernmental Panel on Climate Change: it analyses the findings in the report through the lens of 'Loss and Damage', that is, it analyses the impacts of slow-onset and extreme weather events, and the ensuing economic and non-economic losses and damages, by geographic region to the extent possible. I carry out a qualitative content analysis on the report, focusing on Chapter 3 on impacts. Further, I conduct text analytics to understand the relationship of the terms, 'Loss', 'Damage', '1.5°C', '2°C' with terms relevant to impact sectors. Lastly, I use an integrated environmental assessment framework to explore environmental and socio-economic cause-effect interactions that result in losses and damages in Small Island Developing States in the Pacific region. The analysis sheds light on often forgotten connections, one being that non-economic losses are far more important in developing countries, yet because of their very nature, they go unreported, thus masking the actual impacts of climate change in developing countries. Developed countries have actively avoided framing L&D in terms of liability, to fend off developing country requests for compensation. The framing of L&D questions the values, judgement, political choices and notions of justice of all stakeholders involved. The findings of this thesis underline the need for an assessment framework that effectively accounts for the full extent of non-economic L&D.

Keywords: IPCC, Loss & Damage, Climate Change, Non-Economic Losses, Adaptation, Irreversible impact, Sustainable Development Goals

KURZFASSUNG

Während durch den Anstieg des Meeresspiegels Inseln im Pazifik förmlich untergehen, Asien und Afrika von einer Hitzewelle nach der anderen überrollt wird, verwüsten extreme Wetterereignisse den Rest der Welt. Selbst wenn wir die globale Erwärmung auf 1,5°C begrenzen, sind viele Regionen der Welt immer noch mit drastischen Veränderungen ihrer Umwelt konfrontiert. Das Konzept *Loss and Damage* (L&D, zu deutsch *Verluste und Schäden*) beschäftigt sich mit jenen Folgen des Klimawandels, die aufgrund zu später Gegenmaßnahmen, unzureichender oder inadequaten Adaption bzw. Grenzen der Adaptionsmöglichkeiten irreversibel sind. Als relativ neues Konzept ist L&D noch nicht einheitlich definiert und in der globalen Klimapolitik bisher weitgehend unbeachtet. Ziel dieser Arbeit ist es, auf Basis der bestehenden Literatur das Ausmaß von L&D unter zwei verschiedenen Klimaszenarien qualitativ zu untersuchen: einem durchschnittlichen, globalen Temperaturanstieg am Ende des Jahrhunderts um *1,5°C* bzw. *2°C* relativ zum vorindustriellen Niveau. Dabei baut die Arbeit auf dem Sonderbericht, *Special Report on 1.5°C*, des zwischenstaatlichen Ausschusses für Klimaänderungen auf und analysiert die Ergebnisse des Berichts durch eine L&D-Linse; d.h. es werden die Auswirkungen von langsam einsetzenden und extremen Wetterereignissen und die daraus resultierenden wirtschaftlichen und nicht-wirtschaftlichen irreversiblen Verluste und Schäden, sofern möglich, nach geographischen Regionen untersucht. Dazu führe ich eine qualitative Inhaltsanalyse des Berichts durch, wobei ich mich insbesondere auf Kapitel 3 konzentriere, das sich mit den Auswirkungen der Klimaveränderung beschäftigt. Ferner untersuche ich durch eine Textanalyse die Beziehung der vier Begriffe "Loss", "Damage", "1,5°C", "2°C". Schließlich verwende ich integriertes Umweltmodell, um ökologische und sozioökonomische Ursache-Wirkungs-Interaktionen darzustellen, die im Pazifik in Inselstaaten zu irreversiblen Verlusten und Schäden führen. Die Ergebnisse implizieren, dass nichtwirtschaftliche Verluste gerade in Entwicklungsländern eine wichtige Rolle spielen, dass sie aufgrund ihrer Natur jedoch häufig unbeachtet bleiben, wodurch das tatsächliche Auswirkungsausmaß des Klimawandels in Entwicklungsländern meist nicht akkurat eingeschätzt wird. Bisher wurde es durch die Industrieländer vermieden L&D aktiv politisch miteinzubeziehen, da sich daraus potenzielle Entschädigungsforderungen von Entwicklungsländern ableiten ließen. Die Ergebnisse dieser Arbeit unterstreichen die Notwendigkeit eines Bewertungsrahmens, der das gesamte Ausmaß der nichtwirtschaftlichen, irreversiblen Verluste und Schäden wirksam berücksichtigt.

ACKNOWLEDGEMENTS

I would like to thank my supervisors, Prof. Willibald Loiskandl (BOKU IDR), Dr Daniel Puig (UNEP-DTU, Copenhagen), Dr Andreas Melcher (BOKU IDR) and Dr Anne Gravsholt Busck (UCPH) for their guidance and advice during the past year. I would like to thank my supervisor Prof. Willibald Loiskandl for giving me the opportunity to gain invaluable experience through my thesis. I would like to thank Dr Daniel Puig for the endless Skype calls, detailed emails and limitless patience owing to which I was able to tackle a topic quite complex in nature. Further, I would like to thank Dr Anne Gravsholt Busck for her support and advice during my thesis. I would also like to thank Dr Andreas Melcher for his feedback, advice and introduction to the scientific exchange within the Institute for Development Research. I am glad to have had the opportunity to learn from all of my supervisors during the past year. My appreciation also extends to Mag. Manuel Schwaninger (University of Vienna) for his insight and support throughout my thesis, especially with using RStudio. I would like to thank especially my parents, Dr Parul Cariappa and Col Dr M.P Cariappa, my aunt, Dr Gitanjali Ponnappa and my grandparents, Usha Ponnappa, Col M.K Ponnappa and Adv. Mohan Sehgal not only for their support and enthusiasm in encouraging me to do the very best I can but also for giving me the opportunity to study abroad. Additionally, I would like to thank my internship supervisor, Mr Gentjan Sema from the United Nations Industrial Development Organisation, Vienna for giving me the time to work on my thesis (during my internship) and introducing me to people with an interest in Loss and Damage. Lastly, I would like to thank my dog, Rio, whose company I dearly missed during the writing process. This would have not been possible without all the support!

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LIST OF ABBREVIATIONS

.CSV	Comma-separated file
AR5	Fifth Assessment Report (2014)
CDR	Carbon Dioxide Removal
COP	Conference of the Parties
CRDPs	Climate Resilient Development Pathways
DPSIR	Driving Forces – Pressures – State – Impacts – Responses
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GMST	Global Mean Surface Temperature
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
L&D	Loss and Damage
LDC	Least Developed Countries
NDCs	Nationally Determined Contributions
NELs	Non-Economic Losses
PEA	Probabilistic Event Attribution
QCA	Qualitative Content Analysis
RCP	Representative Concentration Pathway
RFC	Reasons for Concern
SDGs	Sustainable Development Goals
SIDS	Small Island Developing States
SLR	Sea Level Rise
SR1.5	Special Report on Global Warming of 1.5°C (2018)
SRM	Solar Radiation Modification
SSP	Shared Socioeconomic Pathway
UNFCCC	United Nations Framework Convention on Climate Change
WIM	Warsaw International Mechanism for Loss and Damage Associated with Climate Change Impacts

1. Introduction and Aims of the Study

Over the past centuries, human ingenuity has helped increase the prosperity of many, raising both the literacy and life expectancy rates of a growing population. However, this growth has not been uniform, with many still living in poverty, and ecosystems being increasingly stressed. As abundantly documented in the reports by the Intergovernmental Panel on Climate Change, anthropogenic climate change aggravates these problems. With spatial and temporal variability in the impacts of climate change, the worst affected regions are often low- and middle-income countries (IPCC, 2018). As of now, the Paris Agreement was a step in the right direction, providing impetus to further global climate action. Yet, even if mitigation and adaptation efforts are ramped up in the coming years, certain negative impacts are now inevitable. These residual, unavoidable impacts are what has come to be known as 'Loss and Damage' (L&D).

The financial implications (i.e. claims for compensation) associated with L&D have made it a politically sensitive topic. However, over the past few years it has gained some prominence in the UNFCCC decisions. At present, L&D has been included in the Global Stocktake of the Paris Agreement, yet, reporting on it is only voluntary (in the context of Paris Agreement's transparency framework). Against this background, the crucial role played by the Intergovernmental Panel on Climate Change (IPCC) become fully apparent. The IPCC is responsible for assessing the scientific literature relevant to climate change and it's impacts on nature, economics and society. Based on these assessments, the IPCC publishes reports which allow for science to feed into the political process and drive climate ambition. With over 6,000 scientific references and wide range of authors, editors and reviews, the Special Report on Global Warming of 1.5°C (SR1.5) provides a comprehensive overview of what scientific literature has to say about climate change, across two warming scenarios, thus allowing for comparisons that are directly relevant to policy making.

To date, the IPCC has not prepared an assessment of the literature on L&D. However, over the past years, the reports have covered L&D, directly or, mostly, indirectly. Since the famous, 'Burning Embers' image in its Fifth Assessment report (AR5, 2014), the IPCC finds that levels of risk have increased for four of the five Reasons for Concern (RFCs)[1]. Thus, an

[1] The five RFCs are: **RFC1** for Unique and threatened systems, **RFC2** for Extreme weather events, **RFC3** for Distribution of impacts, **RFC4** for Global aggregate impacts, **RFC5** for Large-scale singular events.

analysis of the report through the lens of L&D provides a unique insight of what the scientific literature has to say on the topic. van der Geest and Warner (2019) conducted a similar assessment on the AR5.

Compared to the AR5, the SR1.5 makes for a more interesting analysis, from the point of view of L&D, as it allows for the possibility of comparing between the two warming levels, 1.5°C and 2°C. The findings of this thesis reflect on the usage of the terms, 'loss' and 'damage' and their connection with various parameters such as 1.5°C versus 2°C and economic versus non-economic losses. Further, the thesis identifies which stressors and impact sectors are associated with 'loss' and 'damage'.

There is a need for a better understanding of what goals should L&D policies aim to reach, the justification of who is liable to seek compensation from whom and how these measures should be implemented. There is a pressing need to translate this understanding about what L&D is into effective policies and mechanisms to assist those in need. Most vulnerable communities face an unprecedented amount of losses and damages, due to the volatile nature of extreme weather events in combination with the uncertainty of their occurrence (Kreft et al., 2013). Together with slow onset events such as sea level rise (SLR), ocean acidification, the need for addressing L&D is nigh!

This thesis is guided by the following research question: What can be learnt about Loss and Damage from the IPCC Special Report on Global Warming of 1.5°C? The intent of this thesis is to gain a better understanding of losses and damages arising from a variation of impacts and stressors between the two warming scenarios considered in the report, namely 1.5°C versus 2°C. I aim to analyse how the terms 'loss' and 'damage' are used in the report in order to highlight knowledge gaps. The thesis focuses on irreversible climate change impacts, whether they are driven by slow onset events or extreme weather events, and whether the losses they bring about can be appraised in economic terms or not. Based on the literature review, the following research questions were developed in order to identify existing knowledge gaps:

1. Which climatic stressors are loss and damage often associated with in the report?
2. In what context are the terms 'loss' and 'damage' used with human and natural systems in the report?
3. Is there a difference in the coverage of economic- and non-economic Loss and Damage in connection with the effect of climate change on systems in the report?

4. Taking Pacific Small Island Developing States as an example, what is the causal change between socio-economic and environmental drivers, pressures on the state of the environment, and climate change impacts resulting in loss and damage?
5. What possible response can governments put in place to counter the climate change impacts that result in loss and damage?

Through a comprehensive literature review, the main determinants of L&D were identified. A qualitative data analysis software was used to screen the contents of the report against these determinants. Further, text analytics software was used to the same end – identify connections between topics, to gauge whether the choice of technique resulted in significant differences in the analysis. These methods allow for a systematic approach to uncover connections between topics that may not be readily apparent to the reader when using a traditional approach to reviewing scientific literature. Lastly, based on a review of literature by Daniel Puig (2019), I use the DPSIR Framework[2] to explore environmental and socio-economic cause-effect interactions which result in losses and damages in Small Island Developing States in the Pacific region. Further, I draw parallels between the Sustainable Development Goals (SDGs) and elements of the framework so as to emphasise the relevance of addressing L&D in order to achieve the targets set under the SDGs.

The thesis provides input to the Strengthening International Cooperation on Climate Change Research (SINCERE project)[3]. Specifically, it will benefit from, and contribute to, a task[4] in the project focused on L&D, which is led by the University of Natural Resources and Life Sciences, Vienna (BOKU), and to which the Danish Technical University, Copenhagen (DTU) is contributing.

This thesis is structured in the following way: First, I set the context of L&D within current international climate change negotiations and highlight the relevance of 1.5°C of warming.

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[2] The DPSIR framework is used in integrated environmental assessments. It provides a stylised representation of the causal links between Drivers (D) of environmental degradation, the resulting Pressures (P) on, and States (S) of, the environment, the associated Impacts (I) on biophysical and human systems, and the Responses (R) governments introduce to revert negative trends.

[3] SINCERE is a EC H2020 Coordination and Support Action (Grant agreement ID: 776609). Within the operation of SINCERE, your name, surname, institution and e-mail address may be shared with the partners of the SINCERE consortium and parties involved in SINCERE activities and used in reports that may be publically available. We will delete your data one year after completion of the SINCERE project. We will never actively share your data with any third parties that are not involved in SINCERE activities. At any time you can withdraw your consent to use your personal data or to receiving SINCERE e-mails by contacting Coordinator.Sincere@belspo.be.

[4] Identifying research gaps in the field of loss and damage is one of the multiple goals of the SINCERE project (http://www.jpi- climate.eu/sincere).

The following section presents a summary of the IPCC SR1.5, highlighting key arguments made in the chapters of the report. Following which, I describe the methods utilised in this thesis, and discuss the merits and limitations of the same. Next, I provide a succinct review of relevant literature on L&D and its determinants based on which a coding scheme is designed. Further, I present the findings from the qualitative content analysis, and the text analytics, followed by the illustration on small-island states in the Pacific, which draws on the so-called DPSIR Framework in connection with the SDGs. The findings of the research are outlined in the discussion, noting how they reflect on the current status of L&D in international climate change negotiations and in academia. Lastly, the conclusion examines the relevance of the outcomes from this thesis and highlights existing research gaps.

2. Context and Relevance

Climate change is regarded by some as a distant problem as a means to evade the need for immediate action. However, the Paris Agreement has brought climate change into perspective for the global community, framing it as a crisis of the utmost urgency (Section 2.1). Due to the increase in anthropogenic greenhouse-gas emissions, the concentration of global-warming pollutants such as carbon dioxide in the atmosphere has led to an increase in surface temperature (IPCC, 2013). The complexity of the climate system makes it difficult to measure the change of Earth's temperature as it depends on several factors such as climatic feedback loops, radiative forcing, and energy storage within the climate system (IPCC, 2013).

Nearly half of the global greenhouse gas (GHG) emissions can be attributed to ten percent of the world's population, which makes one question the global interpretation of emissions as production-based accounting of CO_2 emissions and the need to shift from merely focusing on emissions at production to consumption-based emissions (Afionis et al., 2017). The current state of affairs seems to tip the scales in favour of carbon-rich economies while the poorest bear the brunt of the burden, being the most vulnerable to climate change (Gore, 2015). There is a radical need for decarbonization to shift from carbon-rich to zero carbon economies and further, the need for effective policies to reinforce commitments (King, 2017). Since 2012, the United Nations Environment Program releases the 'Emissions Gap Report' highlighting the inefficiency of current policies in regulating GHG emissions (Olhoff and Christensen, 2018). The difference between the implementation of the conditional and unconditional INDCs is nearly 3 $GtCO_2e$ with the former resulting in the reduction of 6 $GtCO_2e$ compared to the current policy trajectory (ibid.). This amount of emission reductions falls woefully short of meeting the goals of the United Nations Framework Convention on Climate Change (UNFCCC).

The Paris Agreement was effective in instigating and fuelling climate action, solutions, innovations, and most importantly, shining the spotlight on the severity of the problem we face. The impacts of climate change are multifaceted and intricate. For this reason, covering all impacts would be unfeasible in the context of a MSc thesis.

2.1. The Paris Agreement and the SDGs

The Paris Agreement was signed by 195 countries during the twenty-first conference of the parties to the UNFCCC, held in Paris, France, in 2015 (COP21) (UNFCCC, 2015). Currently, it has been ratified by 173 countries. The agreement is a global two-headed target to keep the average global temperature below 2°C (relative to pre-industrial levels) and to put in additional effort to limit the increase to 1.5°C (UNFCCC, 2015). The agreement called for parties to the Convention – through the so-called nationally determined contribution (NDC) – to commit to “fair and ambitious” specific emission reductions by 2020 and to aim for zero net greenhouse gas emissions by 2050. Regardless of a country’s economic status, such global agreement to curb carbon emissions is a seen as a key milestone in international climate-change negotiations. Further, the Sustainable Development Goals, a series of 17 goals, were adopted by all UN Member States and serve as a blueprint to achieving sustainable development and growth by 2030. The goals include several targets and are interconnected, covering a range of topics such as health, gender equality, climate action and sustainable communities (United Nations, 2020).

Bringing together actors on an unprecedented scale, the Paris Agreement is often referred to as a diplomatic success, one that is inclusive and transparent. Furthermore, the agreement institutionalised the role of non-state actors in the Convention (Bäckstrand et al., 2017). The so-called Non-State Actor Zone for Climate Action illustrates the wide range of non-state actors who have made more or less explicit commitments to support climate change mitigation and/or adaptation.

The key differentiator of the Paris Agreement from other international agreements was the bottom-up approach the agreement embodied, a call to arms for states, irrespective of their historic responsibilities to take action against a collective problem (Falkner, 2016). The Paris Agreement is a symbolic victory, representing global cooperation, sending a strong message to climate change naysayers. Notwithstanding, the Paris Agreement failed to specify financial support which is a key element for developing countries for adopting their conditional INDCs (Falkner, 2016).

2.2. The Warsaw Implementation Mechanism and the UNFCCC

The Paris Agreement refers to the necessity of addressing L&D (UNFCCC, 2015). The Warsaw Implementation Mechanism (WIM) was established by the UNFCCC at COP19 in Poland in 2013. The primary functions of the WIM are to enhance the understanding and knowledge of risk management approaches to L&D; strengthening cooperation amongst stakeholders; enhancing support and action in the form of technology, finance and capacity building (UNFCCC, 2014). While the WIM creates a space to allow for dialogue and research based on evidence as to how to tackle this challenge, the discussion has been plagued by disagreement between developed and developing states over the definition of L&D (Surminski and Lopez, 2015). During the COP25, the executive committee of the WIM was asked to explore ways in which developed countries could access Green Climate Funds financing for activities consistent with the WIM's programme of work. The WIM was scheduled to go under review in the coming COP in 2020. However, due to the COVID-19 pandemic, the COP has been postponed to 2021.

As mentioned previously, the losses experienced while easily quantifiable in terms of Gross Domestic Product (GDP) and physical value, go beyond economics. The need for assessment of non- economic losses is essential to ensure that policies address the issue of L&D in its entirety (Warner et al., 2012).

2.3. The Intergovernmental Panel on Climate Change (IPCC)

Comprised of 195 member states, the IPCC is the United Nations body tasked to assess the available science related to climate change. It facilitates comprehensive reviews of the science available on climate change, through a transparent and open process, by publishing so-called assessment reports (IPCC, 2019). These assessment reports provide independent information on climate change, its causes and potential impacts along with possible measures, to give decision-makers a comprehensive overview, allowing them to understand the potential implications and costs of their decisions (ibid.). By assessing over thousands of scientific papers, scientists prepare the comprehensive assessment reports, which are updated in five-year cycles, the latest one being the Fifth Assessment Report (AR5), which was released in 2014 (the Sixth Assessment Report is set to be published in stages in 2021 and 2022). These reports allow for the readers to identify where there is a consensus amongst the scientific community and the knowledge gaps that exist and require further research (ibid.).

2.4. The Fifth Assessment Report (AR5)

The AR5 brings an interesting perspective to equity describing it as having three dimensions: fairness between generations (intergenerational), fairness between states (international) and fairness between individuals (national). Equity has been widely discussed in climate negotiations regarding how the costs and benefits of climate action should be distributed amongst states. Equity is especially relevant in the context of L&D, in that non-economic losses are often overlooked, because they are (from a financial point of view) small in developed countries. Yet, in developing countries, where most of the economy may be informal and insurance is underdeveloped, most losses attributable to climate change can be qualified as non-economic losses.

The AR5 adopted four so-called representative concentration pathways (RCPs), each with a corresponding temperature range. The RCPs are trajectories of GHG concentrations in the atmosphere. They are consistent with the full range of plausible emission scenarios. Their advantage over previous scenario approaches lies in the emphasis on both the endpoint (concentrations in 2100) and the trajectory followed to reach that endpoint (the pathway).

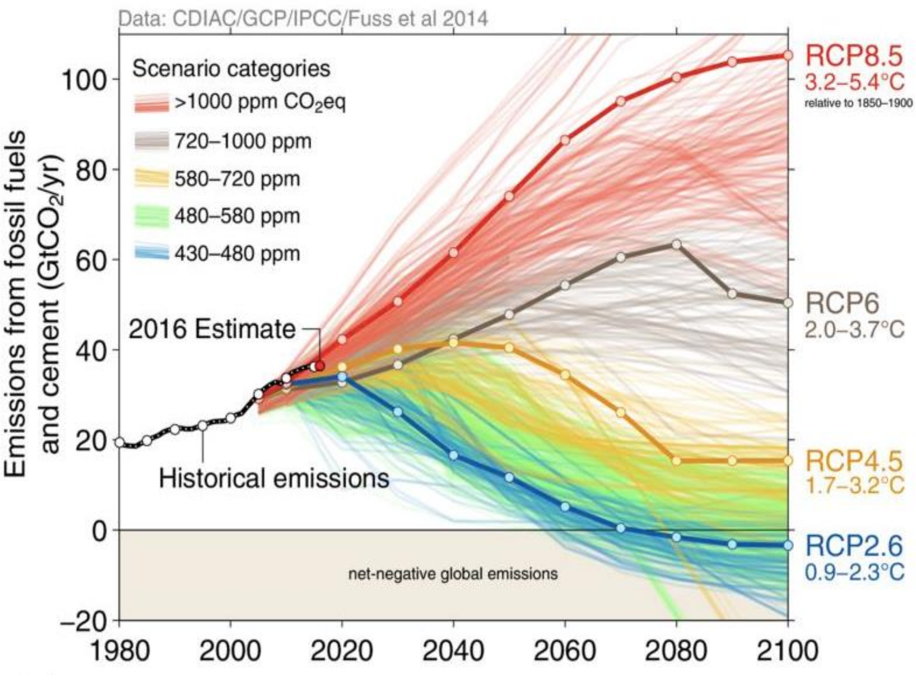

Figure 1: Graph depicting the Representative Concentration Pathways and corresponding temperatures (in °C) (Global Carbon Project, 2017)

Figure 1 shows the graphical representation of the four RCPs. For example, RCP 8.5 corresponds to a ‘business as usual’ scenario (that is, an average increase in global temperatures of between 3.2 °C and 5.4 °C, compared to pre-industrial levels), while RCP 6 reflects on a scenario where there is low policy development with regards to limiting emissions. To meet the 2°C limiting target as stated in the Paris Agreement would require the shift of the current carbon dependent economy to a green economy as in RCP 4.5. Further, to reach RCP 2.6 which corresponds to a warming of 1.5°C would require the decoupling of the global economy from carbon, in other words (Global Carbon Project, 2017).

Apart from publishing Assessment Reports, the IPCC also publishes Methodology Reports and Special Reports (IPCC, 2019). The former provides a methodology guidance on a variety of issues. The latter are produced on an ad-hoc basis for a specific issue such as the Special Report on Global Warming of 1.5°C (SR1.5). Published in October 2018, the SR.15 is the first report published after the signing of the Paris Agreement. The report allows the reader to compare the potential impacts between the two warming scenarios, 1.5°C versus 2°C (i.e. RCP 2.6 and 4.5, respectively).

2.5. 1.5°C versus 2°C

Schleussner et al. (2016) provide a comprehensive assessment of the variations in climate change impacts at 1.5° and 2°C of warming. They assess impacts such as extreme weather events, agricultural yield, water availability, SLR and risk of coral reef loss (Schleussner et al., 2016). Their results reveal that the additional 0.5°C increase in global-mean temperature has severe implications for the interaction of society with their natural environment (ibid.). For example, the additional 0.5°C increase in global-mean temperature translates into the risk of the total loss of coral reefs by the turn of the century whereas, for a 1.5°C scenario, the risk is significantly lower (70%). They also find that agricultural yields projections vary significantly depending on type and region of the world, with regions in higher latitudes benefiting, and regions in lower latitudes facing reductions in yield. By comparing the potential impacts in both scenarios, Schleussner et al. (2016) bring attention to the importance of an additional 0.5°C increase in global-mean temperature along with the regional variation of impacts, risks, and vulnerabilities.

The difference of 0.5°C of global warming is central to the debate on climate justice. It has been well established that the spatial and temporal dimension of the impacts of climate change plays a key role in charging the debate for climate justice and equity (Kreft et al., 2013). While L&D will affect all countries, there is undeniable evidence that the impacts of climate change are concentrated in regions, often those vulnerable and unable to adapt to the pace of climatic changes they witness, the need for addressing L&D is essential (van der Geest and Warner, 2019). The Global Climate Risk Index for 2015 reports that low-mid income countries rank amongst the highest on the risk index scale (Kreft et al., 2014). The temporal dimension comes about as the impacts of climate change not only affect our current environment but span time, affecting future generations and future environmental conditions to come (Kreft et al., 2013). Furthermore, this emphasises the need to address L&D with effective policies to ensure that communities that face impacts presently and will in the future are prepared to adapt to changes.

Driven by GHG emissions, climate change will have manifold negative impacts. These impacts will determine the adaptability of communities (Kreft et al., 2013). Dependent on the ambitiousness of NDCs regarding the emission targets, the effectiveness of mitigation and adaptation efforts will determine the degree to which states will face losses and damages, present and future. It is important to note that rapid phase-out of CO_2 emissions and reductions in emissions are integral to follow 1.5°C consistent pathways. In order to do so, broad transformations are essential across sectors (IPCC, 2018). These transformations will entail both mitigation and adaptation effort, some of which will be harder to implement in the Global South.

It is important to understand the interplay between the impacts of climate change and the social vulnerability of a community and how it affects the ability of the community to adapt to these changes. This vulnerability arises for two reasons: first, the geographical location of certain communities makes them predisposed to varying climate impacts, second, the socio-economic conditions of the regions can exacerbate the negative impacts (van der Geest and Warner, 2015). It is essential for policy development to be centred around the understanding of social vulnerability and its impact on social resilience to the changing climate as Warner et al. (2012) state the need for this basis to understand the implication of L&D on society.

Adaptation and mitigation strategies have been widely discussed in several IPCC reports and scientific journals. Despite our efforts to curb emissions, it is evident that climate change is potentially one of the most challenging situations humankind is facing. The IPCC Report (2018) shows the drastic irreversible changes that the world would face even with the increase in temperature by 0.5℃. Is it possible that there are limits to adaptation? The emergence of L&D as the third pillar of action under the UNFCCC would address an understated yet very important facet of climate change.

3. The IPCC Special Report on Global Warming of 1.5°C

The following section explores the chapters, their contents and arguments in the SR1.5 (IPCC, 2018). Increase in global temperatures, erratic weather patterns and extreme events, the IPCC SR1.5 stems from the two-pronged temperature goal on the Paris Agreement. The SR1.5 assessed the impacts of 1.5°C of warming in the context of poverty eradication and sustainable development. In addition, based on evidence, the report assessed the conditions that would enable society to achieve the 1.5°C target. Utilising peer-reviewed scientific literature as the key source of information along with grey literature, this report provides a wholesome overview into the variation of impacts and to what extent that will be seen between 1.5°C and 2°C of warming. This report emphasises the usage of information published after the IPCC AR5 in 2015 and updates key findings from the previous report (AR5) where necessary.

Rising temperatures in combination with a finite adaptive capacity in relation to exposure to climate change multiply the risks associated with 1.5°C of warming and even more so at 2°C of warming. Pathways and scenarios allow scientists and decision-makers to explore various factors that enable certain conditions, potential impacts, cost and limitations associated with them. These pathways are dependent on the choices and actions taken now, which will determine the trajectory of global warming. In addition, they allow the stakeholder to comprehend the degree of societal transformation that will be required to ensure that targets within these pathways are met. This report utilises two main conceptual pathways, in one the global temperature stabilises at, or just below, 1.5°C. The other pathway knowns at the Overshoot pathway involves the global temperature temporarily exceed 1.5°C before returning to 1.5°C. Overshooting has severe implications for natural and human systems as some risks may be long-lasting and irreversible thus, the report emphasises on the need to limit the extent of the overshoot. The need to reduce GHG emissions is paramount and adaptation measures must be scaled up and in synchrony with other measures taken globally.

Released in October 2018, the SR1.5 is the first and latest report published by the IPCC since the Paris Agreement (as of July 2019). Additionally, the SR1.5 is the first in a series of Special Reports to be produced in the IPCC's Sixth Assessment Cycle. The report's full name is *Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change,* *sustainable development, and efforts to eradicate poverty*. Comprised of five chapters with additional Supplementary Material, a Summary for Policymakers, and a Technical Summary, the SR1.5 provides a wholesome overview into the recent scientific literature available on climate change, its potential impacts and measures.

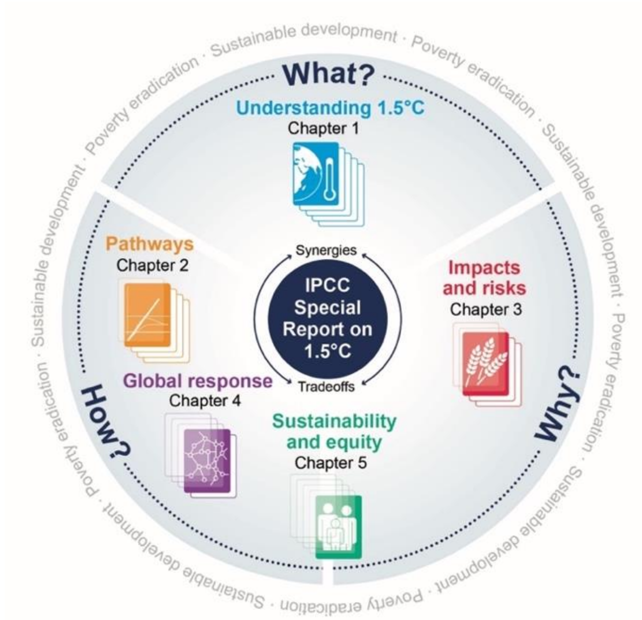

Figure 2: Schematic depicting the storyline of the SR1.5 (IPCC, 2018)

3.1. Chapter 1

Chapter 1 dives into how the target of 1.5°C is defined, what are the conditions that will enable us to achieve this target, what level of warming are we currently at and the associated trajectory of temperature. Further, this chapter explores the interplay of the 1.5°C target to the SDGs, equity, poverty eradication and ethics. With the purpose of framing the context, this chapter provides the reader with the necessary details to understand the implications that entail warming of 1.5°C above pre-industrial levels. This chapter espouses the need for synchrony in climate action, sustainable development and poverty eradication.

The report defines warming at a given point in time as the "global average of combined land surface air and sea surface temperature for a 30-year period centred on that time relative to 1850-1900 (pre-industrial level)". The SR1.5 adopts a working definition of '1.5°C relative to pre-industrial levels' that "corresponds to global average combined land surface air and sea surface temperatures either 1.5°C warmer than the average of the 51-year period 1850–1900, or 0.63°C warmer than the decade 2006–2015."

Feasibility in the report is referred to as the ability of the system in its entirety to achieve a specific target and the enabling conditions to limit warming to 1.5°C, which requires the assessment of various factors across various dimensions. The need to understand the synergies and trade-offs between mitigation, adaptation and sustainable development is widely covered in this report. In addition, the need to assess dimensions such as socio-cultural, technological, geophysical, environmental, economic and political feasibility and its variability is increasingly important. This chapter explores the implications of a 1.5°C warmer world on society and acknowledges that the feasibility to meet this target is undetermined.

3.2. Chapter 2

Chapter 2 evaluates mitigation pathways that are linked with limiting warming to 1.5°C above pre-industrial levels. While the AR5 assessed mitigation pathways, this report emphasises on the integration of sustainable development and the need for societal transformation. The chapter further delves into the literature regarding the types of mitigation pathways that limit or facilitate the return to global mean warming to 1.5°C. Furthermore, the chapter investigates how these pathways will interact with transitions in various sectors such a sustainable development, energy generation and land use. This chapter gives priority to the technological, geophysical and economic factors of feasibility.

3.3. Chapter 3

By far the most relevant chapter in the SR1.5 when looking at L&D, Chapter 3 focuses on the observed and projected climatic changes, impacts and vulnerabilities that will manifest in a 1.5°C and 2°C warmer world on natural and human systems. The impacts are multifarious, interlinked and uneven in their spatial and temporal distribution. This chapter enables the reader to gain a better understanding of the impacts and their extent that can be avoided by limiting warming to 1.5°C. Moreover, it also espouses the principle that there are limits to adaptation of a system and society. In addition, this report updates the Reasons for Concern (RFC), which are major risk categories that were discussed in the AR5 based on new scientific evidence.

3.4. Chapter 4

It is increasingly clear that current NDCs regarding mitigation and adaptation are far from enough to stay below the temperature targets mentioned in the Paris Agreement. Although sectors such as energy, transportation and agriculture are undergoing transformation, to meet the 1.5°C target, the pace and scale of change globally will need to be greater. Chapter 4 assesses possible strategies and options to strengthen mitigation and adaptation which interact with sustainable development in the context of the Anthropocene. The need for these options to be far-reaching and cross-sectoral, moreover, interlinked with complimentary adaptation actions and sustainable development to meet the 1.5°C target. Some of the technological options assessed for their feasibility are carbon dioxide removal (CDR), and potential solar radiation modification (SRM).

3.5. Chapter 5

The focal point of Chapter 5 is sustainable development especially eradicating poverty and reducing inequality and the interlinkage of climate action in a 1.5°C warmer world. In doing so, elucidating the interdependence of limiting warming to 1.5°C as compared to 2°C, avoiding additional impacts and achieving many of the goals set in the SDGs. While focusing on the SDGs the chapter identifies challenges and opportunities for transformation in A 1.5°C warmer world. Synergies and trade-offs of options and strategies are explored in terms of their implementation and integration and various policy options and instruments, technology and global trends are assessed.

Introduced in the AR5, this chapter explores the literature on Climate Resilient Development Pathways (CRDPs) with relevance to 1.5°C of warming. In doing so, this chapter aims to understand the potential transformations to reduce poverty and inequality through societal and system change. CRDPs are conceptual pathways that utilise adaptation and mitigation to reduce climate change and its impacts while strengthening sustainable development based on climate justice and equity. CRDPs allow for problem-solving at a local level through participative governance, inclusive decision making and transparency alongside technology and innovation while accounting for various needs, agency and rights in order to reduce trade-offs. An interesting aspect of the CRDPs is the inclusion of different starting points between and within countries which is important to take into account in climate negotiations.

The AR5 pointed how climate change and its impacts made it harder to achieve sustainable development and that by harmonising efforts to limit global warming can support the goals such as food security, healthy societies and ecosystems and poverty alleviation. In order to meet the 1.5°C limiting target, adaptation and mitigation must be done at all scales and levels. The interaction of climate action and sustainable development targets can be positive and negative, the former known as synergies and the latter, trade-offs.

An example of synergy is the benefits the local community can potentially reap from a well-managed coastal or agricultural project such as women empowerment. An example of a trade-off is the conversion of natural forests into plantations for bioenergy production.

3.6. Conclusion

The influence of human activity has been a key agent in shifting the world from the relatively stable Holocene period to an era termed as the Anthropocene. The overarching context of this report is that in order to respond to climate change in the Anthropocene there is a need for unprecedented global effort. By limiting global warming to 1.5°C through societal and system transformation would make it easier to eradicate poverty, reduce inequalities and achieve other aspects of sustainable development.

4. Literature Review

In this literature review, I aim to provide a synthesis of knowledge available on L&D and describe my working definition of the term. I organise the review according to the themes identified in a review article by McNamara and Jackson (2019). This review, which has been published in a high impact-factor journal, covers over 122 academic publications on L&D, starting from 2010. It touches upon all the issues discussed in a recent book (Mechler et al., 2019) aimed to provide an overview of L&D.

With the aid of these literature sources, I map out the evolution of the term from the point of view of its definition and scope. Further to this, I analyse the literature, to identify determinants of L&D that I can use in the qualitative analysis of the IPCC's SR1.5. In doing so, I discuss emerging themes and knowledge gaps. This literature review serves as a foundation for the creation of the coding scheme and decisions made during the qualitative content analysis of the SR1.5 and are presented in the following section (Figure 8 and 9).

4.1. Evolution of the term

Faced with the prospective of being held liable to compensate for the losses and damages developing states face presently and will face in the future, developed states have resisted against the inclusion of L&D in global climate change negotiations (Taub et al., 2016). L&D is a term that has been widely contested in terms of the frames used to define it. As a result, the term is yet to be officially defined, even though it entered international climate change negotiations as early as in 1991, when the Alliance of Small Island States raised it in the context of a potential fund to compensate low-lying nations from sea-level rise.

In 2007, the Bali Action Plan (Decision 1/CP.13) invited states to put forward strategies to combat L&D and only in 2012, at COP18 in Doha, did the issue have a firm place in the UNFCCC negotiations (Warner, 2012). With the establishment of the Warsaw International Mechanism (WIM) for Loss and Damage Associated with Climate Change Impacts (UNFCCC, 2014), under the Cancun Adaptation Framework (Decision 1/CP.16, paragraph 26), and especially with the inclusion of Article 8 (on L&D) in the Paris Agreement, the term has gained increasing attention in the climate change policy arena (Boyd et al., 2017). While the Paris Agreement mentions the importance of addressing L&D, the language used is non-binding and vague at best (UNFCCC, 2015; Taub et al., 2016).

Initially, it was framed as an issue of compensation and climate injustice (Vanhala and Hestbaek, 2016). Developed countries have actively avoided framing L&D with a liability lens and have advocated for a risk and insurance frame. This avoids the thorny issue of compensation, while allowing certain climatic events and their consequences to remain unaddressed. This was clearly apparent at COP16 in Cancun, which led to the liability and compensation aspects of L&D policies to be set aside in order for developed countries to accept the inclusion of L&D in the decision eventually adopted (ibid). In a recent paper, Elisa Calliari (2018) explores the power dynamics within the UNFCCC and finds that despite the adoption of Article 8 and the WIM, there is no measurable progress towards the conceptualisation of L&D. Further, the paper describes the negotiating strategies of the opposing parties and simultaneously reflects upon the lack of connectivity of L&D with other heated issues under the UNFCCC, such as historical responsibility and differentiation of responsibilities. Calliari (2018) highlights the importance to join the dots between L&D and relevant issues to bring about systemic change.

Wrathall et al. (2015) provide an overview of operational problems associated with L&D and how these problems could affect the effectiveness of the WIM. Valuation, assessment and compensation of loss are a few of the problems and will be discussed in Section 4.6.

The UNFCCC negotiations and discussions leave much to be desired as there is yet to be an official definition of the term and aspects such as which impacts are covered, what policies and interventions must be employed, who is covered to what extent, and who is to pay for these policies remain unclear at best (Page and Heyward, 2017). Arguably, then, the framing of L&D questions the values, judgment, political choices and notions of justice of all stakeholders involved.

4.2. Definition of the term

Parties to the UNFCCC have not agreed on a definition of L&D, which means that there is no "official" definition of the terms. Nonetheless, in an information note, the UNFCCC does provide a definition: the present and future climate-related impacts and risks that arise owing to slow-onset and sudden-onset extreme events (UNFCCC 2012, 2015). This initial definition was focused on the potential and actual impacts faced by the Global South (McNamara and Jackson, 2019). While the definition takes into account major impacts of climate change, acknowledging the overstepping of thresholds for adaptation, the loose definition of the term allows for its interpretation in several ways, allowing several factors to go unaccounted for (Page and Heyward, 2017; Wrathall et al., 2015). It is worth noting that negotiations within the UNFCCC have mainly been focused around mitigation and adaptation and the recognition of the concept of L&D has only arisen recently (Page and Heyward, 2017). The distinction of L&D from adaptation arises from the varying emphasis on the role of climate change, finance and justice and whether this mechanism is for the prevention or the compensation of L&D (Vulturius and Davis, 2016).

Fekete and Sakdapolrak (2014) provide an interesting perspective on L&D, regarding it as an indicator of social vulnerability. In doing so, they showcase the impacts of climate change in a concrete form. Page and Heyward (2017) provide another dimension to the definition of L&D, stating that loss and damage are 'separate pathways of disruption'. The difference arises when a 'damage' occurs, it impairs the functioning of the good or service. Page and Heyward (2017) stress that it is based on the prioritisation of 'Ends' over 'Means', with 'means' enabling the agent to reach an 'end'[5]. Understand the social vulnerability dimension of the concept is essential, as it influences the scope and design of climate change policies (Goodin, 1991).

McShane (2017) provides an interesting perspective to defining L&D by connecting it to a broader range of understanding of impacts. In her paper, she states there are two possible interpretations of losses and damages, one being connected to the concept of value and the other, to the concept of harm. The overlap between the concepts of harm and value have led to these concepts being viewed as interchangeable. McShane (2017) provides an example where the loss of biodiversity may not harm anyone but due to its intrinsic value would lead to its inclusion as L&D in the WIM. Through this example, McShane (2017) makes a case for a broader, rather than a narrower definition. Far from being arcane academic discussions, these specifics matter, as they will determine which topics will be included under the WIM framework (Shockley and Hourdequin, 2017).

Drawing on my review of the literature, I use the following working definition of the term L&D: the impacts of climate change and related stressors which cannot be mitigated or avoided owing to the threshold limits of a system (society) and the slow pace and ineffectiveness of policy development in mitigation and adaptation efforts. This definition

[5] For example: if an agent were to pursue their education (end) but owing to an extreme event, public transportation and roads were rendered inaccessible (means), it would be considered damage as despite the reversibility of the situation contingent on political, institutional and financial factors, the availability of education to the agent is impaired for a certain duration of time.

has been adapted from the working definitions of van der Geest and Warner (2019) and Vulturius and Davis (2016).

I utilise these two definitions because, together (but not individually), they cover the different aspects of L&D identified through my review of the literature. van der Geest and Warner (2019) define L&D with respect to the principle that systems have a finite capacity of adaptation, which implies that despite mitigation and adaptation efforts, there are certain impacts that cannot be avoided[6]. In contrast, Vulturius and Davis (2016) define L&D as the impacts that arise due to ineffective institutions and slow-paced, unambitious policies. Together, these definitions capture key determinants of L&D.

4.3. Typologies of perspectives on L&D

Through a set of stakeholder interviews, Boyd et al. (2017) uncover four key typologies of perspectives on L&D. These provide an interesting insight into how different perceptions of the issue change the way stakeholders interact with L&D, while illustrating the solutions or drawbacks associated with each of these perspectives. This typology provides a broad overview of the different narratives within the topic of L&D. McNamara and Jackson (2019) utilise this typology in order to identify themes that are repeatedly visited in the literature on L&D.

From an *Adaptation-Mitigation* perspective, L&D is viewed to be politically motivated and the need to differentiate L&D from adaptation is deemed unnecessary Furthermore, under this view, additional financing is thought to be unnecessary.

The 'Risk Management' perspective is based on disaster-risk reduction approaches to public policy, and its integration with climate-change risk reduction. The proponents of this view emphasise the need for insurance schemes and private sector financing to help states cope with L&D (Boyd et al., 2017)[7].

[6] The finite nature of the ability to adapt is not bound by scale, it is equally applicable to individuals as to countries. It is essential to identify the limits to adaptation before reaching the threshold of adaptive capacity, which would lead to severe negative impacts on human welfare, in terms of extreme losses and the need for transformational change (Dow et al., 2013).

[7] A *risk-based* approach focuses on the actor to define social adaptation limits that pertain to their values and an understanding of their notions of risk and vulnerability. Under this view, contextualising the risk versus generalised consequences is more likely to spur the actor into action.

The *Limits to Adaptation* perspective focused on what is beyond adaptation, the vulnerability of communities, the need for increased research to identify adaptation limits and contingency plans for these communities (Boyd et al., 2017)[8]. Limits to adaptation are not solely dictated by exogenous factors such as the economy, ecology, and physical and technological thresholds, but also by endogenous factors such as values, ethics, knowledge, and the culture of a community. Due to the vary diverse ways in which, especially, endogenous factors are perceived across regions, the proponents of this perspective suggest that attention to local specificities is key to managing L&D. Understanding the social factors that limit the capacity of a community to adapt, stress on the dynamic and subjective nature of the concept (Adger et al., 2009)[9].

Finally, the *Existential perspective* addresses the inevitable harm that vulnerable communities are to face, and focuses on mitigation and compensation (Boyd et al., 2017). This perspective emphasises on irreversible loss and non-economic losses that will arise due to the unavoidable transformations of certain communities due to climate change. Interestingly, the sense of urgency to provide options to communities most vulnerable is central to this perspective[10].

At the end of the categorisation of literature on L&D, McNamara and Jackson (2019) found that nearly half (45.1%) of the publications analysed fit under the *Limits to Adaptation* category, considering L&D to be beyond the adaptive capacity of vulnerable communities. However, they state that further analysis is essential to gain a better understanding of the nuances of the conceptualisation that the literature holds, as the publications that they analyse do not perfectly align with the typology provided by Boyd et al. (2017).

4.4. Nature of L&D

The following section explores the interplay between adaptation limits and L&D in order to acquire a better understanding of where the concept arises from. Additionally, this section covers four pathways that result in L&D along with relevant case studies. The scientific

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[8] Defining adaptation limits involves understanding the social, institutional and cultural linkages, which in turn, shape decisions (Dow et al., 2013).

[9] Understanding the diversity in values, perceptions of risk and vulnerability to climate change impacts are the hallmarks of an adaptable society. The inclusion of ethics concerning the treatment and engagement of vulnerable communities is an integral part of the decision-making process for climate change policy development (Adger et al., 2009).

[10] However, when framed as a climatic compensatory approach, L&D detracts attention from the perpetrators and the object of the event, as it aims at restoring conditions prior to the climatic event for the victims and not on preventing or eliminating the vulnerability in the first place (Page and Heyward, 2017).

literature highlights that L&D can be characterised by four traits: the attribution of the impacts of climate change to human activity, the unavoidable nature of the impacts, the irreversible nature of the harm that may prevail, and the intolerable nature of that harm (Vulturius and Davis, 2016).

Kreft et al., (2013) and Lusk (2017) define climatic losses as negative impacts that are permanent, irreversible, and where restoration is impossible; they define climatic damages as negative impacts that are reversible and repairable. According to Dow et al. (2013), tolerable risks are those where additional efforts are essential to reduce the risk but are associated with benefits. Conversely, intolerable risks are those that put unacceptable pressure on a socially negotiated norm, despite adaptation measures, for example, loss of livelihood and access to clean drinking water (see Figure 3).

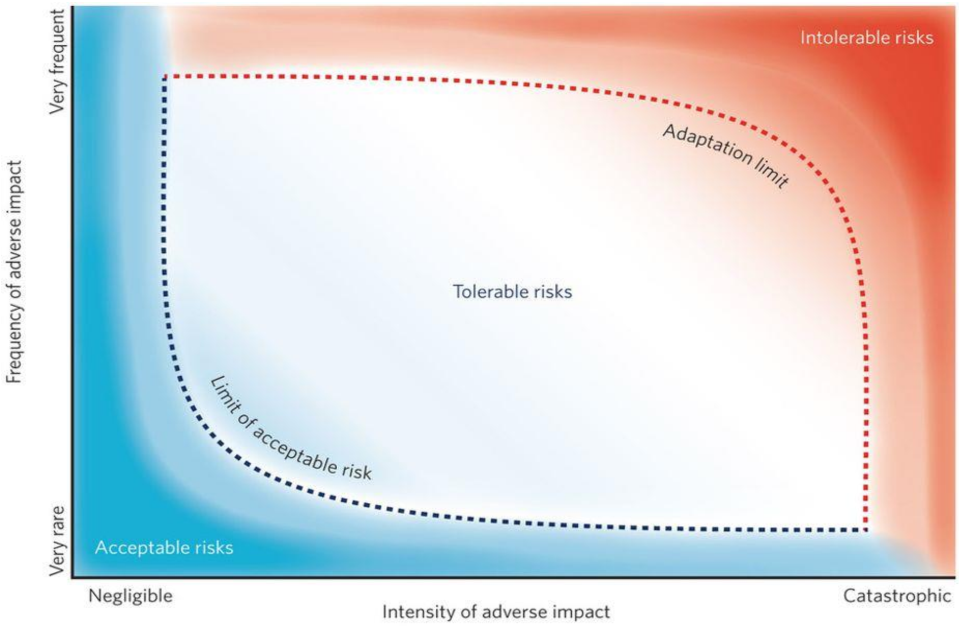

Figure 3: Acceptable, tolerable and intolerable risks in relation to adaptation limits. Drawn by Yuka Estrada, IPCC. (Dow et al., 2013)

There is broad agreement that losses and damages come about due to three reasons. First, despite mitigation and adaptation initiatives that have been and are currently being undertaken, certain impacts of climate change are occurring and lead to losses and damages (Warner et., 2012). Second, the IPCC (2014) report that due to the 'locking in' of our climatic system and slow onset events such as SLR, future losses are inevitable regardless of increased mitigation action (Steffen et al., 2011). Third, Dow et al., (2013) mention that owing to social, institutional and political constraints of states, especially developing states, a certain proportion of impacts cannot be avoided.

In their analysis of the literature on L&D, McNamara and Jackson (2019) found that a great number of publications (45%) referred to L&D as both, occurring and a future condition. Only a small proportion of publications (5.7%) solely focused on potential L&D using various methods to quantify future L&D and gain a clearer understanding of future impacts. They categorise publications in their review based on their framing of L&D as, actual (based on empirical data, past and current policies), potentially occurring or both. A majority of the publications considered L&D as on-ground impacts that have occurred (actual). As identified by Warner and van der Geest (2013) there are four main L&D pathways:

1. Inadequate coping and adaptation mechanisms
2. Measures have non-economic costs that cannot be recovered
3. Measures have negative effects in the long run
4. No possible measures have been adopted or are possible (hard limits of systems)

On-the-ground impacts have been identified across regions[11] and often have disproportionate effects on vulnerable communities. Following the third pathway of L&D (refer Warner and van der Geest, 2013), Beckman & Nguyen (2016) find that policies in Vietnam reinforce practices such as segregating agricultural land from protected forests, which increases the vulnerability of communities to climatic risks and hazards. They use qualitative interviews with local government officials and villages to gain a better understanding of their perspectives regarding L&D, ideas for reducing risk and potential policy reforms. They find that villagers support arguments for increased adaptation and risk reduction measures in the form of improved irrigation and improved land-use practices through integration. However, supporting the first pathway of L&D (refer Warner and van der Geest, 2013) Kusters and Wangdi (2013) find that, despite adaptive action, shortage of water plagues communities in the Punakha district, Bhutan. Similarly, Bauer (2013) examines household vulnerability to flooding and the measures taken in Udayapur district, Nepal. Through a survey of 300 households and focus group discussions, he finds that despite the numerous practices undertaken to decrease the vulnerability and risk, these measures are often unable to avoid or reduce L&D.

[11] Warner and van der Geest (2013) conducted an evidence-based study on L&D in nine least developed and vulnerable countries (Bangladesh, Bhutan, Burkina Faso, Ethiopia, the Gambia, Kenya, Micronesia, Mozambique, and Nepal) presenting present case studies of communities adjusting to the negative impacts of climatic stressors. Through household surveys (n= 3,269) and focus group discussions, they describe L&D from the perspective of those most affected and report that communities face a significant amount of L&D brought about by extreme weather events and slow-onset climate hazards (Warner and van der Geest, 2013).

Traore and Owiyo (2013) report that communities in Burkina Faso have experienced severe effects on crops (96%) and livestock (87%) further to severe droughts in 2004 and 2010. The from the decreased availability of water reduced crop production and yield which in turn affected the availability of food for people and feed for livestock. Moreover, earlier practices of transhumance are no longer a viable option, owing to the lack of adequate pastures, amongst other factors. They find that the cascading impacts of extreme droughts often tend to limit the adaptive capacity of communities to future droughts (Traore and Owiyo, 2013).

Through conjoint experiments in donor countries, Gampfer et al. (2014) explore what forms of institutions are likely to gain more public support regarding climate funding. They find that funding choices made in unison with donor and recipient countries receive more support. Additionally, funding in terms of compensation without contribution to the global mitigation and adaptation ambition is more unlikely to gain support. Their results shed light on the perceptions of the public regarding climate funding from developed states, thus informing future policy decisions such as a liability mechanism for L&D. However, Gsottbauer et al. (2018) suggest a liability mechanism as opposed to compensation claims, as another way to address L&D and increase policy ambition. In their paper, Gsottbauer et al. (2018) find that a liability mechanism encourages and enhances cooperation between parties and subsequently could lead to the minimization of the occurrence of L&D. In both, Gampfer et al. (2014) and Gsottbauer et al. (2018), the current impacts of climate change are considered but L&D is considered to be a potential issue in the future. The section above dives into the nature of L&D, where losses and damages arise from and their interaction with acceptable, tolerable and intolerable risks. By doing so, this section forms a basis to understand the pathways that result in L&D.

4.5. Economic- and Non-Economic L&D

Losses and Damages can be economic or non-economic in nature (Schäfer and Kreft, 2014). In turn, economic and non-economic L&D can be further distinguished as tangible and nontangible L&D. Loss of ecosystems, biodiversity, culture, indigenous knowledge, life, homeland, and heritage are examples of non-economic losses, while assets traded in markets such as loss of property, resources, services, and infrastructure are economic losses (ibid). Figure 4 depicts, as examples, a range of slow onset and extreme events along with economic and non-economic losses that may result from L&D (UNFCCC, 2018; based on UNFCCC, 2012).

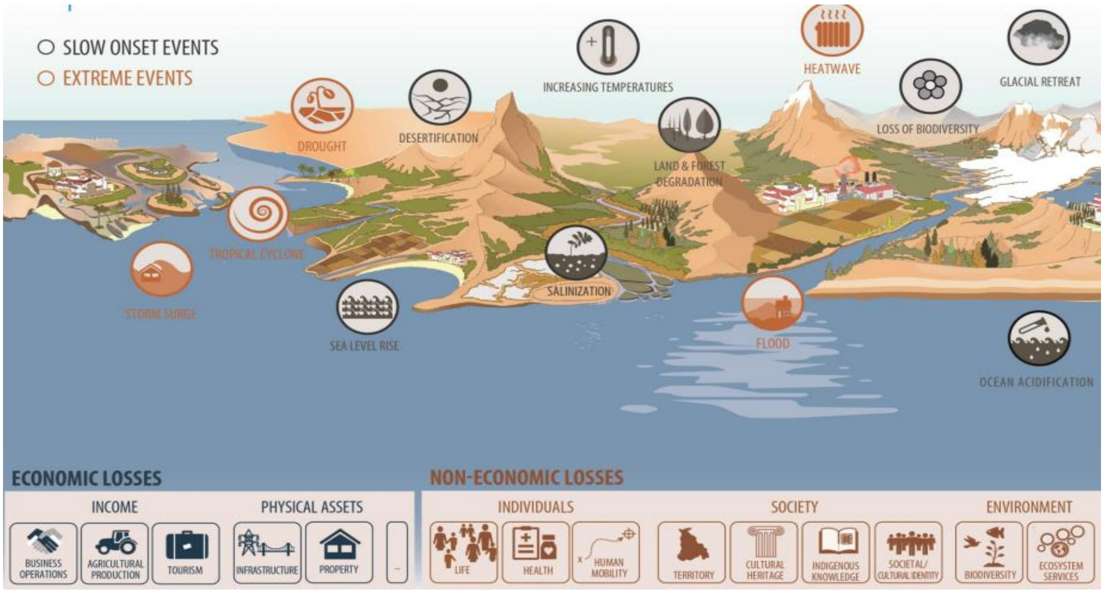

Figure 4: An overview of the impacts of climate change in the context of Loss and Damage (UNFCCC, 2018)

Unsurprisingly, L&D has received the attention of the insurance industry, especially with regard to economic losses. In its annual report from 2018, Munich Re, a reinsurance company, mentions that climate change poses “one of the greatest long-term risks of change for the insurance industry”. The report acknowledges the linkage between climate change and the increase in extreme weather events in the long term, stating that the increase in demand for primary insurance and reinsurance products will be inevitable. For example, in July 2013, the costliest thunderstorm event since 1980 in Germany cost the country a loss of €4.6 billion, of which only €3.5 billion was insured (Faust and Rauch, 2019). Similarly, the Food and Agriculture Organisation of the United Nations reports that the Caribbean region has faced direct and indirect losses adding up to more than US$ 3 billion arising from weather and climate events between 1970 and 2000 (FAO, 2016).

McNamara and Jackson (2019) find that publications prioritize economic losses, however, they acknowledge non-economic losses as well (60% of publications). Non-economic losses (NELs) are not only difficult to quantify but have impacts that go beyond what most research publications analyse. Based on Serdeczny et al. (2018), Figure 5 provides a breakdown and overview of losses based on the type of loss and event (Daniel Puig, unpublished, pers.comm.)

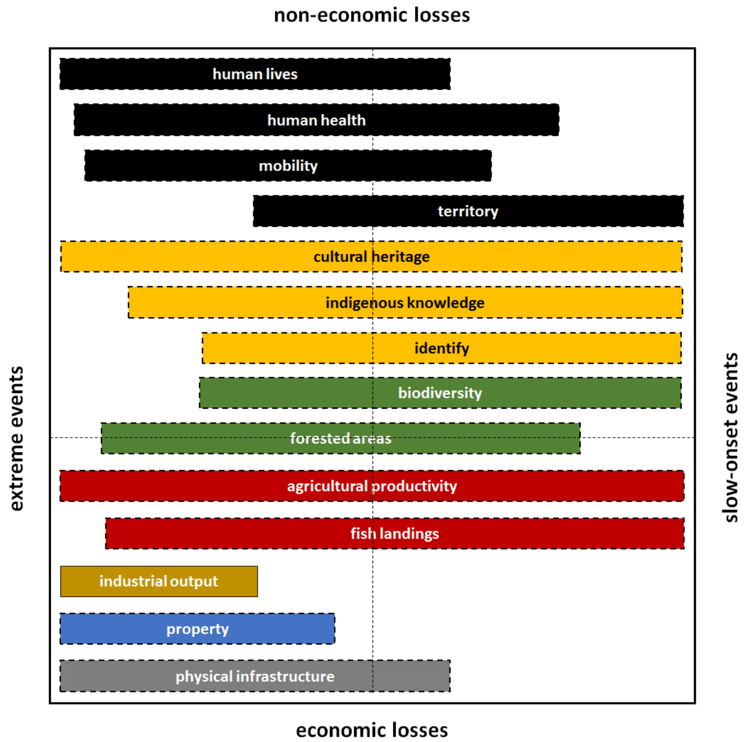

Figure 5: Categorisation of L&D by type of loss and event
(modified after Daniel Puig, unpublished, pers.comm.)

Further, Serdeczny et al. (2018) present a conceptual framework (Figure 6) to categorise non-economic L&D (NELD), distinguishing between physical attributes of items along with the distinction between intrinsic and instrumental values.

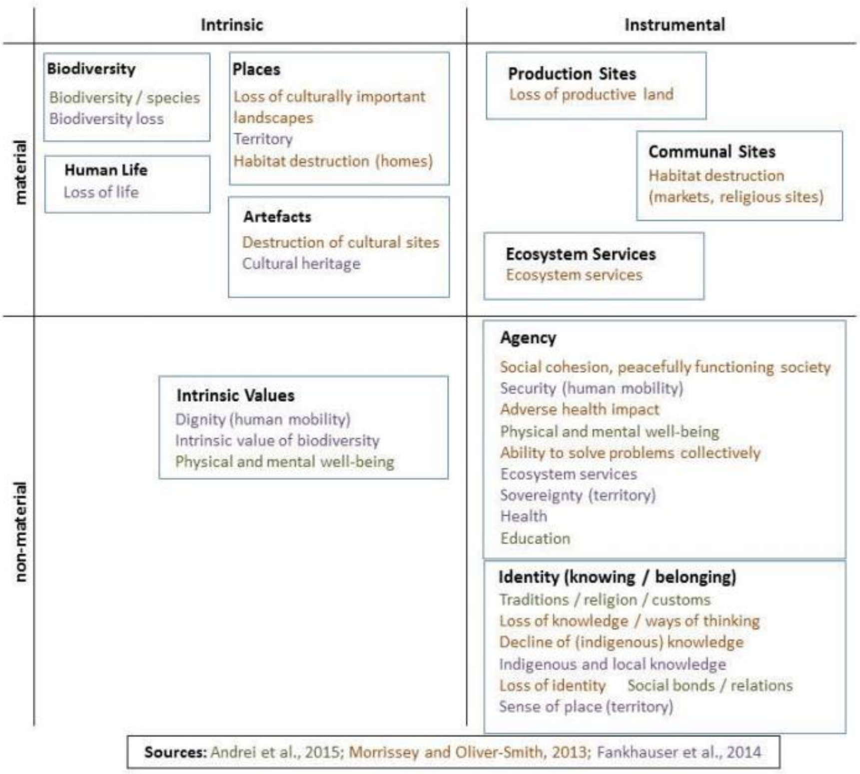

Figure 6: Conceptual framework categorising NELD (Serdeczny et al. 2018)

Serdeczny et al. (2018) provide a review of NELs in climate change literature and explore how the science-policy interface of the UNFCCC allow for increased engagement and participation, in order to develop approaches and responses to tackle NELs ex-ante and ex-post. They stress the need for integration of knowledge and insights regarding NELs and their indicators with decision making and policy development, in order to effectively address NELs.

Preston (2017), through his analysis of the UNFCCC (2013) working paper on NELs, finds that the working paper reframed NELs to fit under the overarching concept of 'total economic value'. The working paper explores NELs in three different domains; private individual, society, and the environment (UNFCCC, 2013). Then categorises them as; cultural capital, social capital, and natural capital, which essentially quantifies losses that have occurred in order to simply provide compensations (UNFCCC, 2013). The working paper goes on to identify common frameworks, based on which perceptions and judgments are made; welfare, well-being, and ethical frameworks. Preston (2017) identifies several shortcomings regarding this conceptualisation of NELs. For example, the valuation of an ecosystem solely based on its economic potential. Additionally, Preston (2017) emphasises on the inherent difficulty associated with the quantification of NELs and cautions against the adjustment of NELs into an economically quantifiable framework. As mentioned in Serdeczny et al. (2018), he reasons that the need for comprehensive conceptualisation of NELs is not to attach a price-tag to loss, but rather to prevent the loss from occurring in the first place. Moreover, he urges for the development of a more insightful and ethical framework regarding NELs, to avoid the oversimplification of the issues faced by vulnerable communities (Preston, 2017). In light of this, it can be said that the prioritisation of economic losses in the UNFCCC could prove to be problematic for the development of approaches to address NELs.

In addition to the normative studies referred to above, a number of authors have conducted case studies aimed to identify and characterise NELs. In their pioneering study, Warner and van der Geest (2013) identify a number of NELs arising from climate change impacts in least-developed countries. Chiba et al. (2017) find that disaster policy in Japan and Bangladesh tend to overlook NELs which, as a result, remain unaddressed. Chiba et al. (2018) take a closer view into NELs in Bangladesh and highlight ways to strengthen disaster-risk reduction plans, with a view to reflecting NELs. In a similar vein, and focusing on climate change-induced displacement, Thomas and Benjamin (2018b) find that national policies overlook NELs. Finally, Huggel et al. (2019) conduct a review of the literature on L&D in the mountain cryosphere and find that most such L&D relate to NELs.

Tschakert et al. (2017) provide an interesting perspective on the losses that people face due to climate change. They find that, often, loss is referred to as tangible, an experience people have lived. They argue that, in doing so, existing methods of valuation do not reflect on what people truly value. Addressing the need for inclusion of values in climate policy and science, they provide insights into the trade-offs that people make between different value priorities and how they may shift over time. Furthermore, they emphasise the need for value- and place-based decision-making process to improve the assessment of potential losses. Tschakert et al. (2017) state that value-centric policies will require a shift in research agendas, starting from the perspective of those who are affected, their decision and actions. By doing so, this would allow for a focus of efforts and resources to what is in fact valued by people. It would also make it possible to come to terms with the reality that not all things we value will be preserved.

The literature on policies to address NELs is scant. The reasons for this are two-fold. First, the understanding of the concept is evolving, as highlighted by Preston (2017). Second, the assessment of NELs is at its infancy, as evidenced by the (limited) number and the conclusions of the case studies available. While some authors view NELs through a disaster risk-reduction perspective and resort to insurance as a response to NELs, others claim that a broader and fundamentally different approach is required – one that takes into account the intangible issues highlighted by Tschakert et al. (2017) among others.

In comparison to valuing the loss of agricultural yields or property, it is much harder to ascertain the value of natural and cultural resources and even more so, to value aspects of affected individual's lives. Often, climate insurance is thought to be the way forward, however, insurance does not cover nontangible assets. Theoretically, compensation seems to be the key go-to option when it comes to making reparation to those who have been adversely affected. However, there is no price tag attached to the loss of livelihood of an individual as it's more than a mere change in form of livelihood, it's the loss of fundamental identity, of a way of life. While in economic theory it might seem straightforward, the reality proves to be rather traumatic (Wrathall et al., 2015).

For example, Jurt et al. (2015) explore the cultural value of glaciers in both, the Global North and Global South. They provide an interesting range of perspectives on the impacts of receding glaciers on livelihoods and the sense of being home, further going on to define the limits to adaptation they observed. Can a monetary metric be placed on lives, livelihood, sense of belonging and culture? Wrathall et al. (2015) argue that compensation simply placates the guilt of the offenders by converting loss into a price and in turn, absolves the offenders of further responsibility.

With the extent of L&D that is currently occurring and will occur in the future, Adger et al. (2009) question policy mechanisms that are currently in place. The choices we make cannot be solely based on scientific knowledge but must also take into account social values. L&D poses a great risk to human diversity and its loss could result in the loss of fundamental identities of vulnerable communities across the world.

4.6. Attribution of impacts of climate change

It goes beyond doubt that anthropogenic activity has been a driver and lead to an increase in frequency and intensity of extreme weather events over the past years (Trenberth et al., 2015). The IPCC (2012) acknowledges the challenge that attribution of single extreme events poses, especially as impacts occur suddenly and effects are seen at local scales.

The uncertainties inherent to global warming make it difficult to attribute extreme weather events to anthropogenic climate change. In turn, this hampers assessments of the extent of L&D in the future (Wrathall et al., 2015). In itself, compensation in the case of attribution places a majority of the burden on the claimants, in this case, the developing states to make a case for their claims creating additional hurdles for developing states to jump over (Verheyen, 2015).

Attribution science plays a key role in characterising L&D, but it must take into account climate variability and social vulnerability. When looking at the irreversible nature of the harm caused, one must take into account the social, non-economic losses which often can lead to an undervaluation of the vulnerability of communities (Tuana, 2017).

Hulme (2014) presents four main types of evidence for weather attribution. Two of these (physical reasoning and a philosophical approach) provide an interesting insight into attribution. The former is based on identifying patterns of weather events and whether or not they are consistent with trends. Whereas, the latter is based on the realisation that climate change is a scientifically proven reality and has effects on the climate, thus avoiding the need for establishing attribution on a case-by-case basis. Aside from statistical analysis and climate modeling, these are the two key approaches used in most empirical case studies. Hulme (2014) additionally suggests that Probabilistic Event Attribution (PEA) will play a key role in attributing single extreme weather events to climate change, even if only partially.

PEA has been steadily progressing over the years, however, McNamara and Jackson (2019) find that amongst the scientific publications reviewed, there are different opinions regarding the utility of PEA with regards to L&D. Thompson and Otto (2015) advocate for the mainstreaming of PEA to inform policy mechanisms, so as to distinguish between those that face L&D from climate change as compared to those who suffer harm from natural hazards. Warner and van der Geest (2013) note that, at the local level, one of the key limitations of case studies on L&D is the difficulty in attributing extreme weather events and local change to climate change.

While there is a significant amount of support for the relevance of PEA to L&D, there are certain drawbacks of PEA. Lusk (2017) points out that PEA does not include societal factors but is solely based on meteorological risk, therefore, it is unlikely to shed any light on potential compensation claims. Furthermore, Lusk traces the evolution of discussions regarding PEA, identifying that the main motivation of PEA is to help society cope with the impacts of climate change, not to develop a clearer understanding of extreme events and their causality. While he acknowledges the role of PEA in event attribution, he states that there are other avenues available to address L&D that would be better suited, as the information from PEA may not be enough in the context of climate justice.

5. Methods

The research approach of this thesis was grounded in qualitative methods of analysis. The following section describes the research design, methods used, and potential limitations of the methods used. The thesis was conducted in the following stages:

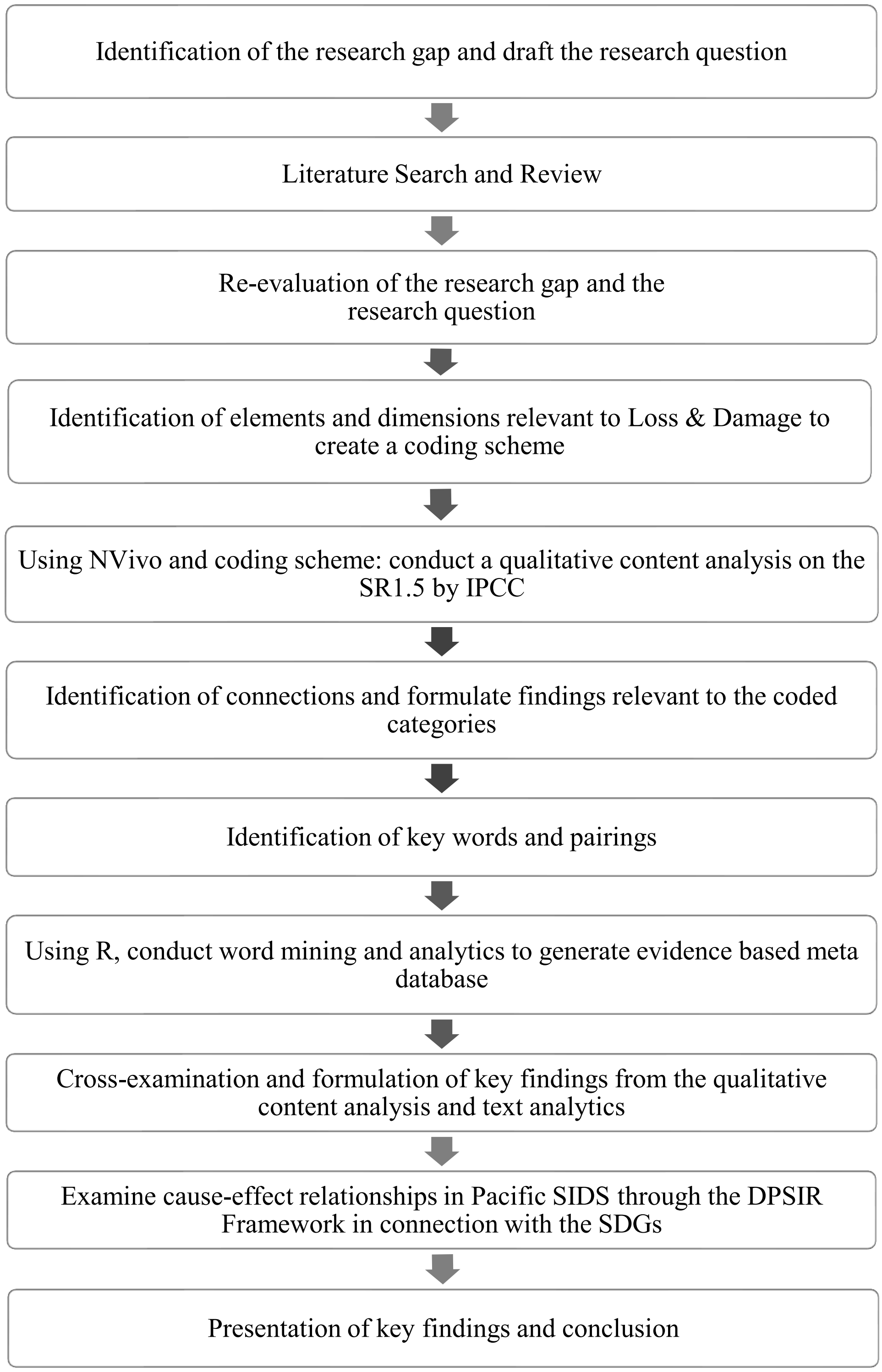

Figure 7: Workflow of the Master's Thesis

Data is often thought to be only in numerical form making quantitative research a distinctive research strategy according to Bryman (2012) and the qualitative research is seen as a contrasting research method solely based on the usage of words as compared to numbers (Creswell, 2009).

Qualitative analysis allows for eclectic methods of research, where data is more than numbers but can be text, videos, audio, and images. Qualitative content analysis (QCA) is one of the many methods employed in qualitative research. Hsieh and Shannon (2005) define QCA as a method of research through which data in the form of text is subjectively interpreted through the identification of patterns and subsequent coding. In doing so, the researcher is able to design, and re-design theories based on the interpretation of the data generated. The need for reflection before and during the research process is essential in order to provide context and a deeper understanding of the work to the reader. This is in order to present a comprehensive overview of the decision of the researcher and the resulting findings, so as to counter the negative connotation regarding the innate subjectivity and bias of this method of research which is unavoidable (Creswell, 2009).

Starting from the book 'Loss and damage from climate change: Concepts, methods and policy options' by Mechler et al. (2018) and an advanced review paper by McNamara and Jackson (2019), a thorough and extensive literature review was conducted on L&D. Based on Wee and Banister (2016), and Webster and Watson, 2002, I identified relevant literature and structured the content of the literature review to provide empirical insights, investigate theories behind the definitions of L&D, and gaps in the literature to provide a wholesome view of the topic. Furthermore, the literature review highlighted the determinants of L&D that I later used to 'code' and 'categorise' the IPCC SR1.5. Saldaña (2015) describes a code in qualitative research as a word or phrase that summarises the essence of a section of data, language or visual-based. Categorisation is the organisation and grouping of similar codes which can often highlight patterns and trends. The Coding Manual for Qualitative Researchers (Saldaña, 2015) provided key insights and guidelines as to the methodology of coding and categorising vast amounts of text, which allowed for the exploration of multiple interlinking themes in the SR1.5.

5.1. Qualitative Content Analysis

NVivo 12 for MAC by QSR International, a QCA software, was used to analyse the five IPCC SR1.5 chapters plus the Summary for Policy Makers, and the Technical Summary.

The report includes over 6000 scientific references and the QCA covers scientific studies conducted across the globe at different scales. A main emphasis is placed on peer-reviewed literature published since the release of the AR5 (2015) till the 15th of May 2018 and draws mainly on papers published in the past 30 years. The usage of NVivo made coding less time-consuming and laborious and allowed me to seamlessly sort, organise and search through the report. The software was used to conduct a content analysis by coding passages and sections under the categories identified through the review of the literature. The categories coded are as follows (Figure 8):

1. Slow Onset Events
2. Sudden Onset Extreme Events
3. Economic Losses
4. Non-Economic Losses
5. Geographical Disaggregation of Impacts
6. Types of impacts
7. Types of stressors
8. 1.5°C vs 2°C of warming

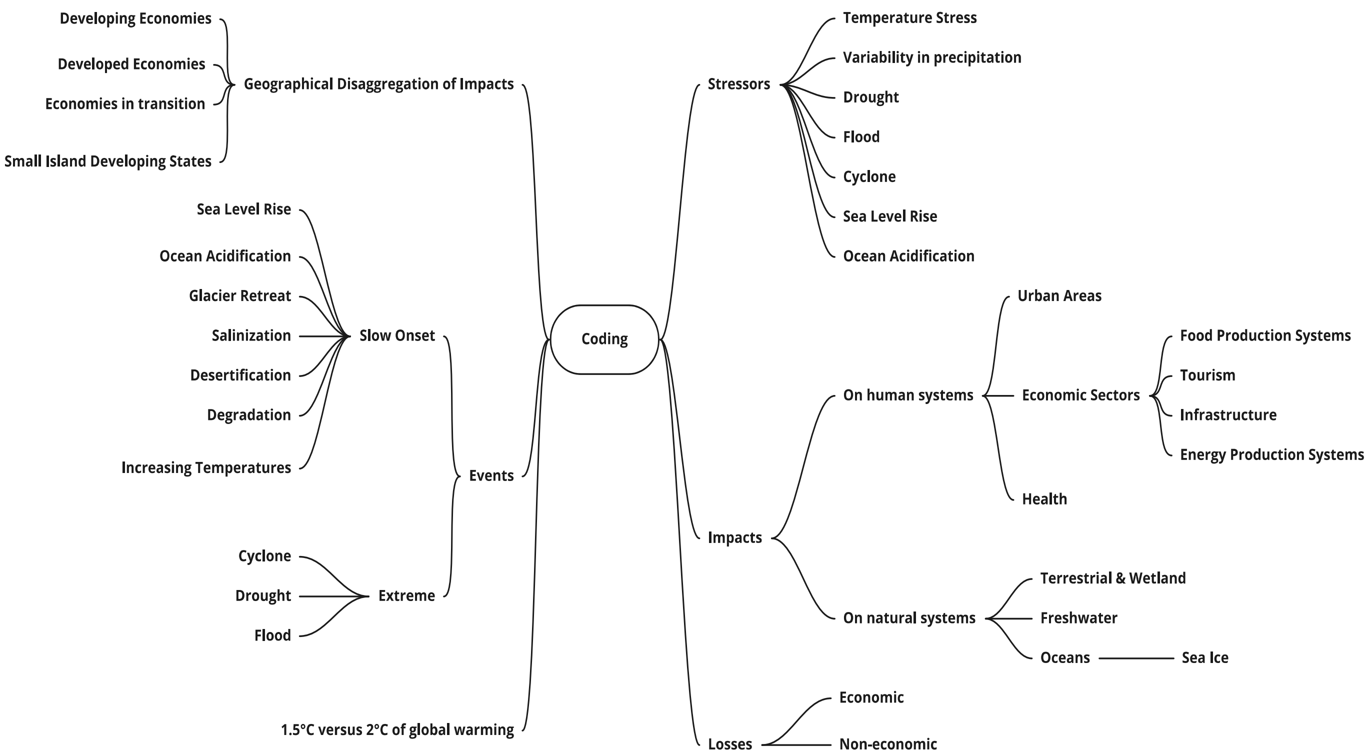

Figure 8: Codes and Categories used for the qualitative content analysis with NVivo 12

Furthermore, based on the content analysis of the SR1.5, several subcategories were coded under 'nodes' (NVivo terminology for codes). The subcategories will be presented in the Results section. The following flow chart (Figure 9) illustrates a broad representation of the decisions I made regarding the inclusion of certain sections as relevant to L&D and its

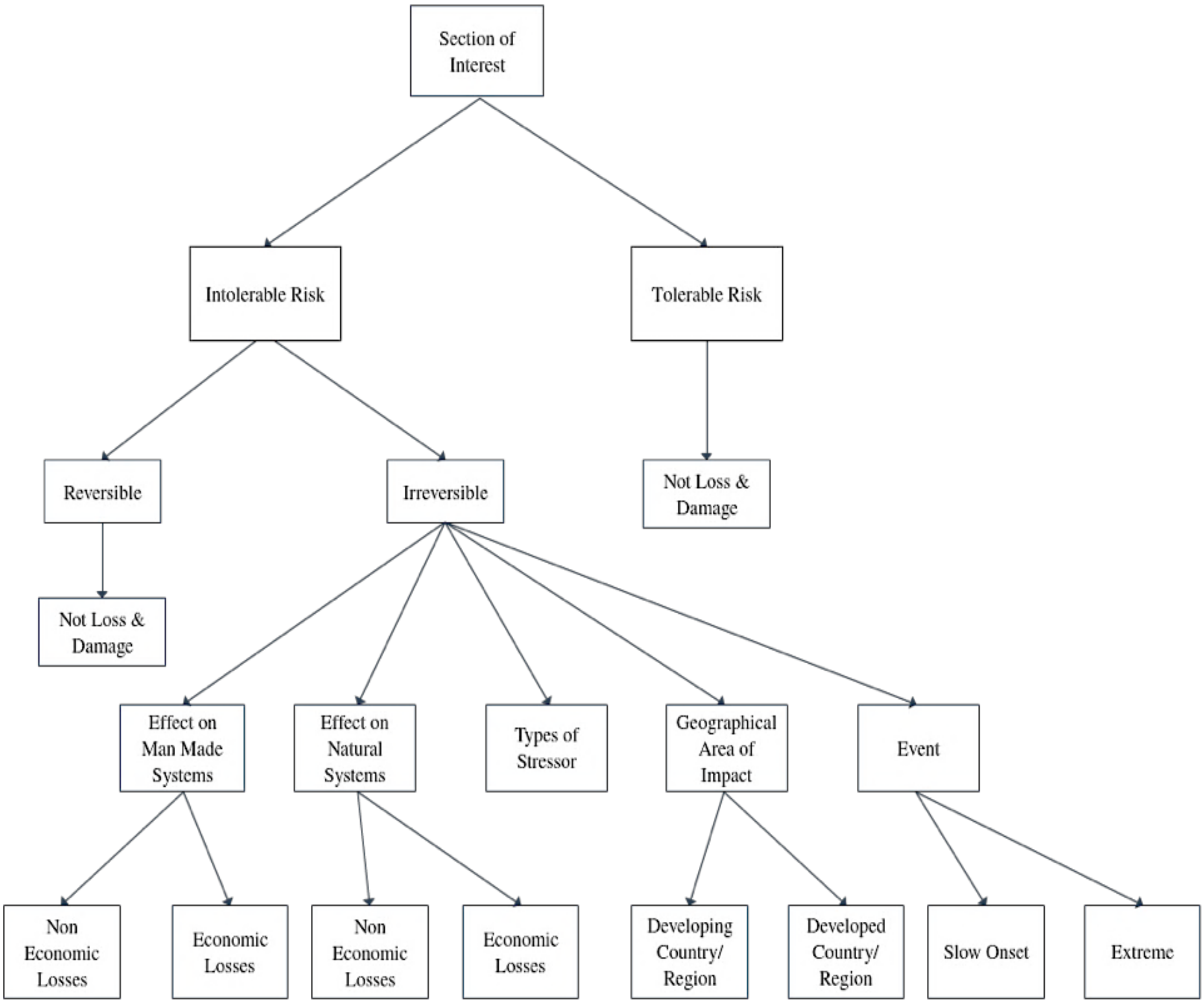

Figure 9: Decision Tree for the inclusion or exclusion of sections

elements. This is done in order to allow for increased transparency in the thesis and the methods used.

5.2. Text Analytics with R

The aim of this task is to explore the connections and networks within the report using software to reduce the bias I might have inadvertently introduced into the qualitative content analysis. For this task, I used R, an open-source statistical computing software to analyse the co-occurrence and correlation of terms relevant to impacts in the same paragraph with loss and damage, and further with 1.5°C and 2°C. Based on the key findings gleaned from the content analysis using NVivo 12 for MAC, words of interests relevant to impacts were selected including their stemmed words such as; loss, losses, lost, losing. The words with the same root/stem were clustered but were screened prior to ensure that the meaning and intent of the word was similar, for example: developed and developing stem from the same word develop but carry different meanings (see Appendix A, Table A.1).

First, the PDF document was converted into a Comma-separated file (.CSV) where each cell contained a paragraph. The analysis of the file was carried out using the texting mining package in R ("tm"). Next, basic stop words (such as and, the, for, but), punctuations and numbers were removed to ensure the accuracy of the software when processing both queries. In total, 15340 unique stem-words were detected in 7843 paragraphs by the software. Further, certain categorisations were made in order to provide a clearer picture of the topics in the report such as the inclusion of 'GDP' under the term 'Economic'. As the focus of this task is to identify the co-occurrence of specific terms within one paragraph, I then coded the occurrence to '1' if a term occurred at least one time and '0' if it did not occur in a paragraph. To identify the correlation between key terms, I used the Phi coefficient which is the measure of the degree of association between two variables (Cramér, 1999). Following these adjustments, the graphs depicting the co-occurrence and correlation were created using R (Figure 12, 13, 14, 15 in Section 6.2).

5.3. DPSIR Framework

Theory

Cause-Effect Conceptual Models are qualitative models that reflect on the associations between sources, stressors and effect. These models can be used to visualise and organise key factors in a complex system and connection between them (Bradley and Yee, 2015). Literature-based cause-effect models provide scientifically sound results through transparent and replicable evaluation. Whereas, cause-effect results are difficult to demonstrate in natural systems owing to various factors such as the natural variability and the lack of replication.

Such models help in identifying knowledge gaps where more research is required and allow for the evaluation of consequences arising from alternative decisions (Bradley and Yee, 2015). Thus, providing a clearer understanding of system dynamics, which is required in sound decision making regarding the design of policies and mechanism (Norris et al. 2011).

System thinking explores problem-solving in a holistic manner and is grounded in the belief that the relationships and interactions between components of a system, provide a better understanding of the system as a whole. Systems thinking allows for the structuring of connections within a system to provide a better understanding of complex or wicked problems (Kristensen, 2004).

Developed by the European Environment Agency (1999), the Driving Forces – Pressures – State – Impacts – Responses (DPSIR) Framework as depicted in Figure 10 has been widely used to structure environmental information regarding environmental problems. The appeal of the framework lies in its ability to connect the causes of environmental pollution with its consequences, with a view to uncovering effective responses and trends, and the dynamic relationships between the various components of the system (Kristensen, 2004). The framework has been used, for example, to inform the development of management plans for agriculture, water resources, public health, biodiversity, and marine resources.

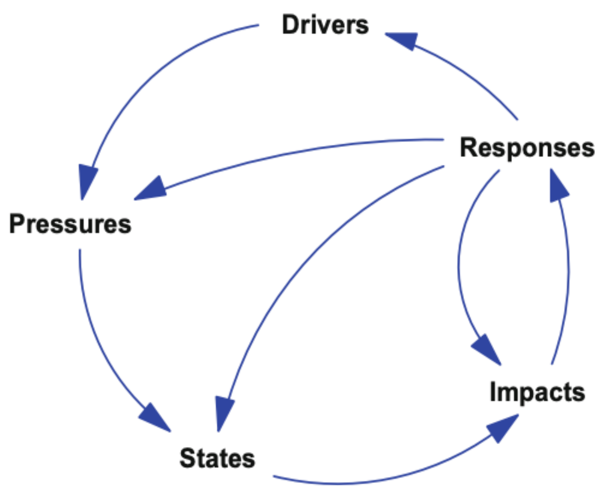

Figure 10: DPSIR Framework (modified from EEA, 2003)

OECD (1994) defines the components of the DPSIR framework as follows:

- ***Driving Forces*:** The factors that influence changes in a system and can be social, economic or ecological in nature. Driving forces can have a negative or positive influence on pressures. Examples: human population, use of resources, industry
- ***Pressures*:** These are the direct effects on a system as a result of the driving forces. Examples: pollution, depletion of resources, change in the chemistry of water resources, climate change

- ***State*****:** The physical, biological and chemical characteristics of a system at a specific time and is affected by pressures. Examples: quality of water, species composition, the productivity of land.
- ***Impacts*****:** These are the effects on human and environmental systems as the result of pressures introduced in the system and the state of the system. The impacts of the system tend to elicit responses. Example: reduction in biodiversity, the incidence of disease, the effect on ecosystem services
- ***Responses*****:** These are the measures taken to cope with the changes brought about impacts on the system. Example: monitoring and evaluation of changes, policies regulating the usage of resources

The DPSIR framework has been successfully used as a communication tool amongst various stakeholders (Kristensen, 2004). As this thesis provides inputs to the SINCERE project under the task focused on L&D in the SIDS in the Pacific region, I shall develop a DPSIR Framework in connection with this task. This DPSIR Framework will be based on the scan of scientific literature concerning climate-induced L&D in SIDS in the Pacific region conducted by Daniel Puig (2019).

Adaptive Management

Following the DPSIR framework, Adaptive Management is a decision learning process that allows for the integration of science and policy in a cyclical manner as represented in Figure 11 (Sendzimir and Schmutz, 2018). This approach allows for the stepwise structuring of primarily four phases, problem assessment, policy formulation, implementation, and monitoring. It facilitates discussion amongst various stakeholders such as policymakers, local practitioners and scientists to establish a common understanding of the problem and the way forward with defined timelines and milestones. Additionally, Adaptive Management incorporates evaluation in the process ensuring the improvement of policy performance (Sendzimir and Schmutz, 2018). Using the Adaptive Management approach avoids a top-down form of management, ensuring that decision making is a circular process as compared to the conventional linear process of crisis-analysis-policy (Magnuszewski et al., 2005)

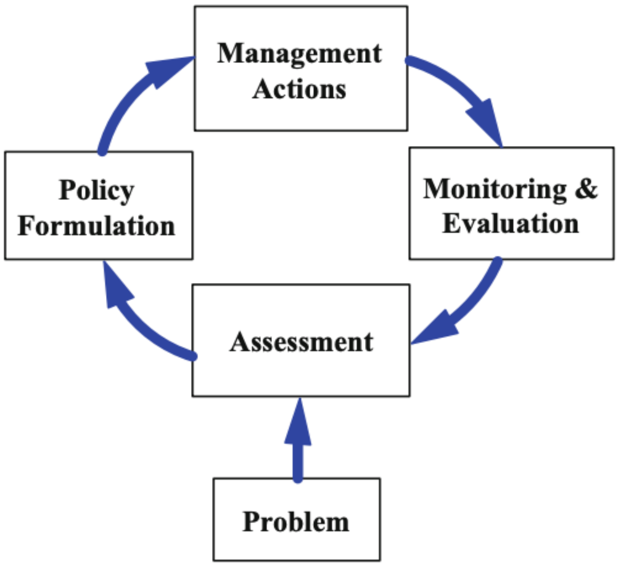

Figure 11: Adaptive management (after Magnuszewski et al. 2005)

The Adaptive Management cycle starts with the *formulation of the problem* and the subsequent *assessment phase* of the problem by stakeholders. It is important to involve stakeholders with diverse perspectives, increasing the probability of innovative solutions to problems, and also increasing stakeholder buy-in for the responses eventually adopted. The *policy formulation phase* involves the identification of objectives, strategies and policies to manage the problem, followed by the implementation of policies in the *management phase*. Further, the *monitoring and evaluation phase* assesses the impacts and consequences of the implemented policies using indicators and thresholds. The last step is crucial to ensure that lessons learned from the process are integrated and used when the system fails to achieve the set objectives. With several developments in policy and science, Adaptive Management plays a key role in enabling processes to keep up with the pace of change (Sendzimir and Schmutz, 2018).

DPSIR Framework on L&D in the SIDS

In this thesis, the framework is based on qualitative evidence collected through the literature review and analysis on the scan of scientific literature (Puig, 2019) which provided a comprehensive overview of 105 documents referring to climate-induced L&D in the SIDS and was prepared under the SINCERE project. This framework depicts the relationships between the key driving forces, pressures, state, impacts and responses concerning L&D in SIDS in the Pacific Region. The QCA on the SR1.5 yielded a number of key findings relevant to the development of this framework. In order to ensure replicability, the selection of literature was conducted using the online database Scopus, through a set of search criteria which resulted in over five hundred documents (refer Annex 1, Puig, 2019). Further selection was based on the content covered in the abstracts, in most cases, narrowing down the selection field to seventy-three documents. Through in-text citations, thirty-two additional documents were identified, resulting in one-hundred and five documents (n=105).

Migration, potential policy responses to L&D, and risk management were the most prominently discussed themes. As a contrast to the key findings yielded by the QCA of the IPCC SR1.5, most of the documents reviewed considered both economic and non-economic losses. Further, most considered both extreme and slow-onset events (refer Annex 2, Puig, 2019). Based on the most frequently used keywords, individual summaries were categorized according to nine themes: migration, policy response, risk management, human health, aid effectiveness, biodiversity loss, traditional knowledge, local beliefs and relocation (Puig, 2019).

The document provides a synthesis of key findings of one-hundred and five documents in the scientific literature which creates the basis of the framework (Figure 16 in Section 6.3). With regard to deciding whether or not a particular document was relevant, in most cases the summary of the document provided sufficient insight. However, in certain cases, the documents had to be consulted (for example, Warner and van der Geest, 2013; Betzold, 2015; Nunn, 2013; Thomas et al., 2019).

5.4. Limitations

Despite the effectiveness of qualitative research methods, the approaches used in this thesis have several limitations. First, by solely conducting text analytics, while being an effective method to analyse the entire report consisting of more than 500 pages, would not provide a full understanding of the coverage of L&D in the IPCC SR1.5. To address this limitation, a QCA was carried out prior to the text analytics, allowing for a better understanding of the text.

Text analytics is used in addition to content analysis so as to reduce biases and identify areas where additional research is required. Despite these methods being inherently subjective, content analysis introduces subjectivity at a different stage as I interpret and analyse the text according to my understanding of what is L&D. Whereas, when performing word analytics, the subjectivity comes about during the selection of words and pairings. Thus, the two methods involve subjectivity at different decision stages.

Second, the usage of numbers allows for the quantification of findings and simplification of observation. Due to the inherent subjectivity of the qualitative methods and the manifold dimensions explored in the SR1.5, it is essential to overcome the lack of transparency and replicability of the research, a concern which is often linked with most qualitative research (Bryman, 2016). In an attempt to do so, the inclusion of a schematic (Figure 9, Section 5.1) for the decision made regarding the consideration of sections as L&D has been included in the thesis, in order to shed some light on the decisions made by me.

Third, while the software helped filter through over 500 pages of the report, the results yielded were numerous and in certain cases, were not relevant to the context. Further, as additional screening of the words and their usage within the context were not possible (as I wasn't able to access the relevant software through university licenses) which could result in the inclusion of words used in the relevant context. To overcome this limitation, I extracted all cells with the word 'Glacier' and 'Habitat' from the comma-separated file and further screened them for co-occurrences of the word 'Loss' and 'Damage' in the same paragraph. The results from R and the manual screening for these terms were within the range of each other (+/- 2). While sifting through the results was time-consuming, it was essential to ensure the reliability of the results.

Lastly, while the DPSIR framework makes it easier to explore the origins and consequences of environmental problems, several researchers criticise the usability and accuracy of the framework to effectively capture real word interactions between human and natural systems (for a review, see Gari et al., 2015). Additionally, there is a risk of oversimplifying problems in its complexity. However, as a field study would not be possible within the scope of this Master's thesis, a framework based on previous research allows one to effectively explore and map key issues pertaining to L&D in the SIDS in the Pacific.

6. Results

The SR1.5 report highlights the robust differences in projected regional climate and associated impacts between current temperatures and global warming up to 1.5°C and between 1.5°C and 2°C (based on selected variables and regions). Section 6.1 provides an in-depth QCA of the report and delves into the coverage of L&D within the stressors and impacts. Further, Section 6.2 provides an analysis of the co-occurrence and correlation of impacts with ‘Loss’, ‘Damage’, ‘1.5°C’ and ‘2°C’. The resulting analysis provides another perspective on the coverage of L&D in SR1.5. Lastly, Section 6.3 explores L&D observed in the SIDS in the Pacific through the DPSIR Framework. The framework provides an overview of the dynamics between driving forces and pressures which result in the change of state of the system, further resulting in increased impacts. Additionally, the framework includes relevant responses to address each element of the framework.

6.1. Qualitative Content Analysis

Based on the categories coded using NVivo (Figure 8, Section 5.1), the results are clustered by stressors (6.1.1, 6.1. 2, 6.1.3…), and further categorized by the affected system (human or natural)[12]. Certain impact sectors are affected by multiple stressors and are covered in Section 6.1.8. Section 6.1.9. provides a succinct analysis of the findings of the SR1.5 through the lens of L&D. These results bring to the forefront, the implications of a 1.5°C warmer world as compared to a 2°C warmer world. Further, the results delve into the geographical disaggregation of impacts, as well as, the non-economic vs. economic losses.

The risk to natural and human systems is projected to be lower at 1.5°C than at 2°C of global warming; owing to the lower frequency and intensity of most stressors associated with a 1.5°C temperature increase (IPCC, 2018). The risk expected in 1.5°C warmer world is larger as compared to the risk at present-day temperatures thus, emphasizing the need for effective adaptation and mitigation measures to be adopted. However, socio-economic conditions will exacerbate impacts more than global climate change and the magnitude of these impacts are projected to be larger in some regions (Arnell et al., 2018). Restricting the increase of global warming to 1.5°C enhances the ability of systems to adapt and be resilient to change. The following section addresses the types of impacts on human and natural systems.

[12] As defined by the IPCC (2018), a human system is ‘any system in which human institutions and organisations play a key role.’ In most cases, the term is synonymous with social system.

6.1.1. Temperature Means and Extremes

Global warming of 1.5°C is projected to lead to higher mean temperature and range both on land and in oceans, as compared to present-day values. The report states that there will be an increase in frequency and duration of land and marine heatwaves; with statistically significant variations in projected temperature means and extremes between 1.5°C and 2°C of warming. With comparison to pre-industrial and present-day climate, both warming scenarios lead to large increases in hot extremes, especially in densely inhabited regions. A warming scenario of 2°C will result in the temperature means and extremes in most land regions to be 2-3 times greater than the increase in GMST projected for some regions (i.e. 4°C/6°C at 2°C GMST).

The largest variation in the number of exceptionally hot days is projected in the tropics as there is low interannual temperature variation in the region (Mahlstein et al., 2011). Further, changes in hot extremes are projected to extend and be the largest at mid-latitudes in eastern and central North America, southern and central Europe, the Mediterranean, western and central Asia and southern Africa (Vogel et al., 2017). Over the last 50 years, subtropical regions of southern Africa have seen a steady increase in temperatures at approximately twice the global rate. Additionally, in the Arctic, 2°C of warming and associated temperature means and extremes have a larger impact on the region than at 1.5°C of warming. Thus, an increase in L&D is observed when moving to a higher warming level. The report states high confidence in the attribution of observed changes in temperature means and extremes to anthropogenic forcing.

Human Systems

Health

Air Quality. With increasing temperatures, risk of morbidity and mortality associated with the exposure to particulate matter and ozone are projected to increase (dependent on emission trajectories and climate projections), with the risk being higher at 2°C than at 1.5°C (Heal et al., 2013; Tainio et al., 2013). Measures to ensure the reduction of GHG emissions will be crucial in order to lessen the health risks associated with air quality (Tainio et al., 2013).

Malnutrition. With a shift in global temperature increase (above pre-industrial levels) from 1.5°C to 2°C, climate change will aggravate health risks connected with reduced food security due to reduced yields (in most regions) and nutrient availability (Cramer et al., 2014; AR5, 2014). Springmann et al. (2016) find that temperature increases are projected to reduce the micronutrient content of major cereal crops. Zhu et al. (2018) find that elevated CO_2 levels and global warming of 2.3°C-3.3°C would result in the reduction of micronutrient and protein of 18 rice cultivars. Rice being a staple food source in Southeast Asia would result in nutritional-related health risks for 600 million people in the region alone. Further, temperature changes are projected to affect the availability of meat, fruit and vegetables which in turn will create nutrition-related health risks and have dire consequences for the nutritional security of countries.

Occupational Health. Depending on the region and nature of work, increasing temperatures will affect the productivity of workers and increase workplace-related health risks. In 2100, the projected difference in economic loss between 1.5°C and 2°C is approximately 0.3% of global GDP to prevent heat-related illnesses in the workplace through scheduled breaks (Takakura et al., 2017). It is estimated that high-temperature subsidies for employees in China will skyrocket from 38.6 billion-yuan yr^{-1} in 1979–2005 to 250 billion-yuan yr^{-1} in the 2030s (approximately 1.5°C) (Zhao et al., 2016).

Vector-borne diseases. As the relationship between the drivers of vector-borne diseases and climate is not always linear, changes in temperature result in complex patterns of change in exposure to diseases; with variation in intensity, seasonality and geographic range of the diseases dependent on the region (Ren et al., 2016). However, the shift in temperature is projected to result in the spread of the following vector-borne diseases: malaria (Ren et al., 2016), dengue, chikungunya, yellow fever, Zika virus (Fischer et al., 2011; Fischer et al., 2013), West Nile virus (Semenza et al., 2016) and Lyme disease. Furthermore, flooding associated with SLR and variability in precipitation is also found to further influence the spread of vector-borne diseases but quantification for the impact of these stressors has not been included in the SR1.5. The regions most affected are lower latitudes (tropics) with vector-borne diseases spreading to higher latitudes (i.e. Europe, North America and Canada).

Urban Areas

Matthews et al. (2017) find that urban impacts are similar at 1.5°C and 2°C. However, impacts are significantly larger compared to the present-day climate. The urban heat island effect of cities often amplifies the impacts of heatwaves. Thus, projections show that constraining global warming to below 2°C would nevertheless result in a substantial increase in deadly heatwaves as compared to present-day climate. The expansion of urban areas, increase in population density, the built environment and socio-economic conditions will further influence the vulnerability of society and the rates of morbidity and mortality (Kusaka et al., 2016).

Extreme heatwaves are projected to be widespread at 1.5°C and potentially deadly heatwaves are projected to increase with a steady rise in global warming to 2°C. Limiting warming to 1.5°C as compared to 2°C is projected to result in 420 million fewer people being exposed to extreme heatwaves (assuming constant vulnerability factors), with approximately 65 million fewer people being exposed to exceptional heatwaves[13].

According to climate projections, extreme heatwaves will emerge earliest in the tropics with West Africa and the Sahel region already experiencing changes in temperature. A study found that at 1.5°C of warming, Northern Hemisphere summer would lead to high monthly temperature, nearly doubling at 2°C of warming for 20% of the land area in low-latitude regions (Coumou and Robinson, 2013).

Tourism

Studies pertaining to projections of tourism demands are primarily limited to Europe and show a significant change in trends and patterns. Ciscar et al. (2014) project losses of up to 11% (€6 billion yr^{-1}) for southern Europe and a potential gain of €0.5 billion yr^{-1} in the UK. Further, they project that European tourism would reduce by 5% ((€15 billion yr^{-1}) based on an econometric analysis of the relationship between regional tourism demand and climate conditions.

Food Production Systems

Crop Production. For each degree Celsius increase in global warming, significant reductions have been projected for the production of wheat (by 6.0 ± 2.9%), rice (by 3.2 ± 3.7%), maize (by 7.4 ± 4.5%), and soybean, (by 3.1%) globally (Asseng et al., 2015; C. Zhao et al., 2017). Interestingly, Iizumi et al. (2017) report that higher rice production is projected at 2°C than at 1.5°C, owing to the increase in CO_2 concentration levels. Several studies conclude that the risk of crop instability and decrease in crop yields

[13]A climate modeling study conducted by Dosio et al. (2018) found that under 1.5°C of warming, approximately 13.8% of the world population would be exposed to 'severe heatwaves' at least once every 5 years, with a threefold increase (36.9%) under 2°C of warming. The projected difference would imply nearly 1.7 billion more people affected between the two global warming levels.

significantly decline when global warming is constrained to 1.5°C (Schleussner et al., 2016; Lana et al., 2017; Challinor et al., 2014). The regions projected to have the highest risks are West Africa, Southeast Asia, and Central and South America.

Livestock Production. Increase in temperature extremes is projected to impact animal feeding, growth rates (André et al., 2011) and reproduction parameters (De Rensis et al., 2015; Barati et al., 2008). Further, changes in physiological processes such as thermal distress and high respiratory rates are expected (Mortola and Frappell, 2000). Knapp et al. (2014) report the increase in methane production at elevated temperatures. As a result of heat stress, livestock mortality has been observed, resulting in economic loss (Vitali et al., 2009). In a 2°C warmer world, Boone et al. (2018) project the decline in livestock to be 7–10%, resulting in associated economic losses between $9.7 and $12.6 billion. While the increase in temperatures will result in the lengthening of the forage growing season, the quality is projected to decrease, causing nutritional deficiencies (Craine et al., 2010; Hatfield et al., 2011).

Fisheries and Aquaculture. The expansion of fisheries to mid- to high-latitudes owing to changing temperatures, increased light levels and retreating sea ice (Cheung et al., 2009), lead to an increase in production and productivity (Hollowed and Sundby, 2014). While productivity increases, the risk of invasive species and diseases poses a threat to fisheries. The risk to high-latitude fishers is projected to remain moderate, irrespective of warming level. However, fin-fish fisheries in lower latitudes face very high risk at 2°C, high risk above 0.9°C and moderate risk under present-day conditions (Cheung et al., 2016).

Natural Systems

Marine Ecosystems

Even in a 1.5°C warmer world, lower latitudes are expected to see a shift in the range of marine species and loss of coastal resources, therefore, affecting the structure and function of the ocean along with food webs (Burrows et al., 2014; Chust et al., 2014). In terms of non-mobile species such as coral reefs and kelp forests, an increase in disease outbreaks and mortality are projected with the increase in temperatures (Rivetti et al., 2014; Maynard et al., 2015; Krumhansl et al., 2016). Similarly, Diaz and Rosenberg (2008) find that changes in ocean mixing and metabolic rates have resulted in an increase of ‘dead zone’ areas due to the increase in temperature and CO_2 concentration.

Sea Ice. The impacts on sea ice are not extensively and comprehensively covered in this report as they are a part of the focus of the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate which was released in September 2019. In recent decades, summer sea ice has been rapidly retreating in the Arctic. In a 1.5°C warmer world, one sea ice-free Arctic summer is projected per century (Jahn, 2018; Screen et al., 2018). Whereas at 2°C of warming, the probability of sea ice-free Arctic summers increases to at least once per decade. However, there is no significant loss in Arctic sea ice during winter irrespective of the level of warming (Niederdrenk and Notz, 2018). Several papers conclude that a further increase of 0.5°C above present-day climate will lead to multilevel impacts, with severe implications for the Arctic Ocean and western Antarctic Peninsula (Turner et al., 2014; Steinberg et al., 2015).

The retreating of sea ice and increasing temperatures will result in the increase of primary productivity of the region owing to the mixing of the water column and photosynthetic communities present on the underside of the ice (Dalpadado et al., 2014). There is evidence that the increase in productivity is already stimulating high-latitude fisheries such as the Barents Sea (potentially short-lived benefits) (Hollowed and Sundby, 2014). Furthermore, the ramifications of changes in productivity on food webs will be significant.

Despite the positive impact on high-latitude fisheries, the loss of sea ice will result in loss of habitats for several species such as polar bears, seals, whales and sea birds (Larsen et al., 2014). Further, sea ice is central to marine ecosystems and people in the Arctic alike with the sea ice being integral to the identity, culture and livelihoods (e.g., fishing, tourism, oil and gas, and shipping) of the region (Ford, 2012; Ford et al., 2015; Meier et al., 2014).

Coral Reefs. Increased coral bleaching, coral disease development and mortality is a result of the increase in temperatures which poses the greatest risk to coral reefs (Cramer et al., 2014; Maynard et al., 2015). The loss of approximately 70-90% of coral reefs is projected at 1.5°C of warming globally (Frieler et al., 2013; Schleussner et al., 2016). Further, these values increase to the loss of 99% of coral reefs at 2°C of warming, leading to the irreversible loss of marine and coastal systems.

6.1.2. Variability in Precipitation

It is worth noting that no statistical quantification of precipitation trends at 1.5°C and 2°C of global warming were included in the text. However, the report finds literature projecting the increase in frequency and intensity of heavy precipitation when moving from 1.5°C to 2°C of warming when aggregated at a global scale (Fischer and Knutti, 2015). While projections for mean and heavy precipitation are more uncertain than temperature means and extremes, they highlight robust increases in mean precipitation in the Northern Hemisphere high latitudes and at the tropics at both 1.5°C and 2°C of global warming compared to pre-industrial conditions. The projections show that there are more areas with increases than decreases in the frequency, intensity and/or amount of heavy precipitation (IPCC, 2018).

The regions with the largest projected increases in heavy precipitation events for 1.5°C to 2°C global warming include high latitude regions such as Alaska, Eastern and Western Canada, Greenland, Iceland, Northern Europe and Northern Asia Asia); and mountainous regions such as the Tibetan Plateau, eastern Asia (including China and Japan) and eastern North America. It is important to note that several large regions are projected to show statistically significant differences in mean precipitation at 2°C compared with that at 1.5°C of global warming such as decreases in the Mediterranean area, including southern Europe, tropical Africa, the Arabian Peninsula and Egypt.

6.1.3. Drought

When comparing drought patterns between 1.5°C and 2°C of warming, an alarming increase in L&D is observed at 1.5°C compared to present-day levels and increase further at 2°C of warming. The report finds that limiting global warming to 1.5°C is expected to substantially reduce the probability of extreme drought, precipitation deficits, and risks associated with water availability in some regions. It is projected that 39% (range 36–51%) of impacts on populations exposed to drought could be globally avoided at 1.5°C compared to 2°C warming under the Shared Socioeconomic Pathway 2 (SSP) population scenario[14] (Arnell et al., 2018). A drying trend is already observed in the Mediterranean region at global warming of less than 1°C. Schleussner et al. (2016) find that Mediterranean water stress from 9% at 1.5°C is projected to increase to 17% at 2°C (compared to 1986-2005 period). The regions

[14] SSP 2 is one of the five narratives describing how socioeconomic trends will influence society. In this pathway, global population growth is moderate and levels off in the second half of the century. In this scenario, development and income growth are unevenly distributed.

projected to be prone to severe droughts at 1.5°C are Central and Southern Europe, the Mediterranean, West Africa, East and West Asia, and Southeast Asia (Liu et al., 2018). With respect to groundwater resources, Portmann et al. (2013) report that 20% of the global land surface would be affected by groundwater reduction of more than 10% at 1.5°C of warming, with the land affected increasing at 2°C. Further, they project an extreme decrease of more than 70% at 2°C of warming for 2% of the global land area (range 1.1-2.6%). With comparison to 2°C of global warming, the risk of water scarcity and stress in specific regions is projected to be approximately half at 1.5°C of global warming[15]. However, socio-economic drivers may exert a greater influence on the availability of water as compared to the variation in climate. Despite the limitation of global warming to 1.5°C, many regions of the world will be affected by water scarcity, especially, Europe, Australia and southern Africa (Gerten et al., 2013). Additionally, populations living in river basins such as the Middle East are projected to be exposed to chronic water scarcity at global warming lower than 2°C. Further, small islands in the Mediterranean, Caribbean and Pacific (recognized as SIDS) are projected to face freshwater stress as a result of projected change in aridity and limiting warming to 1.5°C could circumvent approximately 25% of freshwater stress as compared to 2°C (Karnauskas et al., 2018). Taylor et al. (2018) report that at 2°C of warming, extreme droughts are projected to be 9% longer on average than at 1.5°C in Caribbean SIDS.

Human Systems

Urban Areas

Under constant socio-economic conditions, the number of people (global mean monthly) predicted to be exposed to extreme drought at 1.5°C in 2021–2040 is projected to be 114.3 million, compared to 190.4 million at 2°C in 2041–2060 (Smirnov et al., 2016). Another study finds the difference in urban populations exposed to drought would be greater at 2°C (410.7 ± 213.5 million people) as compared to 1.5°C (350.2 ± 158.8 million people) based on SSP1 population scenario[16] (Liu et al., 2018)[17].

[15] Gerten et al. (2013) through their study determined that based on the world population in 2000, an additional 8% would be exposed to scarcity at 2°C of global warming which would be halved at 1.5°C of global warming, assuming a constant population in the models.
[16] The SSP 1 reflects on a sustainable pathway, emphasising on inclusive development to achieve the developmental goals.
[17] Liu et al. (2018) studied the changes in population exposure to severe droughts in 27 regions around the globe for 1.5°C and 2°C of warming using the SSP 1 population scenario compared to the baseline period of 1986–2005 based on the Palmer Drought Severity Index.

Food Production Systems

Livestock Production. Masike and Ulrich (2008) indicate that a reduction in water supply could lead to an increase in livestock water demand. Due to increased runoff and reduced groundwater availability, livestock populations are projected to experience water stress, especially in sub-Saharan Africa and South Asia.

6.1.4. Flood

Owing to the increase in frequency and intensity of heavy precipitation, the fraction of the global land area affected by flood hazards is projected to be larger at 2°C compared to 1.5°C of global warming with regional variation in risks. These differences are influenced by local socio-economic conditions, as well as topography and hydro-climatic conditions (Tanoue et al., 2016).

Arnell and Lloyd-Hughes (2014) found that at global warming of 1.5°C, the number of people exposed to increased flooding in 2050 could be reduced by 26–34 million as compared to the number of people exposed at 2°C of warming (under SSP 1-5). Based on SSP2 population scenario, it is projected that 39% (range 36–46%) of the impacts of river flooding on populations globally could be avoided by constraining global warming to 1.5°C as compared to 2°C (Arnell et al., 2018). Further, Kinoshita et al. (2018) found that without any adaptation, the increase of warming from 1.5°C to 2°C would lead to an increase in potential flood fatality by 5.7%. Whereas, the projected increase in economic loss (0.9%) is relatively small. Their study indicates that approximately half of the increase in potential economic losses could be mitigated by adaptation. With respect to the impact simulated over the baseline period 1976–2005, flood risk will increase by 580% on average at 4°C for countries representing 73% of the world population (Alfieri et al., 2017). If temperatures are constrained to 1.5°C, the risk is projected to be reduced to a 100% increase and to a 170% increase at 2°C.

Alfieri et al. (2017) report that the largest increases in flood risks would be found in the US, Asia, and Europe, while decreases would be found in only a few countries in eastern Europe and Africa. In Europe, projections show an increase in flood impacts with higher warming levels, from 116% at 1.5°C to 137% at 2°C resulting in €5 billion of losses annually (Alfieri et al., 2018)[18]. Further, 86% of the population in Europe would be affected at 1.5°C of warming as compared to 93% at 2°C[19].

Arnell et al. (2016) concluded that risks are projected to be highest in South and Southeast Asia, assuming there is no upgrade to current protection levels, for all levels of climate warming. Additionally, coastal regions may experience increased flooding as increases in heavy precipitation associated with tropical cyclones combined with increased sea levels may exacerbate flooding issues.

6.1.5. Cyclone

Presently, studies addressing the trends in the occurrence of very intense tropical cyclones (Category 4 and 5) have yielded contradicting results. As there are a limited number of studies, that explore the difference in tropical cyclone statistics 1.5°C versus 2°C, there is not enough evidence to draw conclusions regarding the same. The report finds that the global number of tropical cyclones will be lower under 2°C compared to 1.5°C of global warming, but with an increase in the number of very intense cyclones (Wehner et al., 2018).

6.1.6. Sea Level Rise (SLR)

By 2100, the difference in global mean SLR between the two warming scenarios is projected to be approximately 0.1 m (0.04 – 0.16 m). The SR1.5 references several papers addressing the projections for SLR at 1.5°C and 2°C of warming, which highlight the overlapping uncertainty[20] in the findings (Goodwin et al., 2018; Nicholls et al., 2018; Rasmussen et al., 2018). The report concludes that the projections cover the ranges 0.2-0.8 m and 0.3-1.00 m relative to 1986-2005 for 1.5°C and 2°C of warming, respectively.

Human Systems

Urban Areas

The risks for coastal metropolises are expected to be lower at 1.5°C than 2°C, however, there are difficulties in recording the impacts of SLR as there are multiple drivers of change to take into consideration (Schleussner et al., 2016). Unless further adaptation measures are taken, 136 megacities (port cities with a population >1 million in 2005) are projected to face risks from flooding associated with SLR with projected magnitudes of

[18] For the baseline period (1976–2005)
[19] Based on three case studies in European states (central and western Europe)
[20] Difference in time horizons for exposure and impacts at 1.5°C and 2°C of warming

rise at both, 1.5°C and 2°C of warming in the 21st century (Hanson et al., 2011; Hallengatte et al., 2013). Hinkel et al. (2014) report that without adaptation, flooding will annually affect 0.2-4.6% of the population worldwide in 2100 under 25-123cm of global mean SLR. Further, flooding will result in an estimated annual loss of 0.3-9.3% of global GDP. Of the 136 cities projected to be affected, many are located in South and Southeast Asia making the region with the highest risks, assuming no further changes in protection levels (Arnell et al., 2016).

In their study, Alfieri et al. (2017) report that countries representing 73% of the world population will experience increasing flood risk, with an average increase of 580% at 4°C compared to the impact simulated over the baseline period 1976–2005 (assuming constant population sizes). This impact is projected to be reduced to a 100% increase at 1.5°C and a 170% increase at 2°C. Another study finds that 62.7 million people per year are at risk from flooding at a 1.5°C stabilization scenario in 2100, with this value increasing to 137.6 million people per year in 2300 (average across SSP1–5). These projections assume that no upgrade to current protection levels occurs and no socio-economic change takes place after 2100 (Nicholls et al., 2018). At a 2°C stabilization scenario the number of people at risk increases by approximately 18% in 2030 and by 266% in 2300 if an RCP8.5 scenario is considered (Nicholls et al., 2018).

Assuming no protection from SLR and associated impacts, 128-143 million people will be affected when 1.5°C is first reached as compared to 141-151 million people when 2°C is first reached (Brown et al., 2018; Goodwin et al., 2018). In 2100, 31–69 million people globally at 1.5°C are projected to be exposed to flooding owing to SLR, as compared with 32–79 million people globally at 2°C, assuming no adaptation or protection at all (2010 population values) (Rasmussen et al., 2018).

SIDS are already experiencing impacts associated with climate change and compounding impacts from interactions between climate drivers may increase the exposure to SLR. At 1.5°C of global warming, approximately 60,000 fewer people will be exposed to SLR in SIDS as compared to 2°C of global warming by 2150 (Rasmussen et al., 2018).

Tourism

Scott and Verkoeyen (2017) find that in 19 Caribbean countries, 1m SLR could result in the partial or complete inundation of 29% of 900 coastal resorts with 49%-60% vulnerable to coastal erosion. In terms of cultural heritage, an analysis of SLR risk to 720

UNESCO Cultural World Heritage sites found that under 1°C of warming, 47 sites might be affected with the number increasing to 110 and 136 sites under 2°C and 3°C, respectively (Marzeion and Levermann, 2014).

Food Production Systems

Fisheries and Aquaculture. SLR poses a risk to coastal infrastructure and hatcheries (Weatherdon et al., 2016) along with the increasing incidence of alien species (Kittinger et al., 2013) and invasion of parasites and pathogens (Asplund et al., 2014). In combination with non-climatic stressors, McClanahan et al. (2009) project a decline in harvesting levels of small-scale fisheries (McClanahan et al., 2015; Cheung et al., 2010). Thus, based on global population growth and the future warming scenarios, a shortage of fish protein will be evident in many regions, specifically in the Pacific Ocean (Bell et al., 2013b) and the Indian Ocean (McClanahan et al., 2015).

6.1.7. Ocean Acidification and Deoxygenation

The impacts on oceans, their associated ecosystem services and biodiversity are projected to increase when shifting from 1.5°C to 2°C of global warming (Burrows et al., 2014; Cheung et al., 2009; Pereira et al., 2010). Ocean acidification, deoxygenation and loss of marine habitats and species are projected to be reduced if temperatures are constrained to 1.5°C of warming. Due to an increase in CO_2 concentrations, ocean acidification will amplify the effects of global warming in turn affecting ocean productivity and the physiology of marine species. By 2100, reaching 1.7°C warming will result in a decrease of 0.2 pH units thus displaying an inverse correlation between the two factors (relative to the pre-industrial period, under RCP 4.5 scenario) (Gattuso et al., 2015; Bopp et al., 2013). The resulting change in ocean chemistry puts organisms with shells and skeletons (of calcium carbonate) at risk due to decalcification (Gattuso et al., 2015; Dove et al., 2013).

Marine Ecosystems

Coral Reefs. Ocean acidification has severe implications for coral communities as the change in the chemistry of water affects the calcification of skeletons, slows growth and recovery of coral communities (Gardner et al., 2005; Dove et al., 2013; Kennedy et al., 2013; Webster et al., 2013).

6.1.8. Multi-stressor impacts

The following section covers the impact of multiple stressors (more than three stressors) on various human and natural systems.

Human Systems

Urban Areas

After the analysis of the report, it is clear that urban areas will face increasing risk at 1.5°C as compared to present-day temperatures from several stressors such as flooding, heatwaves, drought and extreme weather events depending on the geographical location. There is limited literature on the difference between risks at warming of 1.5°C and 2°C in urban areas due to the difficulty in recording the potential compounding impacts of stressors and their interactions. However, the latest research indicates that a 2°C warmer world would pose greater risks to urban areas as compared to 1.5°C of warming. It is important to note that while the warming scenario plays a major role in defining the extent of the impact, human vulnerability and the effectiveness of local adaptation measures are equally important. Urban areas are directly affected by temperature extremes (Dosio et al., 2018), variability in precipitation (Liu et al., 2018) and sea level rise (Nicholls et al., 2018). Further risks may arise due to the compounding nature of stressors and the interaction between human and natural systems.

Human Health

Upon analysis of the report, it is apparent that any increase in global temperatures from present climate is projected to have adverse impacts on human health. The impacts on human health are manifold and manifest as heat-related morbidity and mortality, vector-borne diseases, malnutrition, respiratory diseases and ozone-related morbidity. The increased exposure and vulnerability to climate-related stressors not only hamper the capacity of health systems to manage the impacts but affect livelihoods and productivity of society, hence, affecting economic growth (Hales et al., 2014). Increase in frequency and intensity of extreme weather events, SLR and changing temperatures pose a risk to health with projections for population and geographic distribution increasing at 2°C than at 1.5°C (IPPC, 2018). Restraining global warming to 1.5°C will reduce the projected health risk in certain regions such as the Sahel, the Amazon, western and southern Africa, the Mediterranean and central Europe (Lehner et al., 2017; Betts et al., 2018).

Tourism

Despite limited research on the variation and quantification of risks to global tourism at 1.5°C and 2°C of warming, impacts associated with climate change have already been observed. In comparison to present climate, ski tourism and coastal tourism (in the tropics and subtropics) are projected to face higher risk at 1.5°C of warming. Not only are environmental assets (such as coral reefs, beaches, ski slopes, glaciers and biodiversity) critical for tourism affected, climate change impacts tourism infrastructure, tourist demands patterns (leading to the development of 'last chance to see' tourism markets), sector investments, operational and transportation costs (Scott and Gössling, 2018). Further, these impacts have rippling effects on socioeconomic conditions as certain regions are heavily dependent on tourism for revenue generation particularly in the SIDS (Weatherdon et al., 2016). However, due to the lack of integrated sectoral assessments, it is hard to analyse the full range of compounding impacts and their interactions with relation to tourism (Rosselló-Nadal, 2014). The projected risks are for Africa, the Middle East, South Asia and SIDS in the Caribbean, Indian and Pacific Oceans (Scott and Gössling, 2018) [21]. Tourism represents more than 15% of the GDP in countries within these regions and climate change poses a potential barrier to further development.

Energy Production

With projections for the increase in the number of hot days and nights, climate change could lead to an increased demand for cooling in tropical and subtropical regions (Arent et al., 2014). Additionally, rising temperatures will challenge the efficiency of power generation technologies and affect the GDP of a country. Byers et al. (2018) report that impacts on energy systems will be higher at 2°C of global warming as there is an increased hydro-climatic risk to thermal and hydropower plants especially in Europe, North America, southeast Brazil, South and Southeast Asia.

Due to a decrease in cold spells, heating demands in Europe are projected to decrease (Jacob et al., 2018). Additionally, reduced summer river flows and higher water temperatures are projected to reduce the capacity of thermoelectric power plants to use water for cooling by 5% and 10% for 1.5°C and 2°C of warming respectively for most European countries (Tobin et al., 2018). Interestingly, gross hydropower potential is projected to increase globally by 2.4% under RCP2.6 scenario and by 6.3% under RCP8.5

[21] A global vulnerability index with 27 indications applied to 181 countries

for 2080. Van Vliet et al. (2016) report that Central Africa, Asia, India and higher latitudes in the north are expected to see the most growth.

Infrastructure

There is limited quantitative research on the impacts on climate change on infrastructure, however, a multiplicity of climatic stressors are found to affect infrastructure and are projected to increase with a shift in warming from 1.5°C to 2°C. In particular, SLR (Monioudi et al., 2018; McGranahan et al., 2007); extreme weather events (Hallengatte et al., 2013); and increase in temperatures (Arent et al., 2014) will directly or indirectly impact infrastructure. An increase in temperatures leads to an increase in the number of ice-free days resulting in longer shipping seasons in cold regions having a positive impact on economic growth (Melia et al., 2016). Yumashev et al. (2017) conclude that an increase in shipping resulting pollutants will lead to a 0.005% increase in mean temperature which in turn creates a positive feedback loop[22].

Food Production Systems

Climate change exerts pressure on the food production sector through numerous stressors and their cascading effects such as temperature extremes; drought; flooding, erosion and salinization associated with SLR; oceanic warming; and cyclones. These stressors, in turn, affect crop yields and nutritional content, livestock, fisheries, aquaculture and land use patterns. Food production systems include crop production, livestock production and fisheries. The report concludes that global warming to 2°C would result in larger reductions in projected food availability especially in the Sahel, southern Africa, the Mediterranean, central Europe, and the Amazon, as compared to 1.5°C of warming. However, Rosenzweig et al. (2018) report that CO_2 concentrations associated with a 2°C warmer world would potentially benefit food production and fisheries in higher latitudes. Despite the positive effect projected in higher latitudes, the negative impacts in other regions will outweigh the gain.

Crop Production. At present-day climate, the impacts of climate change are evident across the globe, affecting local crop suitability. The report concludes that a 2°C warmer world would result in a greater reduction of crop yields and crop nutrient content globally as compared to 1.5°C of global warming; attributed to the direct effects of increasing CO_2 concentration level, extreme weather events (Lesk et al., 2016; Betts et al., 2018),

[22] In the North Sea Route

changing temperatures (Schlenker and Roberts; Betts et al., 2018) and variability in precipitation (Rosenzweig et al., 2018), and the indirect effects of the spread of pest and diseases (van Bruggen et al., 2015).

Livestock Production. There are limited studies regarding the impacts of climate change on livestock production. A majority of studies conclude that climate change will have direct effects on the quality and quantity of livestock production (Notenbaert et al., 2017), as well as indirect effects such as the decrease in feed quality and the spread of diseases and pests (Kipling et al., 2016).

Fisheries and Aquaculture. Fisheries and aquaculture play a crucial role in food security and meeting protein demand globally. An increase in temperature and ocean acidification pose a grave threat to fisheries and aquaculture as they have effects on the physiology, habitat, reproduction, disease incidence and survivorship of species (Lacoue-Labarthe et al., 2016; Clements and Chopin, 2017). Interestingly, several studies project the short-term benefits of climate change in high-latitude fisheries due to the retreat of sea ice, increase in water temperatures and the increase in primary productivity (Cheung et al., 2010; Hollowed and Sundby, 2014; Lam et al., 2016). Cheung et al. (2016) find that the potential catch for marine fisheries globally will decrease by more than three million metric tonnes for each degree of warming[23].

The impacts on the food production sector are projected to have severe implications for poverty eradication and sustainable development, thus hindering the ability of society to meet the SDGs (IPCC, 2018).

Natural Systems

Freshwater Ecosystems

Settele et al. (2014) state that freshwater ecosystems are among the most threatened ecosystems on the planet. With comparison to present-day climate, freshwater resources in the Pacific SIDS are projected to be affected by SLR at 1.5°C of warming (0.40m).

Marine Ecosystems

[23] In their study, Cheung et al. (2016) simulated the loss in fishery productivity at 1.5°C, 2°C and 3.5°C above the pre-industrial period.

Oceans play a key role in regulating global temperature and atmospheric gas concentration. In recent decades, increases in ocean temperatures (up to 700 m) and ocean acidification have been observed. The cascading effects of these changes have manifested in several ways such as SLR, marine heatwaves, deoxygenation, recession of summer sea ice in Polar regions and intensification of storms (Levin and Le Bris, 2015; Boyd, 2015).

Coral Reefs. Several studies conclude that a 2°C warmer world would result in the loss of most coral reefs (Donner et al., 2005; Hoegh-Guldberg et al., 2014; Hoegh-Guldberg, 2014; Schleussner et al., 2016). The impacts of warming in combination with ocean acidification will pose a very high risk to coral reefs at 1.2°C of warming with variability across regions (Alvarez-Filip et al., 2009). Coral reefs play a key role in providing a range of ecosystem services (food, livelihoods, cultural services) and habitat for species (Burke et al., 2017). The loss projected at 1.5°C of warming (70-90%) would lead to an increase in poverty in communities dependent on marine resources (Spalding et al., 2014).

Terrestrial Ecosystems

With comparison to 2°C, limiting global warming to 1.5°C holds numerous benefits for terrestrial ecosystems and associated services. At higher levels of warming, several studies conclude that species range loss (Settele et al., 2014), biome transformations (Warszawski et al., 2013), changes in phenology (Roberts et al., 2015) and extinction risks will be widespread. The resulting effects will have dire consequences for ecosystem services and society as we know it.

Biome Transformation. Warszawski et al. (2013) in their study found that in a 2°C warmer world, 13% (range 8–20%) of biomes will transform. Whereas at 1.5°C, approximately 6.5% will transform and at 1°C of warming, only 4% (range 2–7%) will do so[24]. Further, biome shifts in Tibet, Himalayas, southern Africa and Australia would be avoided by limiting warming to 1.5°C (Gerten et al., 2013). The regions to be most affected are predominantly ranging from the tundra region to tropical rainforests (Seddon et al., 2016).

Change in phenology. Warming of 2.1°C–2.7°C above pre-industrial levels could increase the potential risk of phenological mismatch and associated risks for ecosystem functionality (Thackeray et al., 2016). Roberts et al. (2015) project temperate forest

[24] Based on an ensemble of seven Dynamic Vegetation Models driven by projected climates from 19 alternative general circulation models (Warszawski et al., 2013).

phenology to advance by 14.3 days in the period 2010–2039 and 24.6 days in 2040–2069. An estimate of the difference between the two levels of warming is approximately 10 days.

Species range loss. In response to global warming, many species both terrestrial and freshwater have moved approximately 17 km poleward and 11 m up in altitude per decade (Settele et al., 2014; IPCC, 2014). Warren et al. (2018) in their study projected that at 2°C, 18% (6–35%) of insect species, 8% (4–16%) of vertebrate species and 16% (9–28%) of plant species studied would lose >50% of their bioclimatic range[25]. Whereas at 1.5°C, the projected values reduce to 6% (1¬18%) of insect species, 4% (2–9%) of vertebrate species and 8% (4–15%) of the plant species studied. Thus, the projections for the number of vertebrate and plant species to lose over half of their geographic range is reduced by half at 1.5°C of warming as compared to 2°C (Warren et al., 2018). Similarly, the number of insect species is reduced by two-thirds. Despite limiting warming to 1.5°C, species on average will lose 20-27% of their range. Additionally, Smith et al. (2018) estimate that at 1.5°C of warming, 5.5–14% more of the globe's terrestrial land area could act as climatic refugia for plants as compared to 2°C.

Ecosystem vulnerability. Jacob et al. (2018) report that at 2°C of warming, ecosystem vulnerability would increase by 40-50% as compared to the vulnerability at 1.5°C. The risk of fires increases from 37.8% of the global land area at 1.2°C (2010-2039) to 61.9% at 3.5°C (2070–2099) (Moritz et al., 2012).

Degradation of permafrost. Chadburn et al. (2017) predict that under 1.5°C of warming the projected thawing of permafrost is 17-44% as compared to 28-53% under 2°C of warming. They project that the thawing of approximately 1.5 to 2.5 million km^2 of permafrost could be avoided by constraining warming to 1.5°C as compared to 2°C. The thawing of permafrost will potentially result in the decomposition of a large carbon source and subsequent release of carbon dioxide and methane into the atmosphere (Dolman et al., 2010). The Fynbos biome in South Africa is predicted to face an increasing risk of fires owing to increasing temperatures. Engelbrecht and Engelbrecht (2016) project that with respect to 1961-1990, the biome will lose approximately 20%, 45% and 80% of its current suitable climate area under 1°C, 2°C and 3°C of global warming, respectively.

[25] Warren et al. (2018) studied the change in range for 105, 501 species (19,848 insect species, 12,429 vertebrate species, 73,224 plant species) by 2100 for warming levels of 1.5°C and 2°C.

The biomass of tropical rainforests in Central America are projected to reduce by approximately 40% and 20% at 3°C and 1.5°C of warming by 2050, respectively (Lyra et al., 2017). Further, they find that much of the rainforest will be replaced by savanna and grassland.

Wetland Ecosystems

Salinization of coastal wetlands has severe implications for the structure and ecological functions of wetlands. In combination with rising` temperatures, Settele et al. (2014) study the projected shift in freshwater species distributions and the reduction of water quality. Coastal wetlands comprising of mangroves, seagrasses and salt marshes are affected by extreme weather events and SLR alike (Di Nitto et al., 2014; Ellison, 2014). They are further put under pressure by anthropogenic activity. It is estimated that nearly 1% of wetlands are lost per annum across a number of countries (Blankespoor et al., 2014; Alongi, 2015). The report concludes that the response of wetlands to the changing climate is unclear, but the ecosystem would benefit from the constraint of global warming to 1.5°C versus 2°C (IPCC, 2018).

6.1.9. The IPCC report through the lens of loss and damage

Table 1 below summarises the findings of the IPCC report from the point of view of L&D. The necessary information is only available for certain impacts, which means that the table is not a reflection of all the loss-and-damage-relevant information included in the IPCC report.

Table 1: L&D findings in the SR1.5

Impacts	Losses	Damages
Urban Areas	Compared to **2°C of warming**, a **1.5°C world** is better as: • Without any adaptation, the increase of warming from **1.5°C** to **2°C** would lead to an increase in potential flood fatality by 5.7%, globally. • With respect to groundwater resources, 20% of the global land surface would be affected by groundwater	Compared to **1.5°C** and **2°C of warming**, **present-day climate** is better as 136 megacities (port cities with a population >1 million in 2005) are projected to face risks from flooding associated with SLR with projected magnitudes of rise at both, **1.5°C** and **2°C of warming**. Compared to **2°C of warming**, a **1.5°C world** is better as:

	reduction of more than 10% at **1.5°C of warming**, with the land affected increasing at **2°C**. Further, an extreme decrease of more than 70% at **2°C of warming** for 2% of the global land area (range 1.1-2.6%) is projected.	• In terms of heatwaves, 420 million fewer people will be exposed to extreme heatwaves (assuming constant vulnerability factors), and approximately 65 million fewer people will be exposed to exceptional heatwaves. • The number of people (global mean monthly) predicted to be exposed to extreme drought at **1.5°C** in 2021–2040 is projected to be 114.3 million, compared to 190.4 million at **2°C** in 2041–2060 (under constant socio-economic conditions). Another study finds the difference in urban populations exposed to drought would be greater at **2°C** (410.7 ± 213.5 million people) as compared to **1.5°C** (350.2 ± 158.8 million people) based on SSP1 population scenario. • It is projected that 39% (range 36–51%) of impacts on populations exposed to drought could be globally avoided at **1.5°C** compared to **2°C** warming under the SSP2 population scenario • Assuming no protection from SLR and associated impacts, 128-143 million people will be affected when **1.5°C** is first reached as compared to 141-151 million people when **2°C** is first reached. • In Europe, 86% of the population would be affected at **1.5°C** as compared to 93% at 2°C. • At **1.5°C**, approximately 60,000 fewer people will be exposed to SLR in SIDS as compared to **2°C** by 2150. **<u>Economic Loss</u>** • Without further adaptation, flooding will result in an estimated annual loss of 0.3-9.3% of global GDP (under 25-123cm of global mean SLR in 2100).

		• Projections show changes in flood impacts in Europe to rise with warming levels, resulting in €5 billion of losses annually. • Without any adaptation, the increase of warming from **1.5°C** to **2°C** would lead to an increase in potential economic loss by 0.9% due to flooding **<u>Stressors</u>** • Without further adaptation, flooding will annually affect 0.2-4.6% of the population worldwide in 2100 under 25-123cm of global mean SLR. • In Europe, projections show an increase in flood impacts with higher warming levels, from 116% at **1.5°C** to 137% at **2°C**. • Limiting warming to **1.5°C** could circumvent approximately 25% of freshwater stress as compared to **2°C** in SIDS. • Mediterranean water stress is projected to increase from 9% at **1.5°C** to 17% at **2°C** (compared to 1986-2005 period). • At **2°C**, extreme droughts are projected to be 9% longer on average than at **1.5°C** in Caribbean SIDS.
People Affected		• Without further adaptation, flooding will annually affect 0.2-4.6% of the population worldwide in 2100 under 25-123cm of global mean SLR. • Countries representing 73% of the world population will experience increasing flood risk, with an average increase of 580% at **4°C** compared to the impact simulated over the baseline period 1976–2005. This impact is projected to be reduced to a 100% increase at **1.5°C** and a 170% increase **at 2°C**.

		• 62.7 million people per year are at risk from flooding at a **1.5°C** stabilization scenario in 2100, with this value increasing to 137.6 million people per year in 2300 (average across SSP1–5). At a **2°C** stabilization scenario the number of people at risk increases by approximately 18% in 2030 and by 266% in 2300 if an RCP8.5 scenario is considered • At **global warming of 1.5°C**, the number of people exposed to increased flooding in 2050 could be reduced by 26–34 million as compared to the number of people exposed at **2°C of warming** (under SSP 1-5). • Based on SSP2 population scenario, it is projected that 39% (range 36–46%) of the impacts of river flooding on populations globally could be avoided by constraining **global warming to 1.5°C** as compared to **2°C**. • In 2100, 31–69 million people globally at **1.5°C** are projected to be exposed to flooding owing to SLR, as compared with 32–79 million people globally at **2°C**, assuming no adaptation or protection at all (2010 population values).
Human Health	In comparison with **2°C of warming**, a **1.5°C warmer would** reduce the risk for human health as the risk of morbidity and mortality associated with the exposure to particulate matter and ozone are projected to increase with temperatures (dependent on emission trajectories and climate projections).	A **1.5°C warmer world** is better in comparison to a **2°C warmer world** as the economic loss between **1.5°C** and **2°C** is approximately 0.3% of global GDP to prevent heat-related illnesses in the workplace through scheduled breaks in 2100. With comparison to **present-day climate**, **1.5°C of warming** is projected to result in the variation of intensity, seasonality and geographic range of the diseases dependent on the region the

	Further, decline in food quality and production could result in nutritional-related health risks. For example, over 600 million people in Asia could be at high risk due to the reduction of micronutrient and protein in rice at higher temperatures.	spread of the following vector-borne diseases: malaria, dengue, chikungunya, yellow fever, Zika virus, West Nile virus and Lyme disease. Furthermore, flooding associated with SLR and variability in precipitation is also found to further influence the spread of vector-borne diseases.
Energy Production		With comparison to **2°C of warming**, a **1.5°C warmer world** as the capacity of thermoelectric power plants to use water for cooling will reduce by 5% and 10% for **1.5°C** and **2°C of warming** respectively for most European countries owing to reduced summer river flows and higher water temperatures.
Food Production Systems	Compared to **2°C of warming**, a **1.5°C world** is better as several studies conclude that the risk of crop instability and decrease in crop yields significantly decline when global warming is constrained to **1.5°C.**	Compared to **2°C of warming**, a **1.5°C world** is better as: • In a **2°C warmer world**, the decline in livestock is estimated to be 7–10%, resulting in associated economic losses between \$9.7 and \$12.6 billion. • Fin-fish fisheries in lower latitudes face very high risk at **2°C**, high risk above **0.9°C** and moderate risk under **present-day conditions.**
Tourism	Limiting warming to **1°C** would be better in comparison to higher warming temperatures in terms of cultural heritage. An analysis of SLR risk to 720 UNESCO Cultural World Heritage sites found that under **1°C of warming**, 47 sites might be affected with the number increasing to 110 and 136 sites under **2°C** and **3°C**, respectively. An eventual 1m SLR could result in the partial or complete	A **1.5°C warmer world** is better as at **2°C of warming**, the projected losses are up to 11% (€6 billion yr^{-1}) for southern Europe. Further, European tourism would reduce by 5% ((€15 billion yr^{-1}). However, in comparison to present-day climate, **1.5°C of warming** would put coastal and ski tourism at a higher risk.

	inundation of 29% of 900 coastal resorts with 49%-60% vulnerable to coastal erosion in 19 Caribbean countries.	
Marine Ecosystems	Compared to **present-day temperatures**, a **1.5°C warmer world** poses higher risks to marine ecosystems owing to an increase in temperatures, non-mobile species such as coral reefs and kelp forests, an increase in disease outbreaks and mortality are projected with the increase in temperatures. Additionally, changes in ocean mixing and metabolic rates have resulted in an increase of 'dead zone' areas due to the increase in temperature and CO_2 concentration. The loss of approximately 70-90% of coral reefs is projected at **1.5°C of warming** globally. Further, these values increase to the loss of 99% of coral reefs at **2°C of warming**. In a **1.5°C warmer world**, one sea ice-free Arctic summer is projected per century. Whereas at **2°C of warming**, the probability of sea ice-free Arctic summers increases to at least once per decade.	
Terrestrial Ecosystems	With comparison to **2°C**, limiting global warming to **1.5°C** holds numerous benefits for terrestrial ecosystems and associated services: • At **2°C**, 18% (6–35%) of insect species, 8% (4–16%) of vertebrate species and	• In a **2°C warmer world**, 13% (range 8–20%) of biomes will transform. Whereas at **1.5°C**, approximately 6.5% will transform and at **1°C of warming**, only 4% (range 2–7%). • At **2°C of warming**, ecosystem vulnerability would increase by 40-

	16% (9–28%) of plant species studied would lose >50% of their bioclimatic range. Whereas at **1.5°C**, the projected values reduce to 6% (1¬18%) of insect species, 4% (2–9%) of vertebrate species and 8% (4–15%) of the plant species studied. • Under **1.5°C of warming** the projected thawing of permafrost is 17-44% as compared to 28-53% under **2°C of warming**. They project that the thawing of approximately 1.5 to 2.5 million km^2 of permafrost could be avoided by constraining warming to **1.5°C** as compared to **2°C**. In terms of risk of fires: • Constraining warming to **1.2°C** would reduce risk to 37.8% of the global land area (2010-2039) as compared to 61.9% at **3.5°C** (2070–2099). With respect to 1961-1990, the Fynbos biome will lose approximately 20%, 45% and 80% of its current suitable climate area under **1°C**, **2°C** and **3°C of global warming**, respectively. Additionally, the biomass of tropical rainforests in Central America are projected to reduce by approximately 40% and 20% at **3°C** and **1.5°C** of warming by 2050, respectively.	50% as compared to the vulnerability at **1.5°C**.

6.2. Text Analytics

The text analytics component of the work was conducted using R[26]. The objective was to identify, by paragraph, the co-occurrence and correlation of terms relevant to impacts with 'Loss' and 'Damage' and, separately, with '1.5°C' and '2°C'. As mentioned in the Methods (Section 4.2), the terms listed in Table A.1 (Appendix A) are based on the key findings gleaned from QCA (Section 6.1). Figure 12 and Figure 14 show the co-occurrence of the keywords across impacts in the SR1.5 and highlights the increased coverage of (i) 'Loss' as compared to 'Damage' and (ii) '1.5°C' compared to '2°C'.

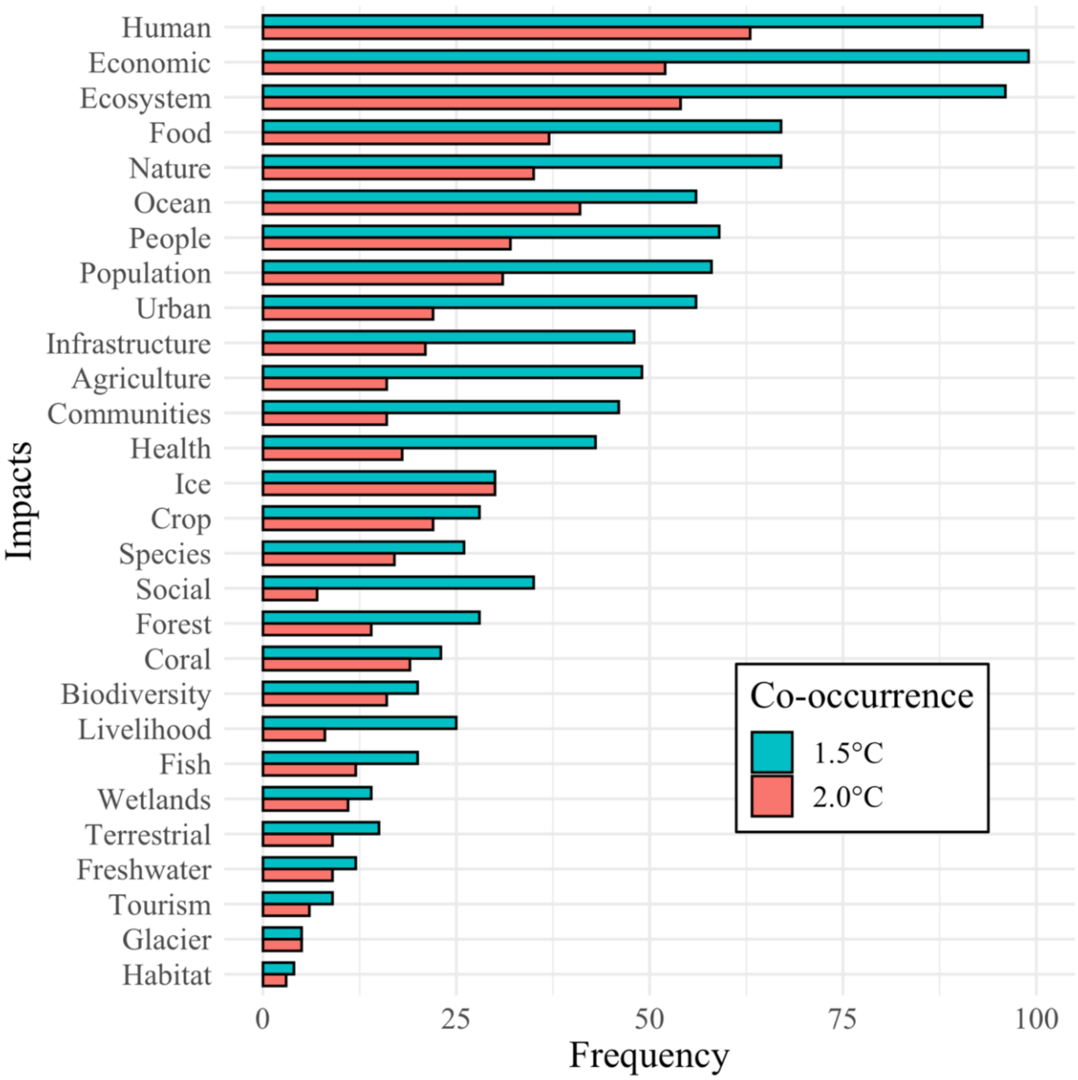

Figure 12: Co-occurrence of Impacts with 1.5°C and 2°C of global warming

[26] R is a programming language and free software environment used for statistical computing. The R language is widely used for data mining, among other applications.

For each of the various impacts considered, Figure 12 shows a relatively even distribution of occurrences of '1.5°C' and '2°C' in the SR1.5, with the three highest co-occurring terms being human, economic and ecosystem. In most instances, the co-occurrence of '1.5°C' is higher than '2°C'. This is due to the fact that '1.5°C' occurs more often than '2°C' (see Table A.1, Appendix A). The general patterns of occurrence of '1.5°C' and '2°C' appear similar. In fact, the two terms are significantly correlated (Corr. = .52, $p < .01$). However, the absolute co-occurrence does not account for the relative frequencies of impacts and warming levels. For example, 'Economic' appears more often in the text as compared to 'Glacier' which biases the comparison. Therefore, to allow for a better comparison across impacts and between warming levels, Figure 13 depicts the correlation between the impacts and the temperature levels based on the Phi coefficient.

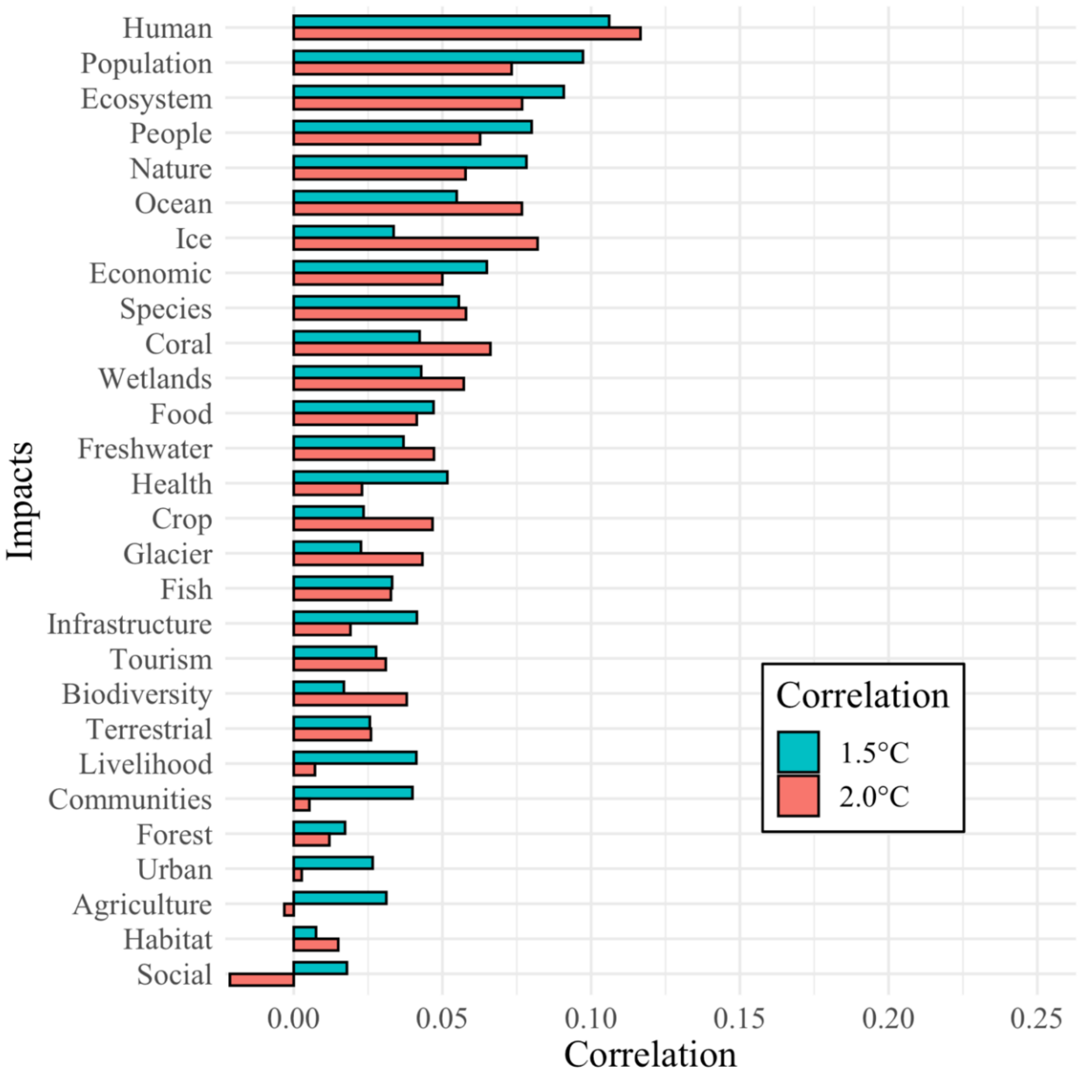

Figure 13: Correlation graph for Impacts with 1.5°C and 2°C of global warming

Figure 13 shows that the correlation between warming levels and impacts, which accounts for the difference of the absolute occurrence of '1.5°C' and '2°C', to be more similar between the warming levels, as compared to the co-occurrence (Figure 12). Furthermore, accounting for the absolute occurrences of the impacts changes the order of association between impacts and warming levels. For example, in Figure 12 'Economic' has a higher association with the warming levels relative to the other impacts as compared to in Figure 13. Furthermore, the analysis reveals that several correlations between the impacts and the warming levels are statistically not significant on a 5%-level. In fact, the correlation between both warming levels and 'Forest', 'Habitat' and 'Social' are statistically not distinguishable from zero. Moreover, '1.5°C' does not correlate with 'Biodiversity', whereas '2°C' does not correlate with 'Infrastructure', 'Livelihood', 'Communities', 'Urban', and 'Agriculture'. Aside from these cases, all terms have not only a substantive but also a significant relation with the warming levels (each, $p < .05$).

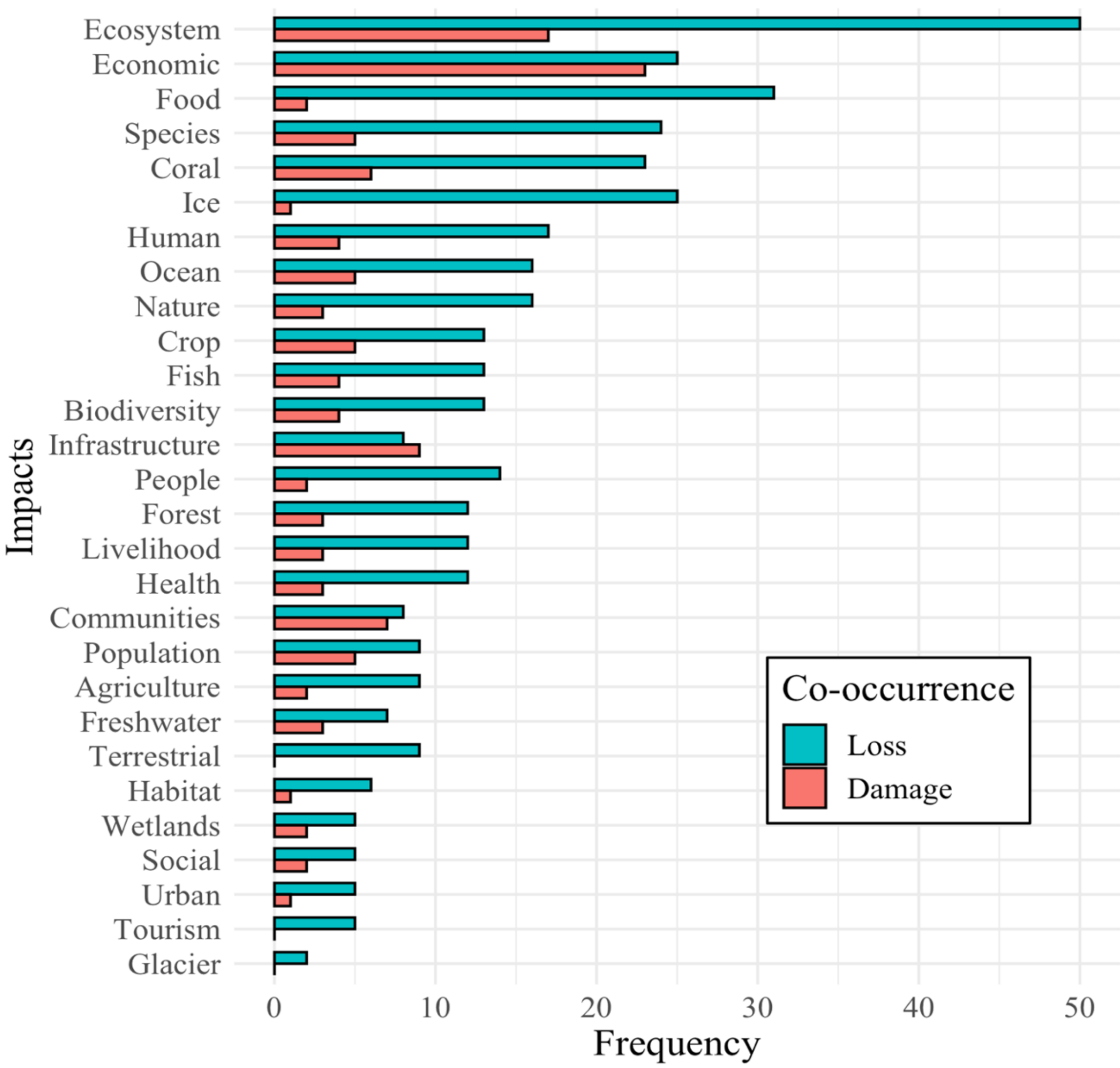

Figure 14: Co-occurrence graph for Impacts with Loss and Damage

Similar to the previous analysis, Figure 14 and Figure 15 show the co-occurrence and correlation between 'Loss' and 'Damage' and impacts. The results suggest the higher coverage of 'Loss' as compared to 'Damage' in the SR1.5, with the three highest co-occurring terms being 'Ecosystem', 'Economic' and 'Food'.

It is important to note that 'Loss' and 'Damage' occur less often in the text as compared to '1.5°C'and '2°C'. However, the correlation between the impacts with 'Loss' and 'Damage' is stronger as compared to the correlation of impacts with the warming levels in the majority of cases. The correlation between 'Loss' and 'Damage' is significant (Corr. = .28, $p < .01$), this implies that the terms occur together frequently in the text. When looking at 'Loss', all impacts except 'Urban' show statistical significance. Whereas, a series of impacts[27] do not show statistical significance with 'Damage', thus implying that damage has lower coverage with impacts in the SR1.5.

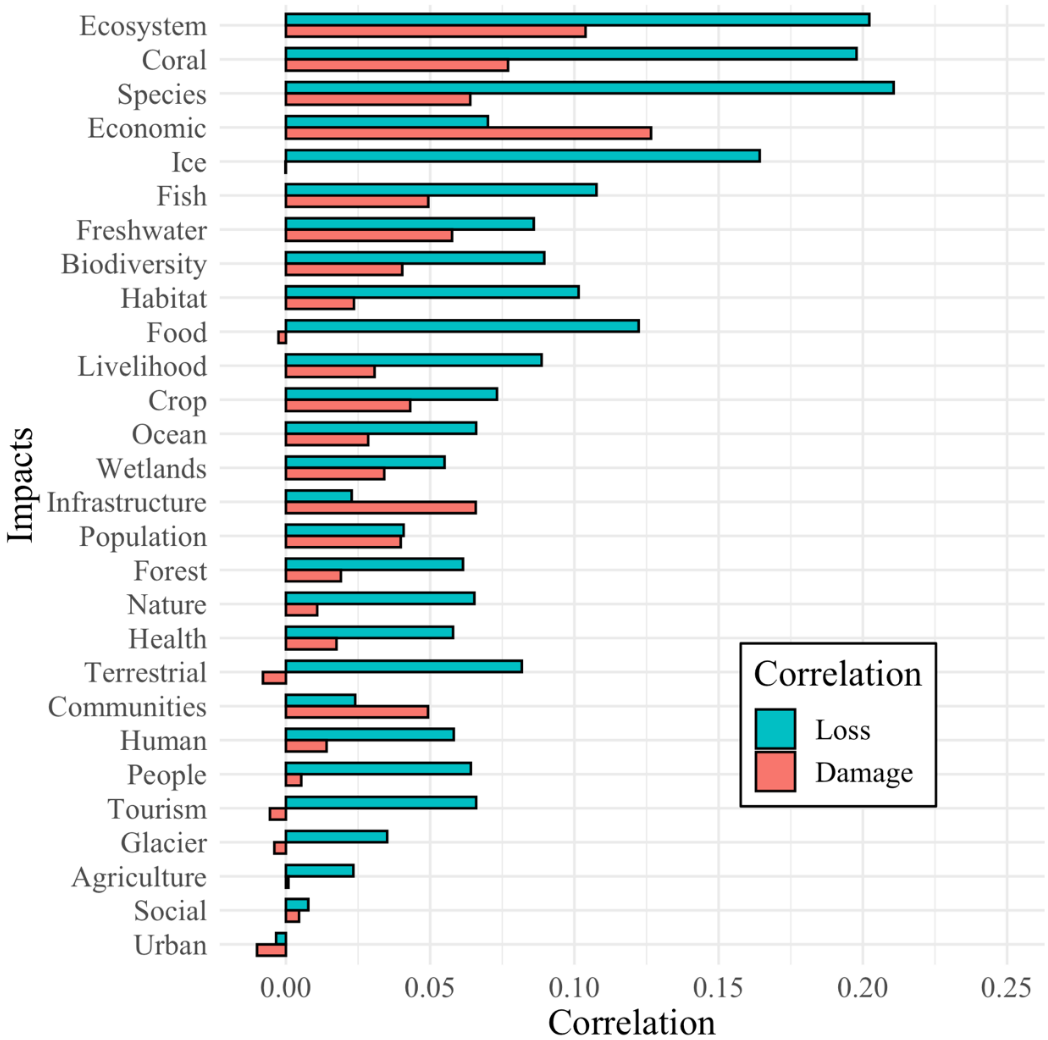

Figure 15: Correlation graph for Impacts with Loss and Damage

[27] 'Agriculture', 'Food', 'Forest', 'Glacier', 'Health', 'Human', 'Ice', 'Nature', 'People', 'Social', 'Tourism', 'Urban'

6.3. DPSIR Framework on L&D in the SIDS

The DPSIR framework effectively captures the cause-effect interactions in the Pacific SIDS in a simplified way. Following the cyclical process of adaptive management, the framework incorporates viable response options to address the driving forces, pressures, stressors and impacts in the systems. By further connecting the framework to the SDGs, the framework presents relevant information on L&D in a meaningful format which in turn can be used to inform decision making. Moreover, the framework can aid in effective science communication, bridging the gap across scientific disciplines and further to policy and management.

This framework (Figure 16) depicts the relationships between the key driving forces, pressures, state, impacts and responses concerning L&D in SIDS in the Pacific Region. The framework identifies driving forces which exert pressure and in turn lead to changes in the state of the system, which then result in impacts on human systems. Subsequently, appropriate societal responses are required. I include a list of references so as to link the literature to the elements of the DPSIR framework (see Appendix B).

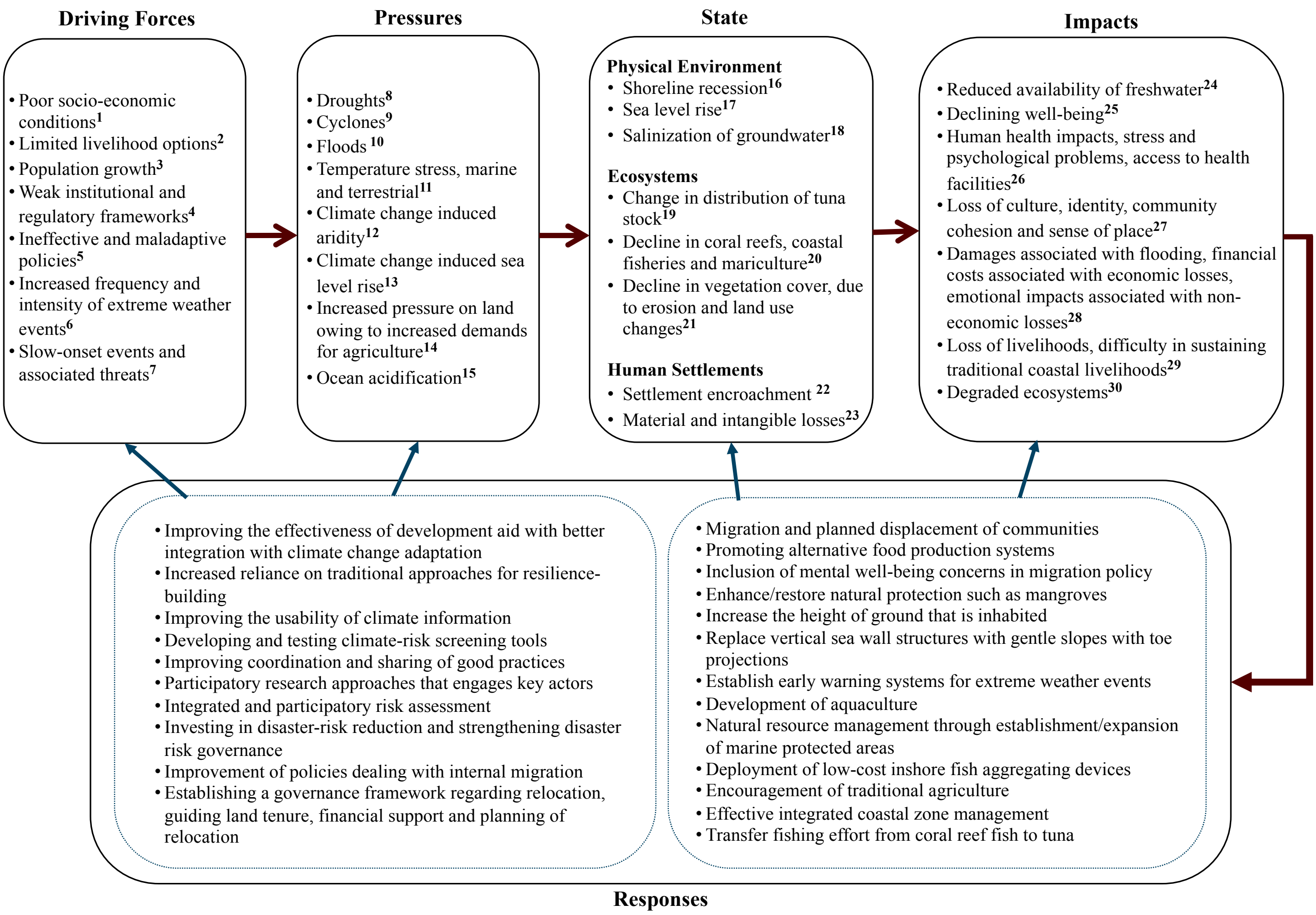

Figure 16: DPSIR Framework for L&D in SIDS in the Pacific.

Figure 17 and Figure 18 map the elements of extreme and slow-onset events through the DPSIR framework. Additionally, I draw connections between the elements mentioned in the framework with the SDGs to highlight the importance and interlinkages of L&D (in the Pacific SIDS) with the SDGs. The list of specific SDG targets is included in Appendix B (Table B.5, B.6).

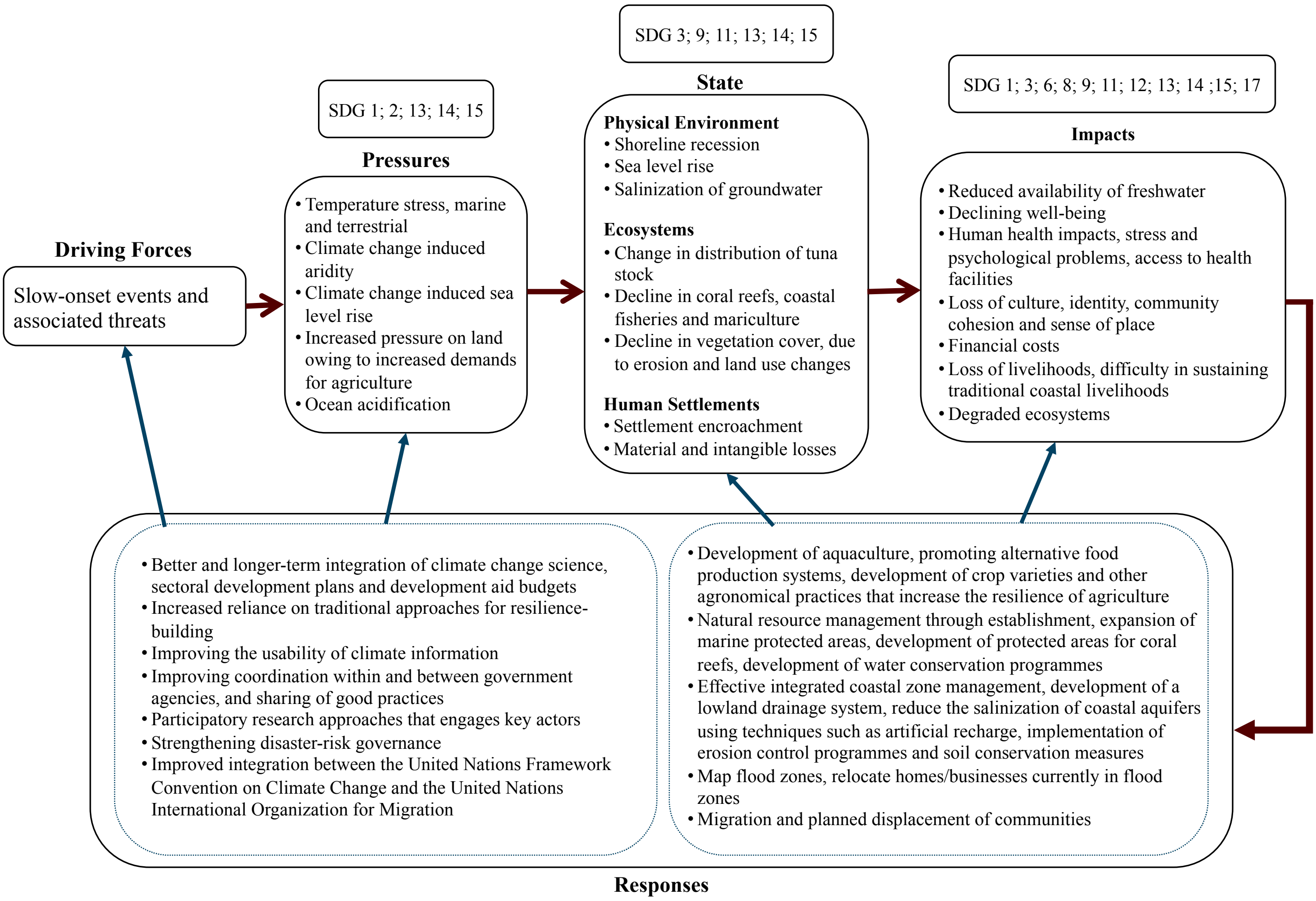

Figure 17: Focused DPSIR Framework on slow-onset events (based on Puig, 2019)

The focused frameworks (Figure 17 and Figure 18) allow for the exploration of individual driving forces and the resulting chain of events arising from pressures exerted on the system. These driving forces as they are prominent within the region and closely linked to L&D. Further, the driving forces elicit contrasting responses when addressing changes in state and the impacts observed. While the responses in the DPSIR framework on slow-onset events includes mostly mitigation-focused responses, the framework on extreme weather events reflects on adaptation-focused approaches. This indicates that an integrated series of mixed policies must be undertaken to reduce the impacts experience in the region. These policies must address both, the reduction of GHG emissions and coping strategies to deal with the consequences of global warming.

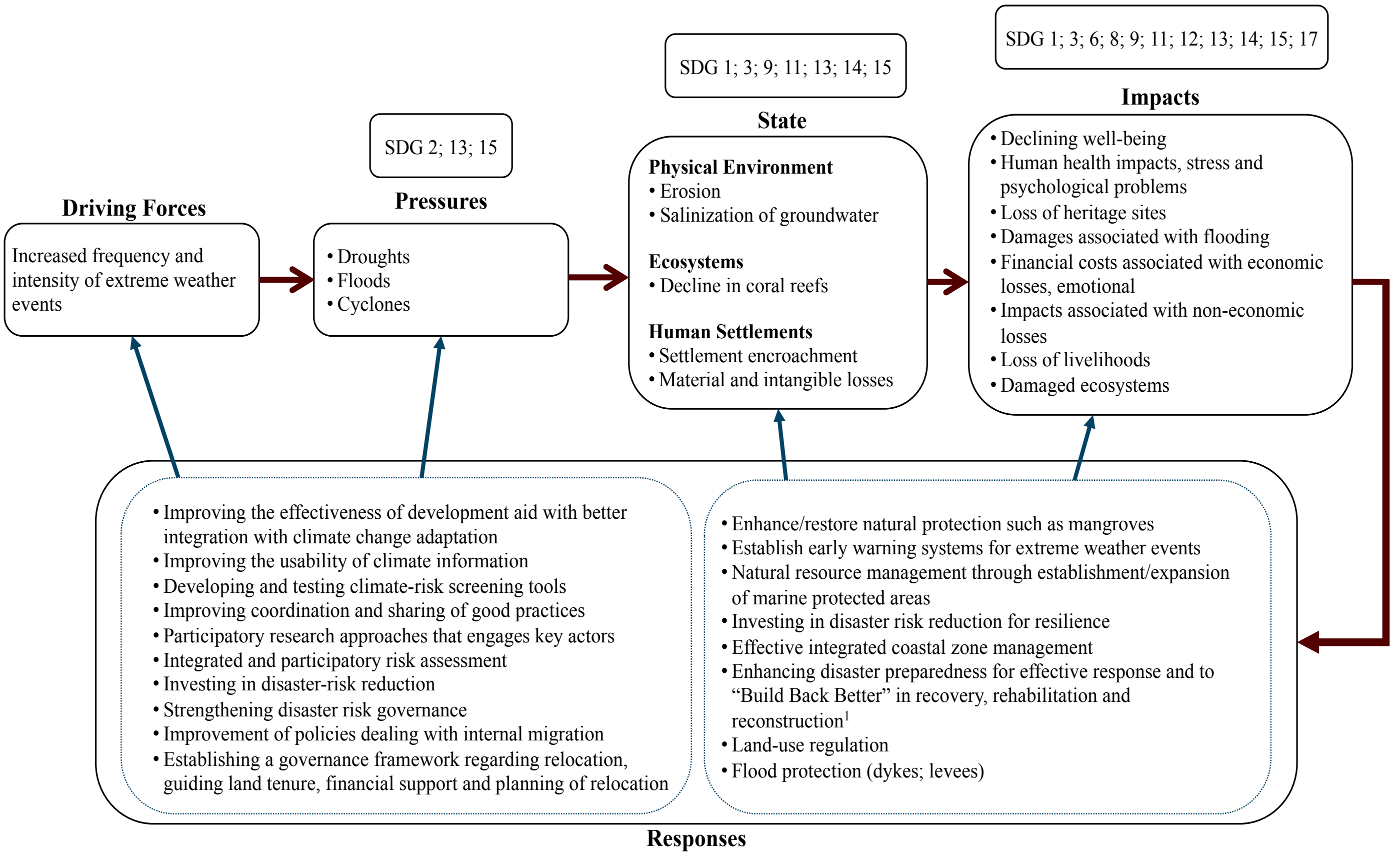

Figure 18: Focused DPSIR Framework on extreme weather events (based on Puig, 2019)

7. Discussion

In the following section, I discuss the findings from the QCA (7.1) and the text analytics (7.2) of the SR1.5. Following which, I analyse the DPSIR framework on L&D in the SIDS in the Pacific (7.3) while drawing parallels with the SDGs (7.4). Lastly, I discuss the relevance of the outcomes to the current state of L&D in connection with the Paris Agreement (7.5) in order to put the results into perspective.

Even in current mitigation and adaptation efforts are strengthened in the coming years, the world is committed to a certain amount of global warming. Some of the impacts of global warming will be impossible to adapt to or cope with. We term these impacts loss and damage (L&D). L&D is a heavily debated topic in international climate change negotiations, with the definition of the term and the implementation of actions to address L&D still ambiguous. The aim of this thesis is to explore the extent of L&D at 1.5°C and 2°C of global warming, drawing on the contents of the IPCC SR1.5. So far, the reports by the IPCC have not touched upon L&D in an explicit manner, as the controversy surrounding the topic has led some governments to exclude L&D from the scope of the IPCC reports. Simply put, L&D has been actively avoided, in a bid to stifle demands of compensation from developing countries.

7.1. Qualitative Content

The analysis of the IPCC SR1.5 through the lens of L&D makes it possible to compare how impacts may vary across the two warming scenarios. The report does not prominently feature L&D but it does conclude with very high confidence that the risk of unavoidable losses and damages, economic and non-economic alike, will increase if global warming increases to 2°C by the end of the century. Despite the explicit coverage of L&D being limited to a 'Cross-Chapter Box' spanning two-pages, the SR1.5 is the first report to directly mention L&D (Chapter 5, pp 454)[28]. However, throughout the report, the evidence of losses and damages presently occurring, and the risk of future L&D is discussed (see Table 1, Section 6.1). Overall, the results of the QCA indicate that there would be a steep increase in L&D across sectors when moving from 1.5°C to 2°C of global warming.

When the stressors covered by the report are analysed for the comparative impacts at 1.5°C and 2°C, it is evident that a 1.5°C warmer world would have lesser negative impacts as

[28] The cross-chapter box discusses soft and hard limits to adaptation and the need for transformational adaptation in order to restrict global warming to 1.5°C.

compared to a 2°C warmer world. However, 1.5°C of global warming would nevertheless hold severe implications for society as compared to present-day climate. This implies that attempts to achieve sustainable development, eradicate poverty, reduce inequalities and protect the well-being of natural and human systems will be more challenging at 1.5°C of warming as compared to the current warming level of 1°C (IPCC, 2018). The QCA of the SR1.5 revealed that across all stressors the increase of global warming to 2°C increases both the severity and geographical spread of the impacts. Notably, the effects of most stressors, if not already observed, will first affect developing regions even if global warming is limited to 1.5°C.

Through my analysis of the report, I found that L&D was mostly covered in relation to the impacts of flooding. This could be due to the increased availability of research on flooding patterns and modeling studies. The SR1.5 provides statistical quantification for projected risks of most stressors, except precipitation and cyclone patters. Yet, it fails to emphasise on the interaction between stressors and their cascading impacts. One key example is the amplification of impacts associated with storm surges and wave action by SLR, which leads to salinization, flooding and erosion, increasing the risk to coastal communities and ecosystems. This in turn impacts livelihoods and cultures intertwined with marine systems, particularly in SIDS.

In terms of natural systems (marine, terrestrial and wetland), the report emphasizes on the irreversible loss of habitats and ecosystems that would occur owing to various stressors. The projected loss of 99% of coral reefs at 2°C of warming, along with the increasing risk of loss of 45% of the Fynbos Biome are some examples discussed in the report. Further, the SR1.5 reports that the projections for the number of vertebrate and plant species to lose over half of their geographic range is reduced by half at 1.5°C of warming as compared to 2°C. Similarly, across the two warming scenarios, the number of insect species is reduced by two-thirds.

The coverage of natural systems in the report is mainly dominated by losses in comparison to damages as the assessment of losses is relatively straightforward. This is due to the lack of certainty when ascertaining the extent of damages that would occur. For example, although the increase in temperature will result in the melting of sea ice and glaciers, it is difficult to state with high certainty the degree of damage resulting from it. The report highlights the staggering difference in impacts between the two warming levels, concluding that a 2°C would have disastrous implications for natural systems. Unsurprisingly, a major part of the report is devoted to the economic losses and damages associated with the loss of natural systems such as the loss of productivity of regions, loss of ecosystem services and reduction of available natural resources. In the case of marine ecosystems, the report repeatedly highlights the implications of climatic stressors on the productivity of fisheries, which will face high risk at 2°C of warming in lower latitudes.

The report has more extensive coverage of the impacts of climate change on human systems as compared to natural systems. This could be due to the lack of available literature on natural systems or the constellation of authors involved in the report (Carey et al., 2014). In addition, the report tends to cover economic L&D more than NELD, which could be due to the difficulty in assessing and quantifying NELD's. For example, the report gives relatively less attention to the loss of culture and agency due to climate change, despite the availability of scientific literature (Kim, 2011; Adger et al., 2013; Tschakert et al., 2017). Another example is the substantial coverage of the impacts of flooding, which focuses mainly on the economic damages that will affect the global population and urban areas. When it comes to the number of people affected by flooding and human health, we see that coverage of damages dominates the report. While the report presents statistical quantification for the projected number of people at risk from various stressors, the SR1.5 fails to dig deeper and discuss the social implications of these stressors at 1.5°C and 2°C of global warming.

Unlike the AR5, the SR1.5 does address losses and damages arising from gradual climatic changes (van der Geest and Warner, 2019). Yet, the report falls short of discussing the compounding nature of climatic stressors, and the interaction of slow-onset events and extreme weather events. After the qualitative analysis of the report, it is refreshing to see the relatively equal coverage of both, developing and developed countries in relation to L&D. One explanation for the increased coverage could be due to the increased scientific research being conducted in developing countries (with comparison to 2014) and the increased availability of robust literature on L&D arising from slow-onset events. However, there has been considerably less research available on slow-onset events as compared to extreme weather events. This is due to difficulty in ascertaining the full extent of losses and damages occurring and their costs. In conclusion, the coverage of L&D is rather polarized and focuses mainly on the economic losses and damages, which is far from the real losses and damages resulting from climatic changes occurring in developing countries. This could be due to the lack of integrative studies that analyse L&D across different regions.

Based on the findings of this thesis, the following hypotheses can be formulated:

1. The higher the coverage of the effects of climate change on human systems, the more likely they focus on damages instead of losses.
2. The higher the coverage of the effects of climate change on natural systems, the more likely they focus on losses instead of damages.
3. If scientific literature discusses Loss and Damage in connection with affected systems, then it focuses more on economic losses and damages than on non-economic.

7.2. Text Analytics

To complement the QCA and to mitigate possible biases, the text analytics examines the co-occurrence and correlation of ‘Loss’, ‘Damage’, ‘1.5°C’ and ‘2°C’ with terms relevant to impacts. A first finding from this analysis is that, in relation to the warming levels, the coverage of human systems dominates quantitatively that of natural systems. This corroborates the findings from the QCA. A second finding (Figure 12) is that the term ‘1.5°C’ is used much more often than the term ‘2°C’. In order to compare the relationship between the impacts and the warming levels, one must take into account that the frequency of certain words might be arbitrarily higher than the rest. Therefore, Figure 13 depicts the correlation graph and the results show that the correlation between the warming levels and the respective impacts is more similar than Figure 12 suggests. Interestingly, the term ‘Economic’ displays a relatively low correlation given that it has the second highest cooccurrence with the warming levels. This implies that the term ‘Economic’ is a reoccurring theme in the report, which is in line with the findings from the QCA. Vice versa, the term ‘Population’ shows a relatively high correlation even though the cooccurrence ranked somewhat lower, in comparison to the other terms. This indicates that ‘Population’, when mentioned, is often associated in the text with the warming levels. Additionally, there are terms such as ‘Ocean’, ‘Ice’, ‘Glacier’ and ‘Biodiversity’ that show a higher correlation with 2°C as compared to 1.5°C, which could speak to the severe effects of the higher warming level. The words ‘Social’ and ‘Agriculture’ have a negative correlation with ‘2°C’, which could indicate that the report is less likely to mention 2°C in connection with these impacts. However, the correlation for these terms is statistically not different from zero.

When looking at the terms ‘Loss’ and ‘Damage, Figure 14 and 15 reveal that, in comparison to ‘Damage’, the term ‘Loss’ is mentioned more often in the report. This could indicate that losses are easier to study or simply more relevant. Further, in comparison to the warming levels, the terms ‘Loss’ and ‘Damage’ have a stronger correlation with the various impacts considered. Similar to the findings from the QCA, Figure 15 reveals that the terms ‘Ecosystem’, ‘Coral’ and ‘Species’ are strongly emphasised in the text. Moreover, the text analytics further confirms the QCA findings showing the highest correlation of the term ‘Damage’ with ‘Infrastructure’ and ‘Economic’.

Interestingly, the terms ‘Tourism’ and ‘Food’ do not show statistically significant correlations with damage. In the case of ‘Tourism’, this could be because the report often mentions the *loss* of coral reefs, beaches and ski fields in connection with tourism, which results in economic *damage*. Further, when considering ‘Food’, the term is often related to the *loss* of yield and productivity, which in fact refers to *damage* in the report. Similarly, an explanation for the relatively high correlation of ‘Damage’ with ‘Communities’ could be attributed to the usage of damage in certain cases to imply permanent damage and, therefore loss. Therefore, these instances highlight the need for QCA in addition to text analytics in order to gain a better understanding of the themes and topics addressed in any written text.

A key observation from Figure 15 is that the terms ‘Loss’ and ‘Damage’ cover two different themes, where ‘Loss’ is used more often in connection with natural systems and ‘Damage’ with human systems. Overall, this finding is aligned with the connotations of irreversibility (associated with ‘Loss’) and reversibility (associated with ‘Damages’), as implied in several studies (McNamara & Jackson, 2019; Tschakert et al., 2017). In sum, the findings from the text analytics support those of the QCA.

7.3. DPSIR Framework

To put the perspective of L&D into the context of SIDS in the Pacific, the DPSIR framework is used (Figure 16) to provide a stylised description of the relationships between the socio-economic drivers of L&D, the associated environmental pressures, states and impacts, and the responses considered to manage L&D in the region. The information presented in Figure 16 draws on one of the outputs of a European Union-funded project (the so-called SINCERE project). In turn, the project will draw on the relationships depicted in Figure 16 to identify existing knowledge gaps, in collaboration with researchers from Pacific island states.

Climate change along with poor socio-economic conditions leads to an increasing number of losses and damages (McIver et al., 2015; Puig, 2019). Extreme weather and slow-onset events such as cyclones and SLR exert pressure on the system and, in combination with anthropogenic factors such as population growth and weak institutional frameworks, further lead to a change in the state of the environment (Mcleod et al., 2010; Gard and Veitayaki, 2017). The changed state manifests as a range of impacts such as declining well-being, economic losses and degraded ecosystems (Fisher, 2011; Birk and Rasmussen, 2014; Bell et al., 2013a). Policies aimed at reverting the drivers of change include improving the usability of climate information and policies dealing with internal migration in conjunction with participatory research approaches to enhance the resilience of communities in order to mitigate risks (Birk and Rasmussen, 2014; Agrawala and Van Aalst, 2008; Cvitanovic et al., 2016). Policies aimed at reducing pressures include improving the effectiveness of development aid through better integration with adaptation efforts should be pursued (Gero et al., 2011). Policies to address the change of state include the promotion of alternative food production systems and effective integrated coastal management amongst other suggestions (Nunn, 2013; Bell et al., 2013a). Policies focused on reducing negative impacts include the promotion of alternative livelihoods in order to combat further poverty (Nunn, 2013). Further, the development of aquaculture and the usage of low-cost onshore fish-aggregating devices could help sustain traditional coastal livelihoods (Bell et al., 2013a). Gero et al., find that the lack of effective and holistic polices contribute to the increase in losses and damages. Thus, the successful implementation of these responses relies on effective political strategies that are grounded in participatory research approaches.

Figure 17 reflects on slow-onset events such as SLR and ocean acidification in the Pacific region (Monnereau and Abraham, 2013; Fabricius et al., 2011). Changes in the state of the environment include shoreline recession, settlement encroachment and alterations in the distribution of fish stock (Albert et al., 2016; Bell et al., 2013b; Giardino et al., 2018). Observed impacts of this changed state are the reduced availability of freshwater, and financial losses due to change in fish stock (Karnauskas et al., 2018; Brown et al., 2017). Driver and pressure-based responses include improved integration between the UNFCCC and the United Nations International Organization for Migration and the strengthening of disaster risk governance within the region (Barnett, 2017; Thomas and Benjamin, 2018b). Further, to address the change in state and resulting impacts, responses such as effective natural resource management and planned displacement of communities could be considered (Rosegrant et al., 2016; Nalau and Handmer, 2018). Similarly, Figure 18 presents a framework covering extreme weather event such as floods and cyclones in SIDS in the

Pacific. Investment in disaster-risk reduction and development of climate-risk screening tools are key responses identified to address drivers and pressures (Nalau and Handmer, 2018; Agrawala and Van Aalst, 2008). State and impact-based responses focus on enhancing disaster preparedness and early warning systems for extreme weather events (Edmonds and Noy, 2018; Gawith et al., 2016). An interesting outcome of the focused DPSIR frameworks is that the responses for slow-onset events are mostly adaptation-centric, while responses for extreme weather events are mostly mitigation-centric.

7.4. DPSIR Framework and the SDGs

Figures 17 and 18 show how the various SDGs relate to the different elements in the two DPSIR frameworks. The analysis finds that 12 out of 17 of the SDGs are directly linked and the list of specific SDG targets are included in Appendix B (Table B.5 and B.6). This mapping highlights that, at the level of environmental pressures, slow-onset events touch upon a larger number of SDGs. Stated differently, heightened efforts will be needed to manage slow-onset events, if the SDGs are to be achieved. Tragically, slow-onset events are receiving little attention, compared to extreme-weather events. Two main reasons account for this. First, the time frames associated with extreme-weather events mean that their events are more amenable to being included in governmental plans and strategies, typically through disaster-risk management programmes. Second, the knowledge required to manage slow-onset events is largely missing, and the governance arrangements at the international level are sub-optimal. Spurred by the latter, the Warsaw International Mechanism recently launched a call for research outputs in the area of slow-onset events. Undoubtedly, these research outputs will highlight the comparatively larger impact that these events have on human development, as depicted in crude terms in the two figures, 17 and 18.

7.5. L&D in international climate change negotiations

Article 8 in the Paris Agreement focuses exclusively on L&D. Since the adoption of the Paris Agreement in 2015, steadily albeit slowly, L&D has gained traction in international climate change negotiations. Yet, issues such as financing for L&D or the mandate of the WIM remain unresolved. During the 2019 conference of the parties to the UNFCCC, discussions on a finance mechanism for L&D resulted in a reference to the importance of scaling up the mobilization of resources, relying where possible on funding already allocated to the Green Climate Fund (UNFCCC, 2019). Nonetheless, a separate funding stream for L&D, which is a longstanding claim from developing countries, was not agreed. Similarly, the 2019 conference of the parties to the UNFCCC resulted in no agreement on the mandate of the WIM. Developing countries wish the WIM to operate under both the Convention and the Paris Agreement. The former does not preclude compensation, which the latter does, but it places little emphasis on L&D, which the latter does not. Developed countries wish the WIM to operate under the Paris Agreement only, which explicitly precludes compensation. Despite these setbacks, agreement was reached on the establishment of a "Santiago Network", operating under the WIM. This network shall provide vulnerable countries with the much-needed technical assistance and knowledge to avoid, minimise and recover from L&D. In addition, the WIM's Executive Committee was requested to establish two expert groups, one on slow onset event and non-economic losses, and the other in charge of the plan of action on finance, outreach and collaboration (Puig et al., 2019a). Due to the difficulty in assessing the full cost of L&D associated with slow-onset events, especially NELD, they have often been unaccounted for. Further, the discussion around finance mechanisms for L&D is highly contentious. Thus, the establishment of expert groups on these topics is essential in order to provide support to developing countries. There is a need for socially engaged research, which aims to understand what communities and individuals value the most and strategies for the affected to cope with these losses. The Paris Agreement provides the opportunity for evidence-based scientific research to play a key role in the political process.

8. Conclusion

Loss and Damage (L&D) has steadily risen to the forefront of climate change negotiations, as it has become apparent that, irrespective of increased initiative through mitigation and adaptation efforts, there are certain climatic feedbacks that we are locked into and certain that are inevitable (Hirsch et al., 2015; Steffen et al., 2011). This thesis demonstrates the variation of impacts and stressors between the two warming scenarios, 1.5°C versus 2°C, and the resulting losses and damages through a three-fold analysis.

The review of literature on L&D provided empirical insight into the topic, and served as a foundation for the development of the coding scheme used in the qualitative content analysis (QCA). The analysis of the SR1.5 highlights the steep increase in losses and damages across systems when moving from 1.5°C to 2°C. When analysed across stressors and their resulting impacts, the report does not discuss in detail the compounding nature of stressors, which could indicate the lack of available research on the subject. The coverage of natural systems was mainly dominated by losses, however, the coverage of damages arising was substantial. This reflects on the sufficient availability of research on the valuation of ecosystem services. The literature on human systems focused mostly on the damages. Further, the literature cited in the report tends to have a greater focus on economic L&D as compared to non-economic loss and damage (NELD), which could be due to the difficulty in assessing and quantifying NELDs. Yet, NELD arising from climatic changes have been reported to be far more significant than economic losses and damages in most countries.

In order to reduce biases that might have been introduced during the QCA, I analysed the text quantitatively to understand the relationship between impact sectors and the warming levels, and later with 'Loss' and 'Damage'. Studying the co-occurrence of terms (within a paragraph) and correlation provides an alternative way of identifying themes and connections within the report. The findings of the text analytics identify the term 'Economic' to be a reoccurring theme in the report. Further, the results present a higher correlation between 'Loss' and terms relevant to natural systems and between 'Damage' and terms relevant to human systems. Overall, the findings of the text analytics corroborate those of the QCA.

Lastly, I present a DPSIR framework (Figure 16) on L&D in SIDS in the Pacific, based on a review of literature conducted by Daniel Puig (2019). Doing so contextualizes the findings from the QCA and text analytics, providing a deeper understanding of the cause-effect relationships in the region. Climatic changes reinforced by anthropogenic drivers such as population growth and ineffective policies lead to the change in the state of the environment, consequently leading to an increase in losses and damages. The recommended responses to manage L&D in the region include participatory research methods, increased targeted financing, and a holistic portfolio of policies which focus equally on adaptation and mitigation. This framework contributes to one of the work packages of the SINCERE project serving as a basis for researchers in the SINCERE project to identify existing knowledge gaps. I further reflect on slow-onset events and extreme weather events in two DPSIR frameworks (Figure 17 and 18) and identify connections between the elements of the framework and the SDGs. The analysis reveals that managing slow-onset events will be integral to achieving the targets set in the SDGs. Yet, in comparison to extreme-weather events, there is a large gap in knowledge and lack of policies addressing slow-onset events. In order to design policies that minimize the negative impacts of climate change, future research efforts could address the management of slow-onset events and assess the real extent of resulting losses and damages.

The SR1.5 report acknowledges that the worst impacts of climate change fall on developing countries, who are the least responsible for the current climate crisis. These countries lack the resources and capacity to cope with the current crisis, yet, the questions of attribution of climate change, liability and compensation have overshadowed the real burden that these countries face. The literature review and findings of this thesis indicate that L&D policies must address two factors. First, reduce future losses and damages that can be avoided through effective mitigation measures. Second, include measures that tackle the unavoidable losses and damages that society faces today and will face in the future (Serdeczny et al. 2016). The confusion arises as to which impacts must be taken into account, and how these losses and damages shall be compensated. While the loss of a house is easier to quantify, how is the loss of life, sense of place, belonging and culture quantified? Arguably, next to the political debate about financing, the stakes for loss and damage will turn around two issues. First, understanding what people value most and why, which effectively sets the limits to adaptation. Second, the recognition and study of the various non-economic losses associated with climate change. These two issues have emerged in the analysis, though only partially. This lack of coverage highlights that the literature covered in the IPCC reports misses central aspects of the loss and damage debate. This is no surprise, as the scope of the various reports is a political, not scientific decision. Yet, the lack of coverage is inconsistent with the IPCC's stated goal, namely synthesising all climate change science. In this context, the politicization of science to a certain extent is inevitable, however, it must be kept within check to ensure scientific freedom and credibility.

Key Findings

- Adapted from van der Geest and Warner (2019) and Vulturius and Davis (2016), I put forward a working definition for L&D: the impacts of climate change and related stressors which cannot be mitigated or avoided owing to the threshold limits of a system and the slow pace and ineffectiveness of policy development in mitigation and adaptation efforts.
- The findings of the QCA and text analytics find the term, 'Economic' to be a recurring theme in the report and an emphasis on damages affecting human systems. This highlights an important research gap, non-economic L&D, which has been reported to be far more significant than economic L&D (Doktycz and Abkowitz, 2019). Future research efforts should focus on the management of slow-onset events and the development of an assessment framework that effectively accounts for the full extent of non-economic L&D.
- The DPSIR Framework elucidates the key role that addressing L&D has to play in achieving the targets under the SDGs in the Pacific SIDS. Further, the framework emphasises on the need for a portfolio of policies (local and international), which are grounded in participatory methods and evidence-based research in order to reduce the extent of L&D occurring in the region.
- More ambitious mitigation and more and better adaptation will reduce the amount of L&D the world will suffer. Nonetheless, there will be residual impacts, which will cause L&D. Such impacts can be associated with three situations. First, a conscious choice, grounded in economic arguments, to limit adaptation efforts. Second, ineffective adaptation. Third, impacts that exceed the limits to adaptation. All three situations call for heightened efforts to understand and manage L&D

9. References

Adger, W.N., Barnett, J., Brown, K., Marshall, N. and O'brien, K., 2013. Cultural dimensions of climate change impacts and adaptation. Nature Climate Change, 3(2), p.112.

Adger, W.N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D.R., Naess, L.O., Wolf, J. and Wreford, A., 2009. Are there social limits to adaptation to climate change?. *Climatic change*, *93*(3-4), pp.335-354.

Afionis, S., Sakai, M., Scott, K., Barrett, J. and Gouldson, A., 2017. Consumption-based carbon accounting: does it have a future?. Wiley Interdisciplinary Reviews: Climate Change, 8(1), pp.e438.

Agrawala, S. and Van Aalst, M., 2008. Adapting development cooperation to adapt to climate change. Climate policy, 8(2), pp.183-193.

Albert, S., Leon, J.X., Grinham, A.R., Church, J.A., Gibbes, B.R. and Woodroffe, C.D., 2016. Interactions between sea-level rise and wave exposure on reef island dynamics in the Solomon Islands. Environmental Research Letters, 11(5), 054011.

Alfieri, L., Bisselink, B., Dottori, F., Naumann, G., de Roo, A., Salamon, P., Wyser, K. and Feyen, L., 2017. Global projections of river flood risk in a warmer world. Earth's Future, 5(2), pp.171-182.

Alfieri, L., Dottori, F., Betts, R., Salamon, P. and Feyen, L., 2018. Multi-model projections of river flood risk in Europe under global warming. Climate, 6(1).

Allen, M.G., 2015. Framing food security in the Pacific Islands: empirical evidence from an island in the Western Pacific. Regional Environmental Change, 15(7), pp.1341-1353.

Allgood, L. and McNamara, K.E., 2017. Climate-induced migration: Exploring local perspectives in Kiribati. Singapore Journal of Tropical Geography, 38(3), pp.370-385.

Alongi, D.M., 2015. The impact of climate change on mangrove forests. Current Climate Change Reports, 1(1), pp.30-39.

Alvarez-Filip, L., Dulvy, N.K., Gill, J.A., Coˆté, I.M. and Watkinson, A.R., 2009. Flattening of Caribbean coral reefs: region-wide declines in architectural complexity. Proceedings of the Royal Society B: Biological Sciences, 276(1669), pp.3019-3025.

André, G., Engel, B., Berentsen, P.B.M., Vellinga, T.V. and Lansink, A.O., 2011. Quantifying the effect of heat stress on daily milk yield and monitoring dynamic changes using an adaptive dynamic model. Journal of Dairy Science, 94(9), pp.4502-4513.

Arent, D.J., Tol, R.S., Faust, E., Hella, J.P., Kumar, S., Strzepek, K.M., Tóth, F.L., Yan, D., Abdulla, A., Kheshgi, H. and Xu, H., 2014. Key economic sectors and services. 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.659-708.

Arnell, N.W. and Lloyd-Hughes, B., 2014. The global-scale impacts of climate change on water resources and flooding under new climate and socio-economic scenarios. Climatic Change, 122(1-2), pp.127-140.

Arnell, N.W., Brown, S., Gosling, S.N., Hinkel, J., Huntingford, C., Lloyd-Hughes, B., Lowe, J.A., Osborn, T., Nicholls, R.J. and Zelazowski, P., 2016. Global-scale climate impact functions: the relationship between climate forcing and impact. Climatic Change, 134(3), pp.475-487.

Arnell, N.W., Lowe, J.A., Lloyd-Hughes, B. and Osborn, T.J., 2018. The impacts avoided with a 1.5 C climate target: a global and regional assessment. Climatic change, 147(1-2), pp.61-76.

Asplund, M.E., Baden, S.P., Russ, S., Ellis, R.P., Gong, N. and Hernroth, B.E., 2014. Ocean acidification and host–pathogen interactions: blue mussels, M ytilus edulis, encountering V ibrio tubiashii. Environmental Microbiology, 16(4), pp.1029-1039.

Asseng, S., Ewert, F., Martre, P., Rötter, R.P., Lobell, D.B., Cammarano, D., Kimball, B.A., Ottman, M.J., Wall, G.W., White, J.W. and Reynolds, M.P., 2015. Rising temperatures reduce global wheat production. Nature climate change, 5(2), pp.143-147.

Bäckstrand, K., Kuyper, J., Linnér, B. and Lövbrand, E., 2017. Non-state actors in global climate governance: from Copenhagen to Paris and beyond. *Environmental Politics*, 26(4), pp.561-579.

Barati, F., Agung, B., Wongsrikeao, P., Taniguchi, M., Nagai, T. and Otoi, T., 2008. Meiotic competence and DNA damage of porcine oocytes exposed to an elevated temperature. Theriogenology, 69(6), pp.767-772.

Barnett, J., 2001. Adapting to climate change in Pacific Island countries: the problem of uncertainty. World development, 29(6), pp.977-993.

Barnett, J., 2011. Dangerous climate change in the Pacific Islands: food production and food security. Regional Environmental Change, 11(1), pp.229-237.

Barnett, J., 2017. The dilemmas of normalising losses from climate change: Towards hope for Pacific atoll countries. Asia Pacific Viewpoint, 58(1), pp.3-13.

Barnett, J., Tschakert, P., Head, L., & Adger, N. E., 2016. A science of loss. Nature Climate Change, 6, pp.976–978.

Bauer, K., 2013. Are preventive and coping measures enough to avoid loss and damage from flooding in Udayapur District, Nepal?. International Journal of Global Warming, 5(4), pp.433-451.

Beckman, M. and Nguyen, M.V.T., 2016. Upland development, climate-related risk and institutional conditions for adaptation in Vietnam. Climate and Development, 8(5), pp.413-422.

Bell, J.D., Ganachaud, A., Gehrke, P.C., Griffiths, S.P., Hobday, A.J., Hoegh-Guldberg, O., Johnson, J.E., Le Borgne, R., Lehodey, P., Lough, J.M. and Matear, R.J., 2013a. Mixed responses of tropical Pacific fisheries and aquaculture to climate change. Nature Climate Change, 3(6), pp.1-9.

Bell, J.D., Reid, C., Batty, M.J., Lehodey, P., Rodwell, L., Hobday, A.J., Johnson, J.E. and Demmke, A., 2013b. Effects of climate change on oceanic fisheries in the tropical Pacific: implications for economic development and food security. Climatic Change, 119(1), pp.199-212.

Betts, R.A., Alfieri, L., Bradshaw, C., Caesar, J., Feyen, L., Friedlingstein, P., Gohar, L., Koutroulis, A., Lewis, K., Morfopoulos, C. and Papadimitriou, L., 2018. Changes in climate extremes, fresh water availability and vulnerability to food insecurity projected at 1.5 C and 2 C global warming with a higher-resolution global climate model. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376, 20160452.

Betzold, C., 2015. Adapting to climate change in small island developing states. Climatic Change, 133(3), pp.481-489.

Birk, T. and Rasmussen, K., 2014, February. Migration from atolls as climate change adaptation: Current practices, barriers and options in Solomon I slands. In Natural Resources Forum, 38(1), pp.1-13.

Blankespoor, B., Dasgupta, S. and Laplante, B., 2014. Sea-level rise and coastal wetlands. Ambio, 43(8), pp.996-1005.

Boone, R.B., Conant, R.T., Sircely, J., Thornton, P.K. and Herrero, M., 2018. Climate change impacts on selected global rangeland ecosystem services. Global change biology, 24(3), pp.1382-1393.

Bopp, L., Resplandy, L., Orr, J.C., Doney, S.C., Dunne, J.P., Gehlen, M., Halloran, P., Heinze, C., Ilyina, T., Seferian, R. and Tjiputra, J., 2013. Multiple stressors of ocean ecosystems in the 21st century: projections with CMIP5 models. Biogeosciences, 10, pp.6225-6245.

Boyd, E., James, R.A., Jones, R.G., Young, H.R. and Otto, F.E., 2017. A typology of loss and damage perspectives. *Nature Climate Change*, *7*(10), pp.723-729.

Boyd, P.W., 2015. Toward quantifying the response of the oceans' biological pump to climate change. Frontiers in Marine Science, 2, p.77.

Bradley, P. and Yee, S., 2015. Using the DPSIR framework to develop a conceptual model: technical support document. US Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division.

Brown, P., Daigneault, A. and Gawith, D., 2017. Climate change and the economic impacts of flooding on Fiji. Climate and Development, 9(6), pp.493-504.

Brown, S., Nicholls, R.J., Goodwin, P., Haigh, I.D., Lincke, D., Vafeidis, A.T. and Hinkel, J., 2018. Quantifying land and people exposed to sea-level rise with no mitigation and 1.5 C and 2.0 C rise in global temperatures to year 2300. Earth's Future, 6(3), pp.583-600.

Bryman, A., 2016. Social research methods. Oxford university press.

Burke, L.M., Reytar, K., Spalding, M. and Perry, A., 2017. Reefs at risk revisited: World Resources Institute.

Burrows, M.T., Schoeman, D.S., Richardson, A.J., Molinos, J.G., Hoffmann, A., Buckley, L.B., Moore, P.J., Brown, C.J., Bruno, J.F., Duarte, C.M. and Halpern, B.S., 2014. Geographical limits to species-range shifts are suggested by climate velocity. Nature, 507(7493), pp.492-495.

Byers, E., Gidden, M., Leclère, D., Balkovic, J., Burek, P., Ebi, K., Greve, P., Grey, D., Havlik, P., Hillers, A. and Johnson, N., 2018. Global exposure and vulnerability to multi-sector development and climate change hotspots. Environmental Research Letters, 13(5), 055012.

Calliari, E., 2018. Loss and damage: a critical discourse analysis of Parties' positions in climate change negotiations. Journal of Risk Research, 21(6), pp.725-747.

Carey, M., James, L.C. and Fuller, H.A., 2014. A new social contract for the IPCC. Nature Climate Change, 4(12), pp.1038-1039.

Chadburn, S.E., Burke, E.J., Cox, P.M., Friedlingstein, P., Hugelius, G. and Westermann, S., 2017. An observation-based constraint on permafrost loss as a function of global warming. Nature Climate Change, 7(5), pp.340-344.

Challinor, A.J., Watson, J., Lobell, D.B., Howden, S.M., Smith, D.R. and Chhetri, N., 2014. A meta-analysis of crop yield under climate change and adaptation. Nature Climate Change, 4(4), pp.287-291.

Cheung, W., WL, Lam V.W.Y., Sarmiento JL, Kearney K., Watson R., Zeller D., Pauly D. 2010. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. Glob. Change Biol, 16, pp.24-3510.

Cheung, W.W., Lam, V.W., Sarmiento, J.L., Kearney, K., Watson, R. and Pauly, D., 2009. Projecting global marine biodiversity impacts under climate change scenarios. Fish and fisheries, 10(3), pp.235-251.

Cheung, W.W., Reygondeau, G. and Frölicher, T.L., 2016. Large benefits to marine fisheries of meeting the 1.5 C global warming target. Science, 354(6319), pp.1591-1594.

Chiba, Y., Prabhakar, S.V.R.K., Islam, M.A. and Akber, M.A., 2018. Priority practices for addressing non-economic loss and damages caused by cyclones in Bangladesh. International journal of disaster resilience in the built environment.

Chiba, Y., Shaw, R. and Prabhakar, S., 2017. Climate change-related non-economic loss and damage in Bangladesh and Japan. International Journal of Climate Change Strategies and Management, 9(2), pp.166-183.

Chust, G., Castellani, C., Licandro, P., Ibaibarriaga, L., Sagarminaga, Y. and Irigoien, X., 2014. Are Calanus spp. shifting poleward in the North Atlantic? A habitat modelling approach. ICES Journal of Marine Science, 71(2), pp.241-253.

Ciscar Martinez, J.C., Feyen, L., Soria Ramirez, A., Lavalle, C., Raes, F., Perry, M., Nemry, F., Demirel, H., Rózsai, M., Dosio, A. and Donatelli, M., 2014. Climate Impacts in Europe. The JRC PESETA II Project. Institute for Prospective and Technological Studies, Joint Research Centre.

Clements, J.C. and Chopin, T., 2017. Ocean acidification and marine aquaculture in North America: potential impacts and mitigation strategies. Reviews in Aquaculture, 9(4), pp.326-341.

Corburn, J., 2009. Cities, climate change and urban heat island mitigation: localising global environmental science. *Urban studies*, 46(2), pp.413-427.

Coumou, D. and Robinson, A., 2013. Historic and future increase in the global land area affected by monthly heat extremes. Environmental Research Letters, 8(3), 034018.

Craine, J.M., Elmore, A.J., Olson, K.C. and Tolleson, D., 2010. Climate change and cattle nutritional stress. Global Change Biology, 16(10), pp.2901-2911.

Cramér, H., 1999. Mathematical methods of statistics (Vol. 43). Princeton university press.

Cramer, W., Yohe, G. and Field, C.B., 2014. Detection and attribution of observed impacts. Cambridge University Press, pp.979-1037.

Creswell, J.W., 2009. Research design: Qualitative, quantitative, and mixed methods approaches. Los Angeles: University of Nebraska–Lincoln.

Cvitanovic, C., Crimp, S., Fleming, A., Bell, J., Howden, M., Hobday, A.J., Taylor, M. and Cunningham, R., 2016. Linking adaptation science to action to build food secure Pacific Island communities. Climate Risk Management, 11, pp.53-62.

Dalpadado, P., Arrigo, K.R., Hjøllo, S.S., Rey, F., Ingvaldsen, R.B., Sperfeld, E., Van Dijken, G.L., Stige, L.C., Olsen, A. and Ottersen, G., 2014. Productivity in the Barents Sea-response to recent climate variability. PloS one, 9(5).

Dannenberg, A.L., Frumkin, H., Hess, J.J. and Ebi, K.L., 2019. Managed retreat as a strategy for climate change adaptation in small communities: public health implications. Climatic Change, 153(1-2), pp.1-14.

De Rensis, F., Garcia-Ispierto, I. and López-Gatius, F., 2015. Seasonal heat stress: Clinical implications and hormone treatments for the fertility of dairy cows. Theriogenology, 84(5), pp.659-666.

Decision 1/CP. 13: Bali Action Plan. FCCC/CP/2007/6/Add.1*.

Decision 1/CP. 16: The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention. FCCC/CP/2010/7/Add.1.

Decision 2/CP. 19: Warsaw international mechanism for loss and damage associated with climate change impacts. FCCC/CP/2013/10/Add.1.

Decision 3/CP. 18: Approaches to address loss and damage associated with climate change impacts in developing countries that are particularly vulnerable to the adverse effects of climate change to enhance adaptive capacity. FCCC/CP/2012/8/Add.1

Decision 7/CP. 17: Work programme on loss and damage. FCCC/CP/2011/9/Add.2.

Di Nitto, D., Neukermans, G., Koedam, N., Defever, H., Pattyn, F., Kairo, J.G. and Dahdouh-Guebas, F., 2014. Mangroves facing climate change: landward migration potential in response to projected scenarios of sea level rise. Biogeosciences, 11(3), pp.857-871.

Diaz, R.J. and Rosenberg, R., 2008. Spreading dead zones and consequences for marine ecosystems. science, 321(5891), pp.926-929.

Doktycz, C. and Abkowitz, M., 2019. Loss and Damage Estimation for Extreme Weather Events: State of the Practice. Sustainability, 11(15), 4243.

Dolman, A.J., Van Der Werf, G.R., Van Der Molen, M.K., Ganssen, G., Erisman, J.W. and Strengers, B., 2010. A carbon cycle science update since IPCC AR-4. Ambio, 39(5-6), pp.402-412.

Donner, S.D., 2009. Coping with commitment: projected thermal stress on coral reefs under different future scenarios. PLoS One, 4(6).

Dosio, A., Mentaschi, L., Fischer, E.M. and Wyser, K., 2018. Extreme heat waves under 1.5 C and 2 C global warming. Environmental research letters, 13(5), 054006.

Dove, S.G., Kline, D.I., Pantos, O., Angly, F.E., Tyson, G.W. and Hoegh-Guldberg, O., 2013. Future reef decalcification under a business-as-usual CO2 emission scenario. Proceedings of the National Academy of Sciences, 110(38), pp.15342-15347.

Dow, K., Berkhout, F., Preston, B.L., Klein, R.J., Midgley, G. and Shaw, M.R., 2013. Limits to adaptation. *Nature Climate Change*, *3*(4), pp.305.

Edmonds, C. and Noy, I., 2018. The economics of disaster risks and impacts in the Pacific. Disaster Prevention and Management: An International Journal.

Ellison, J.C., 2014. Climate change adaptation: Management options for mangrove areas. In Mangrove Ecosystems of Asia. Springer, New York, NY, pp.391-413.

Engelbrecht, C.J. and Engelbrecht, F.A., 2016. Shifts in Köppen-Geiger climate zones over southern Africa in relation to key global temperature goals. Theoretical and applied climatology, 123(1-2), pp.247-261.

European Environment Agency, 1999. Environmental indicators: Typology and overview. European Environment Agency, Copenhagen.

European Environmental Agency, 2003. Environmental indicators: typology and use in reporting. European EnvironmentAgency, Copenhagen.

Fabricius, K.E., Langdon, C., Uthicke, S., Humphrey, C., Noonan, S., De'ath, G., Okazaki, R., Muehllehner, N., Glas, M.S. and Lough, J.M., 2011. Losers and winners in coral reefs acclimatized to elevated carbon dioxide concentrations. Nature Climate Change, 1(3), p.165.

Falkner, R., 2016. The Paris Agreement and the new logic of international climate politics. International Affairs, 92(5), pp.1107-1125.

Fankhauser, S., Dietz, S. and Gradwell, P., 2014. Non-economic losses in the context of the UNFCCC work programme on loss and damage (policy paper). London School of Economics–Centre for Climate Change Economics and Policy, Grantham Research Institute on Climate Change and the Environment.

Faust, E. and Rauch, E., 2019. Series of hot years and more extreme weather: Climate change and its consequences. [online] Munich Re. Available at: https://www.munichre.com/topics-online/en/climate-change-and-natural-disasters/climate-change/climate-change-heat-records-and-extreme-weather.html [Accessed 26 September 2019].

Fekete, A. and Sakdapolrak, P., 2014. Loss and damage as an alternative to resilience and vulnerability? Preliminary reflections on an emerging climate change adaptation discourse. International Journal of Disaster Risk Science, 5(1), pp.88-93.

Fischer, D., Thomas, S.M., Niemitz, F., Reineking, B. and Beierkuhnlein, C., 2011. Projection of climatic suitability for Aedes albopictus Skuse (Culicidae) in Europe under climate change conditions. Global and Planetary Change, 78(1-2), pp.54-64.

Fischer, D., Thomas, S.M., Suk, J.E., Sudre, B., Hess, A., Tjaden, N.B., Beierkuhnlein, C. and Semenza, J.C., 2013. Climate change effects on Chikungunya transmission in Europe: geospatial analysis of vector's climatic suitability and virus' temperature requirements. International journal of health geographics, 12(1), p.51.

Fischer, E.M. and Knutti, R., 2015. Anthropogenic contribution to global occurrence of heavy-precipitation and high-temperature extremes. Nature Climate Change, 5(6), pp.560-564.

Fisher, P.B., 2011. Climate change and human security in Tuvalu. Global Change, Peace & Security, 23(3), pp.293-313.

Food and Agriculture Organisation of the United Nations, 2005. The state of food insecurity in the world: eradicating world hunger—key to achieving the Millennium Development Goals. Rome: Food and Agricultural Organisation of the United Nations.

Food and Agriculture Organisation of the United Nations, 2016. Drought characteristics and management in the Caribbean. Rome: Food and Agricultural Organisation of the United Nations. Available at: http://www.fao.org/3/a-i5695e.pdf [Accessed 27 September 2019].

Ford, J.D., 2012. Indigenous health and climate change. American journal of public health, 102(7), pp.1260-1266.

Ford, J.D., McDowell, G. and Pearce, T., 2015. The adaptation challenge in the Arctic. Nature Climate Change, 5(12), pp.1046-1053.

Frieler, K., Meinshausen, M., Golly, A., Mengel, M., Lebek, K., Donner, S.D. and Hoegh-Guldberg, O., 2013. Limiting global warming to 2 C is unlikely to save most coral reefs. Nature Climate Change, 3(2), pp.165-170.

Gampfer, R., Bernauer, T. and Kachi, A., 2014. Obtaining public support for North-South climate funding: Evidence from conjoint experiments in donor countries. Global Environmental Change, 29, pp.118-126.

Gard, A.R. and Veitayaki, J., 2017. In the wake of Winston- climate change, mobility and resiliency in Fiji. International Journal of Safety and Security Engineering, 7(2), pp.157-168.

Gardner, T.A., Côté, I.M., Gill, J.A., Grant, A. and Watkinson, A.R., 2005. Hurricanes and Caribbean coral reefs: impacts, recovery patterns, and role in long-term decline. Ecology, 86(1), pp.174-184.

Gari, S.R., Newton, A. and Icely, J.D., 2015. A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems. Ocean & Coastal Management, 103, pp.63-77.

Gattuso, J.P., Magnan, A., Billé, R., Cheung, W.W., Howes, E.L., Joos, F., Allemand, D., Bopp, L., Cooley, S.R., Eakin, C.M. and Hoegh-Guldberg, O., 2015. Contrasting futures for ocean and society from different anthropogenic CO2 emissions scenarios. Science, 349(6243), pp. 4722.

Gawith, D., Daigneault, A. and Brown, P., 2016. Does community resilience mitigate loss and damage from climaterelated disasters? Evidence based on survey data. Journal of Environmental Planning and Management, 59(12), pp.2102-2123.

Germont Duret, C., 2017. Paris Agreement: Success or Failure, and What Next?. Climatica.

Gero, A., Fletcher, S., Rumsey, M., Thiessen, J., Kuruppu, N., Buchan, J., Daly, J. and Willetts, J., 2015. Disasters and climate change in the Pacific: adaptive capacity of humanitarian response organizations. Climate and Development, 7(1), pp.35-46.

Gero, A., Méheux, K. and Dominey-Howes, D., 2011. Integrating disaster risk reduction and climate change adaptation in the Pacific. Climate and Development, 3(4), pp.310-327.

Gerten, D., Lucht, W., Ostberg, S., Heinke, J., Kowarsch, M., Kreft, H., Kundzewicz, Z.W., Rastgooy, J., Warren, R. and Schellnhuber, H.J., 2013. Asynchronous exposure to global warming: freshwater resources and terrestrial ecosystems. Environmental Research Letters, 8(3), 034032.

Giardino, A., Nederhoff, K. and Vousdoukas, M., 2018. Coastal hazard risk assessment for small islands: assessing the impact of climate change and disaster reduction measures on Ebeye (Marshall Islands). Regional environmental change, 18(8), pp.2237-2248.

Goodin R (1991) Compensation and Redistribution. In: JW Chapman (ed.) Nomos XXXIII: Compensatory Justice. New York: New York University Press, pp.143–177.

Goodwin, P., Brown, S., Haigh, I.D., Nicholls, R.J. and Matter, J.M., 2018. Adjusting mitigation pathways to stabilize climate at 1.5 C and 2.0 C rise in global temperatures to year 2300. Earth's Future, 6(3), pp.601-615.

Gore, T., 2015. Extreme Carbon Inequality: Why the Paris climate deal must put the poorest, lowest emitting and most vulnerable people first.

Gsottbauer, E., Gampfer, R., Bernold, E. and Delas, A.M., 2018. Broadening the scope of loss and damage to legal liability: an experiment. Climate policy, 18(5), pp.600-611.

Hales, S., Kovats, S., Lloyd, S. and Campbell-Lendrum, D. eds., 2014. Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. World Health Organization.

Hallengatte, S., Green, C., Nicholls, R.J. and Corfee-Morlot, J., 2013. Future flood losses in major coastal cities. Nat. Clim. Change, 3, pp.802-806.

Handmer, J. and Nalau, J., 2019. Understanding loss and damage in Pacific Small Island developing states. In Loss and Damage from Climate Change (pp. 365-381). Springer, Cham.

Hansen, G. and Cramer, W., 2015. Global distribution of observed climate change impacts. Nature Climate Change, 5(3), p.182.

Hanson, S., Nicholls, R., Ranger, N., Hallegatte, S., Corfee-Morlot, J., Herweijer, C. and Chateau, J., 2011. A global ranking of port cities with high exposure to climate extremes. Climatic change, 104(1), pp.89-111.

Hatfield, J.L., Boote, K.J., Kimball, B.A., Ziska, L.H., Izaurralde, R.C., Ort, D., Thomson, A.M. and Wolfe, D., 2011. Climate impacts on agriculture: implications for crop production. Agronomy journal, 103(2), pp.351-370.

Heal, M.R., Heaviside, C., Doherty, R.M., Vieno, M., Stevenson, D.S. and Vardoulakis, S., 2013. Health burdens of surface ozone in the UK for a range of future scenarios. Environment international, 61, pp.36-44.

Hinkel, J., Lincke, D., Vafeidis, A.T., Perrette, M., Nicholls, R.J., Tol, R.S., Marzeion, B., Fettweis, X., Ionescu, C. and Levermann, A., 2014. Coastal flood damage and adaptation costs under 21st century sea-level rise. Proceedings of the National Academy of Sciences, 111(9), pp.3292-3297.

Hirsch, T., Kreft, S., Künzel, V., Schäfer, L., Minninger, S. and Wirsching, S., 2015. Climate-related Loss and Damage–Finding a Just Solution to the Political Challenges. Berlin: Brot für die Welt/Germanwatch/Act Alliance.

Hoegh-Guldberg, O., 2014. Coral reefs in the Anthropocene: persistence or the end of the line?. Geological Society, London, Special Publications, 395(1), pp.167-183.

Hoegh-Guldberg, O., Cai, R., Poloczanska, E.S., Brewer, P.G., Sundby, S. and Hilmi, K., 2014. The Ocean In: Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, et al., editors. Climate Change 2014: Impacts, Adaptation, and Vulnerability Part B: Regional Aspects Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change. Cambridge, United Kingdom and New York, NY.

Hollowed, A.B. and Sundby, S., 2014. INSIGHTS. science, 1251166(1084), p.344.

Hsieh, H.F. and Shannon, S.E., 2005. Three approaches to qualitative content analysis. Qualitative health research, 15(9), pp.1277-1288.

Huggel, C., Muccione, V., Carey, M., James, R., Jurt, C. and Mechler, R., 2019. Loss and Damage in the mountain cryosphere. Regional Environmental Change, 19(5), pp.1387-1399.

Hulme, M., 2014. Attributing weather extremes to 'climate change' A review. Progress in Physical Geography, 38(4), pp.499-511.

Iizumi, T., Furuya, J., Shen, Z., Kim, W., Okada, M., Fujimori, S., Hasegawa, T. and Nishimori, M., 2017. Responses of crop yield growth to global temperature and socioeconomic changes. Scientific reports, 7(1), pp.1-10.

Intergovernmental Panel on Climate Change, 2007. Climate change 2007: Synthesis report. Contribution of working groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, p.104.

Intergovernmental Panel on Climate Change, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp. Available at: http://ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf

Intergovernmental Panel on Climate Change, 2013. Information from Paleoclimate Archives. In: Climate change 2013: the physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Chapter 5.

Intergovernmental Panel on Climate Change, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on

Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland. p.151.

Intergovernmental Panel on Climate Change, 2018: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. In Press.

Intergovernmental Panel on Climate Change, 2019. About — IPCC. [online]. Available at: https://www.ipcc.ch/about/ [Accessed 17 July 2019].

Jacob, D., Kotova, L., Teichmann, C., Sobolowski, S.P., Vautard, R., Donnelly, C., Koutroulis, A.G., Grillakis, M.G., Tsanis, I.K., Damm, A. and Sakalli, A., 2018. Climate impacts in Europe under+ 1.5 C global warming. Earth's Future, 6(2), pp.264-285.

Jahn, A., 2018. Reduced probability of ice-free summers for 1.5 C compared to 2 C warming. Nature Climate Change, 8(5), pp.409-413.

Janif, S., Nunn, P., Geraghty, P., Aalbersberg, W., Thomas, F. and Camailakeba, M., 2016.Value of traditional oral narratives in building climate-change resilience:insights from rural communities in Fiji. Ecology and Society, 21(2).

Jurt, C., Brugger, J.V., Dunbar, K.W., Milch, K. and Orlove, B., 2015. Cultural values of glaciers. In the High-Mountain Cryosphere: Environmental Changes and Human Risks (pp. 90-106). Cambridge University Press.

Karnauskas, K.B., Schleussner, C.F., Donnelly, J.P. and Anchukaitis, K.J., 2018. Freshwater stress on small island developing states: population projections and aridity changes at 1.5 and 2 C. Regional environmental change, 18(8), pp.2273-2282.

Kennedy, E.V., Perry, C.T., Halloran, P.R., Iglesias-Prieto, R., Schönberg, C.H., Wisshak, M., Form, A.U., Carricart-Ganivet, J.P., Fine, M., Eakin, C.M. and Mumby, P.J., 2013. Avoiding coral reef functional collapse requires local and global action. Current Biology, 23(10), pp.912-918.

Kim, H.E., 2011. Changing climate, changing culture: adding the climate change dimension to the protection of intangible cultural heritage. International Journal of Cultural Property, 18(3), pp.259-290.

King, E., 2017. What a great time to be a climate journalist. [online] *Climate Home News*. Available at: http://www.climatechangenews.com/2017/02/10/what-a-great-time-to-be-a- climate-journalist/.

Kinoshita, Y., Tanoue, M., Watanabe, S. and Hirabayashi, Y., 2018. Quantifying the effect of autonomous adaptation to global river flood projections: application to future flood risk assessments. Environmental Research Letters, 13(1), 014006.

Kipling, R.P., Bannink, A., Bellocchi, G., Dalgaard, T., Fox, N.J., Hutchings, N.J., Kjeldsen, C., Lacetera, N., Sinabell, F., Topp, C.F. and Van Oijen, M., 2016. Modeling European ruminant production systems: facing the challenges of climate change. Agricultural Systems, 147, pp.24-37.

Kittinger, J.N., Finkbeiner, E.M., Ban, N.C., Broad, K., Carr, M.H., Cinner, J.E., Gelcich, S., Cornwell, M.L., Koehn, J.Z., Basurto, X. and Fujita, R., 2013. Emerging frontiers in social-ecological systems research for sustainability of small-scale fisheries. Current Opinion in Environmental Sustainability, 5(3-4), pp.352-357.

Knapp, J.R., Laur, G.L., Vadas, P.A., Weiss, W.P. and Tricarico, J.M., 2014. Invited review: Enteric methane in dairy cattle production: Quantifying the opportunities and impact of reducing emissions. Journal of Dairy Science, 97(6), pp.3231-3261.

Kreft, S., Eckstein, D., Junghans, L., Kerestan, C. and Hagen, U., 2014. Global climate risk index 2015: who suffers most from extreme weather events? weather-related loss events in 2013 and 1994 to 2013.

Kreft, S., Warner, K., Harmeling, S. and Roberts, E., 2013, October. Framing the loss and damage debate: A thought starter by the loss and damage in vulnerable countries initiative. In Climate change: International law and global governance. Nomos Verlagsgesellschaft mbH & Co. KG, pp.827-842.

Kristensen, P., 2004. The DPSIR framework. National Environmental Research Institute, Denmark, 10.

Krumhansl, K.A., Okamoto, D.K., Rassweiler, A., Novak, M., Bolton, J.J., Cavanaugh, K.C., Connell, S.D., Johnson, C.R., Konar, B., Ling, S.D. and Micheli, F., 2016. Global patterns of kelp forest change over the past half-century. Proceedings of the National Academy of Sciences, 113(48), pp.13785-13790.

Kumar, L. and Taylor, S., 2015. Exposure of coastal built assets in the South Pacific to climate risks. Nature Climate Change, 5(11), pp.992-996.

Kusaka, H., Suzuki-Parker, A., Aoyagi, T., Adachi, S.A. and Yamagata, Y., 2016. Assessment of RCM and urban scenarios uncertainties in the climate projections for August in the 2050s in Tokyo. Climatic Change, 137(3-4), pp.427-438.

Kusters, K. and Wangdi, N., 2013. The costs of adaptation: changes in water availability and farmers' responses in Punakha district, Bhutan. International Journal of Global Warming, 5(4), pp.387-399.

Lacoue-Labarthe, T., Nunes, P.A., Ziveri, P., Cinar, M., Gazeau, F., Hall-Spencer, J.M., Hilmi, N., Moschella, P., Safa, A., Sauzade, D. and Turley, C., 2016. Impacts of ocean acidification in a warming Mediterranean Sea: An overview. Regional Studies in Marine Science, 5, pp.1-11.

Lam, V.W., Cheung, W.W., Reygondeau, G. and Sumaila, U.R., 2016. Projected change in global fisheries revenues under climate change. Scientific Reports, 6, 32607.

Lana, M.A., Eulenstein, F., Schlindwein, S.L., Graef, F., Sieber, S. and von Hertwig Bittencourt, H., 2017. Yield stability and lower susceptibility to abiotic stresses of improved open-pollinated and hybrid maize cultivars. Agronomy for Sustainable Development, 37(4), p.30.

Larsen, J.N., Anisimov, O.A., Constable, A., Hollowed, A.B., Maynard, N. and Prestrud, P., 2014. Polar regions In: Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, et al., editors. Climate Change 2014: Impacts, Adaptation, and Vulnerability Part B: Regional Aspects Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Lehner, F., Coats, S., Stocker, T.F., Pendergrass, A.G., Sanderson, B.M., Raible, C.C. and Smerdon, J.E., 2017. Projected drought risk in 1.5 C and 2 C warmer climates. Geophysical Research Letters, 44(14), pp.7419-7428.

Lesk, C., Rowhani, P. and Ramankutty, N., 2016. Influence of extreme weather disasters on global crop production. Nature, 529(7584), pp.84-87.

Levin, K., Cashore, B., Bernstein, S. and Auld, G., 2012. Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. Policy sciences, 45(2), pp.123-152.

Levin, L.A. and Le Bris, N., 2015. The deep ocean under climate change. Science, 350(6262), pp.766-768.

Liu, W., Sun, F., Lim, W.H., Zhang, J., Wang, H., Shiogama, H. and Zhang, Y., 2018. Global drought and severe drought-affected populations in 1.5 and 2 C warmer worlds. Earth System Dynamics, 9(1), p.267.

Lusk, G., 2017. The social utility of event attribution: liability, adaptation, and justice-based loss and damage. Climatic Change, 143(1-2), pp.201-212.

Lyra, A., Imbach, P., Rodriguez, D., Chou, S.C., Georgiou, S. and Garofolo, L., 2017. Projections of climate change impacts on central America tropical rainforest. Climatic Change, 141(1), pp.93-105.

Magnuszewski, P., Sendzimir, J. and Kronenberg, J., 2005. Conceptual modeling for adaptive environmental assessment and management in the Barycz Valley, Lower Silesia, Poland. International Journal of Environmental Research and Public Health, 2(2), pp.194-203.

Mahlstein, I., Knutti, R., Solomon, S. and Portmann, R.W., 2011. Early onset of significant local warming in low latitude countries. Environmental Research Letters, 6(3), 034009.

Marzeion, B. and Levermann, A., 2014. Loss of cultural world heritage and currently inhabited places to sea-level rise. Environmental Research Letters, 9(3), 034001.

Masike, S. and Urich, P., 2008. Vulnerability of traditional beef sector to drought and the challenges of climate change: the case of Kgatleng District, Botswana.

Matthews, T.K., Wilby, R.L. and Murphy, C., 2017. Communicating the deadly consequences of global warming for human heat stress. Proceedings of the National Academy of Sciences, 114(15), pp.3861-3866.

Mayer, B., 2017. Migration in the UNFCCC workstream on loss and damage: an assessment of alternative framings and conceivable responses. Transnational Environmental Law, 6(1), pp.107-129.

Maynard, J., Van Hooidonk, R., Eakin, C.M., Puotinen, M., Garren, M., Williams, G., Heron, S.F., Lamb, J., Weil, E., Willis, B. and Harvell, C.D., 2015. Projections of climate conditions that increase coral disease susceptibility and pathogen abundance and virulence. Nature Climate Change, 5(7), pp.688-694.

McClanahan, T., Allison, E.H. and Cinner, J.E., 2015. Managing fisheries for human and food security. Fish and Fisheries, 16(1), pp.78-103.

McClanahan, T.R., Castilla, J.C., White, A.T. and Defeo, O., 2009. Healing small-scale fisheries by facilitating complex socio-ecological systems. Reviews in Fish Biology and Fisheries, 19(1), pp.33-47.

McGranahan, G., Balk, D. and B. Anderson, 2007: The rising tide: Assessing the risks of climate change and human settlements in low elevation coastal zones. Environment and Urbanization, 19(1), pp.17–37.

McIver, L., Kim, R., Woodward, A., Hales, S., Spickett, J., Katscherian, D., Hashizume, M., Honda, Y., Kim, H., Iddings, S. and Naicker, J., 2015. Health impacts of climate change in Pacific Island countries: a regional assessment of vulnerabilities and adaptation priorities. Environmental health perspectives, 124(11), pp.1707-1714.

Mcleod, E., Hinkel, J., Vafeidis, A.T., Nicholls, R.J., Harvey, N. and Salm, R., 2010. Sea-level rise vulnerability in the countries of the Coral Triangle. Sustainability Science, 5(2), pp.207-222.

McNamara, K.E. and Jackson, G., 2019. Loss and damage: A review of the literature and directions for future research. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(2), pp.564.

McShane, K., 2017. Values and harms in loss and damage. Ethics, Policy & Environment, 20(2), pp.129-142.

Mechler, R., Bouwer, L.M., Schinko, T., Surminski, S. and Linnerooth-Bayer, J., 2019. Loss and damage from climate change (p. 557). Springer Nature.

Meier, W.N., Hovelsrud, G.K., Van Oort, B.E., Key, J.R., Kovacs, K.M., Michel, C., Haas, C., Granskog, M.A., Gerland, S., Perovich, D.K. and Makshtas, A., 2014. Arctic sea ice in transformation: A review of recent observed changes and impacts on biology and human activity. Reviews of Geophysics, 52(3), pp.185-217.

Melia, N., Haines, K. and Hawkins, E., 2016. Sea ice decline and 21st century trans-Arctic shipping routes. Geophysical Research Letters, 43(18), pp.9720-9728.

Mimura, N. and Nunn, P.D., 1998. Trends of beach erosion and shoreline protection in rural Fiji. Journal of coastal research, pp.37-46.

Monioudi, I.N., Asariotis, R., Becker, A., Bhat, C., Dowding-Gooden, D., Esteban, M., Feyen, L., Mentaschi, L., Nikolaou, A., Nurse, L. and Phillips, W., 2018. Climate change impacts on critical international transportation assets of Caribbean Small Island Developing States (SIDS): the case of Jamaica and Saint Lucia. Regional Environmental Change, 18(8), pp.2211-2225.

Monnereau, I. and Abraham, S., 2013. Limits to autonomous adaptation in response to coastal erosion in Kosrae, Micronesia. International Journal of Global Warming, 5(4), pp.416-432.

Moritz, M.A., Parisien, M.A., Batllori, E., Krawchuk, M.A., Van Dorn, J., Ganz, D.J. and Hayhoe, K., 2012. Climate change and disruptions to global fire activity. Ecosphere, 3(6), pp.1-22.

Mortola, J.P., 2000. Frappell PB. Ventilatory responses to changes in temperature in mammals and other vertebrates. Annu Rev Physiol, 62, pp.847-874.

Moss, R.H., Edmonds, J.A., Hibbard, K.A., Manning, M.R., Rose, S.K., Van Vuuren, D.P., Carter, T.R., Emori, S., Kainuma, M., Kram, T. and Meehl, G.A., 2010. The next generation of scenarios for climate change research and assessment. Nature, 463(7282), pp.747-756.

Munday, P.L., Cheal, A.J., Dixson, D.L., Rummer, J.L. and Fabricius, K.E., 2014. Behavioural impairment in reef fishes caused by ocean acidification at CO 2 seeps. Nature Climate Change, 4(6), p.487.

Munich Re, 2019. Munich Re Group Annual Report 2018. [PDF] Munich: Münchener Rückversicherungs-Gesellschaft. Available at: https://www.munichre.com/site/corporate/1382025853/mr/assetpool.shared/Documents/0_Corporate_Website/Financial_Reports/2019/annual-report-2018/302-09122.pdf [Accessed 24 September 2019].

Nalau, J. and Handmer, J., 2018. Improving development outcomes and reducing disaster risk through planned community relocation. Sustainability, 10(10), p.3545.

Nicholls, R.J., Brown, S., Goodwin, P., Wahl, T., Lowe, J., Solan, M., Godbold, J.A., Haigh, I.D., Lincke, D., Hinkel, J. and Wolff, C., 2018. Stabilization of global temperature at 1.5 C and 2.0 C: implications for coastal areas. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2119), 20160448.

Niederdrenk, A.L. and Notz, D., 2018. Arctic sea ice in a 1.5 C warmer world. Geophysical Research Letters, 45(4), pp.1963-1971.

Norris, R.H., Webb, J.A., Nichols, S.J., Stewardson, M.J. and Harrison, E.T., 2011. Analyzing cause and effect in environmental assessments: using weighted evidence from the literature. Freshwater Science, 31(1), pp.5-21.

Notenbaert, A.M.O., Cardoso, J.A., Chirinda, N., Peters, M. and Mottet, A., 2017. Climate change impacts on livestock and implications for adaptation: Climate impacts on land use, food production and productivity session.

Nunn, P.D., 2009. Responding to the challenges of climate change in the Pacific Islands: management and technological imperatives. Climate Research, 40(2-3), pp.211-231.

Nunn, P.D., 2013. The end of the Pacific? Effects of sea level rise on Pacific Island livelihoods. Singapore Journal of Tropical Geography, 34(2), pp.143-171.

OECD (Organisation for Economic Cooperation and Development), 1994. Environmental Indicators – OECD Core Set, OECD Paris.

Ogden, N.H., Radojevic, M., Wu, X., Duvvuri, V.R., Leighton, P.A. and Wu, J., 2014. Estimated effects of projected climate change on the basic reproductive number of the Lyme disease vector Ixodes scapularis. Environmental health perspectives, 122(6), pp.631-638.

Olhoff, A. and Christensen, J.M., 2018. Emissions Gap Report 2018.

Ortiz, J.C., Bozec, Y.M., Wolff, N.H., Doropoulos, C. and Mumby, P.J., 2014. Global disparity in the ecological benefits of reducing carbon emissions for coral reefs. Nature Climate Change, 4(12), 1090.

Page, E.A. and Heyward, C., 2017. Compensating for Climate Change Loss and Damage. *Political Studies*, *65* (2), pp.356-372.

Pearce, T., Currenti, R., Mateiwai, A. and Doran, B., 2018. Adaptation to climate change and freshwater resources in Vusama village, Viti Levu, Fiji. Regional environmental change, 18(2), pp.501-510.

Pereira, H.M., Leadley, P.W., Proença, V., Alkemade, R., Scharlemann, J.P., Fernandez-Manjarrés, J.F., Araújo, M.B., Balvanera, P., Biggs, R., Cheung, W.W. and Chini, L., 2010. Scenarios for global biodiversity in the 21st century. Science, 330(6010), pp.1496-1501.

Portmann, F.T., Döll, P., Eisner, S. and Flörke, M., 2013. Impact of climate change on renewable groundwater resources: assessing the benefits of avoided greenhouse gas emissions using selected CMIP5 climate projections. Environmental Research Letters, 8(2), 024023.

Preston, C.J., 2017. Challenges and opportunities for understanding non-economic loss and damage. Ethics, Policy & Environment, 20(2), pp.143-155.

Puig, D, Wewerinke-Singh, M & Huq, S., 2019a. Loss and damage in COP25.

Puig, D., 2019. Climate change-induced loss and damage in small-island developing states in the Pacific: a scan of the scientific literature. Technical University of Denmark. Copenhagen.

Puig, D., Calliari, E., Hossain, M.F., Bakhtiari, F. and Huq, S., 2019b. Loss and damage in the Paris Agreement's transparency framework. Technical University of Denmark, University College London, and Independent University Bangladesh. Copenhagen, London and Dhaka.

Rasmussen, D.J., Bittermann, K., Buchanan, M.K., Kulp, S., Strauss, B.H., Kopp, R.E. and Oppenheimer, M., 2018. Extreme sea level implications of 1.5 C, 2.0 C, and 2.5 C temperature stabilization targets in the 21st and 22nd centuries. Environmental Research Letters, 13(3), 034040.

Ren, Z., Wang, D., Ma, A., Hwang, J., Bennett, A., Sturrock, H.J., Fan, J., Zhang, W., Yang, D., Feng, X. and Xia, Z., 2016. Predicting malaria vector distribution under climate change scenarios in China: challenges for malaria elimination. Scientific reports, 6(1), pp.1-13.

Rivetti, I., Fraschetti, S., Lionello, P., Zambianchi, E. and Boero, F., 2014. Global warming and mass mortalities of benthic invertebrates in the Mediterranean Sea. PloS one, 9(12).

Roberts, A.M., Tansey, C., Smithers, R.J. and Phillimore, A.B., 2015. Predicting a change in the order of spring phenology in temperate forests. Global Change Biology, 21(7), pp.2603-2611.

Roberts, E. and Andrei, S., 2015. The rising tide: migration as a response to loss and damage from sea level rise in vulnerable communities. International journal of global warming, 8(2), pp.258-273.

Rosegrant, M.W., Dey, M.M., Valmonte-Santos, R. and Chen, O.L., 2016. Economic impacts of climate change and climate change adaptation strategies in Vanuatu and Timor-Leste. Marine Policy, 67, pp.179-188.

Rosenzweig, C., Ruane, A.C., Antle, J., Elliott, J., Ashfaq, M., Chatta, A.A., Ewert, F., Folberth, C., Hathie, I., Havlik, P. and Hoogenboom, G., 2018. Coordinating AgMIP data and models across global and regional scales for 1.5 C and 2.0 C assessments. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2119), 20160455.

Rosselló-Nadal, J., 2014. How to evaluate the effects of climate change on tourism. Tourism Management, 42, pp.334-340.

Saldaña, J., 2015. The coding manual for qualitative researchers. Sage.

Salih, M.A.R.M. ed., 2009. Climate change and sustainable development: New challenges for poverty reduction. Edward Elgar Publishing.

Schäfer, L. and Kreft, S., 2014. Loss and damage: Roadmap to relevance for the Warsaw International Mechanism. Germanwatch. Available at: http://germanwatch. org/en/8366.

Schlenker, W. and Roberts, M.J., 2009. Nonlinear temperature effects indicate severe damages to US crop yields under climate change. Proceedings of the National Academy of sciences, 106(37), pp.15594-15598.

Schleussner, C.F., Lissner, T.K., Fischer, E.M., Wohland, J., Perrette, M., Golly, A., Rogelj, J., Childers, K., Schewe, J., Frieler, K. and Mengel, M., 2016. Differential climate impacts for policy-relevant limits to global warming: the case of 1.5 C and 2 C. Earth system dynamics, 7, pp.327-351.

Schmutter, K., Nash, M. and Dovey, L., 2017. Ocean acidification: assessing the vulnerability of socioeconomic systems in Small Island Developing States. *Regional environmental change*, *17*(4), pp.973-987.

Schwerdtle, P., Bowen, K. and McMichael, C., 2018. The health impacts of climate-related migration. BMC medicine, 16(1), p.1.

Scott, D. and Gössling, S., 2018. Tourism and Climate Change Mitigation. Embracing the Paris Agreement: Pathways to Decarbonisation.

Scott, D. and Verkoeyen, S., 2017. Assessing the Climate Change Risk of a Coastal-Island Destination. Global climate change and coastal tourism: recognizing problems, managing solutions and future expectations [Jones, A. and M. Phillips (eds.)]. Centre for Agriculture and Biosciences International (CABI), Wallingford, UK, pp.62-73.

Screen, J.A., Deser, C., Smith, D.M., Zhang, X., Blackport, R., Kushner, P.J., Oudar, T., McCusker, K.E. and Sun, L., 2018. Consistency and discrepancy in the atmospheric response to Arctic sea-ice loss across climate models. Nature Geoscience, 11(3), pp.155-163.

Seddon, A.W., Macias-Fauria, M., Long, P.R., Benz, D. and Willis, K.J., 2016. Sensitivity of global terrestrial ecosystems to climate variability. Nature, 531(7593), pp.229-232.

Semenza, J.C., Tran, A., Espinosa, L., Sudre, B., Domanovic, D. and Paz, S., 2016. Climate change projections of West Nile virus infections in Europe: implications for blood safety practices. Environmental Health, 15(1), p.S28.

Sendzimir, J. and Schmutz, S., 2018. Challenges in Riverine Ecosystem Management. In Riverine Ecosystem Management. Springer, Cham. pp.1-16.

Serdeczny, O.M., Bauer, S. and Huq, S., 2018. Non-economic losses from climate change: opportunities for policy-oriented research. Climate and Development, 10(2), pp.97-101.

Settele, J., Scholes, R., Betts, R.A., Bunn, S., Leadley, P., Nepstad, D., Overpeck, J., Taboada, M.A., Fischlin, A., Moreno, J.M. and Root, T., 2014. Terrestrial and inland water systems. In Climate change 2014 impacts, adaptation and vulnerability: Part A: Global and sectoral aspects. Cambridge University Press. pp. 271-360.

Shockley, K. and Hourdequin,M., 2017. Addressing the Harms of Climate Change: Making Sense of Loss and Damage. *Ethics, Policy & Environment*. 20:2, 125-128, DOI: 10.1080/21550085.2017.1342965

Siméoni, P. and Ballu, V., 2012. The Myth of the "First Climate Refugees"—Population Movement and Environmental Changes in the Torres Islands (Vanuatu, Melanesia). In Annales de géographie . Armand Colin. 3, pp.219-241

Smirnov, O., Zhang, M., Xiao, T., Orbell, J., Lobben, A. and Gordon, J., 2016. The relative importance of climate change and population growth for exposure to future extreme droughts. Climatic Change, 138(1-2), pp.41-53.

Smith, P., Price, J., Molotoks, A., Warren, R. and Malhi, Y., 2018. Impacts on terrestrial biodiversity of moving from a 2 C to a 1.5 C target. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2119), 20160456.

Spalding, M.D., Ruffo, S., Lacambra, C., Meliane, I., Hale, L.Z., Shepard, C.C. and Beck, M.W., 2014. The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. Ocean & Coastal Management, 90, pp.50-57.

Springmann, M., Mason-D'Croz, D., Robinson, S., Garnett, T., Godfray, H.C.J., Gollin, D., Rayner, M., Ballon, P. and Scarborough, P., 2016. Global and regional health effects of future food production under climate change: a modelling study. The Lancet, 387(10031), pp.1937-1946.

Steffen, W., Persson, Å., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., Crumley, C., Crutzen, P., Folke, C., Gordon, L. and Molina, M., 2011. The Anthropocene: From global change to planetary stewardship. Ambio, 40(7), p.739.

Steinberg, D.K., Ruck, K.E., Gleiber, M.R., Garzio, L.M., Cope, J.S., Bernard, K.S., Stammerjohn, S.E., Schofield, O.M., Quetin, L.B. and Ross, R.M., 2015. Long-term (1993–2013) changes in macrozooplankton off the Western Antarctic Peninsula. Deep Sea Research Part I: Oceanographic Research Papers, 101, pp.54-70.

Stern, D., 2014. IPCC Report - Censorship Or Spin?. [online] Crawford School of Public Policy. Available at: https://crawford.anu.edu.au/news-events/news/3951/ipcc-report-censorship-or-spin [Accessed 31 March 2020].

Stocker, T. and Johnsen, S., 2003: A minimum thermodynamic model for the bipolar seesaw. *Paleoceanography*, 18(4).

Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M., 2013. Climate change 2013: The physical science basis. Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change, 1535.

Surminski, S. and Lopez, A., 2015. Concept of loss and damage of climate change–a new challenge for climate decision-making? A climate science perspective. Climate and Development, 7(3), pp.267-277.

Tainio, M., Juda-Rezler, K., Reizer, M., Warchałowski, A., Trapp, W. and Skotak, K., 2013. Future climate and adverse health effects caused by fine particulate matter air pollution: case study for Poland. Regional environmental change, 13(3), pp.705-715.

Takakura, J.Y., Fujimori, S., Takahashi, K., Hijioka, Y., Hasegawa, T., Honda, Y. and Masui, T., 2017. Cost of preventing workplace heat-related illness through worker breaks and the benefit of climate-change mitigation. Environmental Research Letters, 12(6), 064010.

Tanoue, M., Hirabayashi, Y. and Ikeuchi, H., 2016. Global-scale river flood vulnerability in the last 50 years. Scientific reports, 6, 36021.

Taub, J., Nasir, N., Rahman, M.F. and Huq, S., 2016. From Paris to Marrakech: Global politics around loss and damage. India Quarterly, 72(4), pp.317-329.

Taylor, M.A., Clarke, L.A., Centella, A., Bezanilla, A., Stephenson, T.S., Jones, J.J., Campbell, J.D., Vichot, A. and Charlery, J., 2018. Future Caribbean climates in a world of rising temperatures: the 1.5 vs 2.0 dilemma. Journal of Climate, 31(7), pp.2907-2926.

Terry, J.P. and Chui, T.F.M., 2012. Evaluating the fate of freshwater lenses on atoll islands after eustatic sea-level rise and cyclone-driven inundation: A modelling approach. Global and Planetary Change, 88, pp.76-84.

Thackeray, S.J., Henrys, P.A., Hemming, D., Bell, J.R., Botham, M.S., Burthe, S., Helaouet, P., Johns, D.G., Jones, I.D., Leech, D.I. and Mackay, E.B., 2016. Phenological sensitivity to climate across taxa and trophic levels. Nature, 535(7611), pp.241-245.

The Global Carbon Project, 2017. Emissions in context of future scenarios by the Global Carbon Project. [online]. Available at: https://www.globalcarbonproject.org/carbonbudget/ [Accessed 16 June 2019]

Thomas, A. and Benjamin, L., 2018a. Management of loss and damage in small island developing states: implications for a 1.5 C or warmer world. Regional environmental change, 18(8), pp.2369-2378

Thomas, A. and Benjamin, L., 2018b. Policies and mechanisms to address climate-induced migration and displacement in Pacific and Caribbean small island developing states. International Journal of Climate Change Strategies and Management, 10(1), pp.86-104.

Thomas, A.S., Mangubhai, S., Vandervord, C., Fox, M. and Nand, Y., 2019. Impact of Tropical Cyclone Winston on women mud crab fishers in Fiji. Climate and Development, 11(8), pp.699-709.

Thompson, A. and Otto, F.E., 2015. Ethical and normative implications of weather event attribution for policy discussions concerning loss and damage. Climatic Change, 133(3), pp.439-451.

Tobin, I., Greuell, W., Jerez, S., Ludwig, F., Vautard, R., Van Vliet, M.T.H. and Breón, F.M., 2018. Vulnerabilities and resilience of European power generation to 1.5 C, 2 C and 3 C warming. Environmental Research Letters, 13(4), 044024.

Traore, S. and Owiyo, T., 2013. Dirty droughts causing loss and damage in Northern Burkina Faso. International Journal of Global Warming, 5(4), pp.498-513.

Trenberth, K.E., Fasullo, J.T. and Shepherd, T.G., 2015. Attribution of climate extreme events. Nature Climate Change, 5(8), p.725.

Tschakert, P., Barnett, J., Ellis, N., Lawrence, C., Tuana, N., New, M., Elrick-Barr, C., Pandit, R. and Pannell, D., 2017. Climate change and loss, as if people mattered: values, places, and experiences. Wiley Interdisciplinary Reviews: Climate Change, 8(5), p.476.

Tuana, N., 2017. Ethically Valuing the Future: Non-Market Loss and Damage in the Context of Climate Change. *Geo. JL & Pub. Pol'y*, *15*, pp.979.

Turner, J., Barrand, N.E., Bracegirdle, T.J., Convey, P., Hodgson, D.A., Jarvis, M., Jenkins, A., Marshall, G., Meredith, M.P., Roscoe, H. and Shanklin, J., 2014. Antarctic climate change and the environment: an update. Polar Record, 50(3), pp.237-259.

United Nations Framework Convention on Climate Change, 2012. A literature review on the topics in the context of thematic area 2 of the work programme on loss and damage: a range of approaches to address loss and damage associated with the adverse effects of climate change. Note by the secretariat. UNFCCC. Available at: https://unfccc.int/documents/7427.

United Nations Framework Convention on Climate Change, 2013. *Non-economic Losses in the Context of the Work Programme on Loss and Damage*. UNFCCC. Retrieved from http://UNFCCC,.int/resource/docs/2013/tp/02.pdf

United Nations Framework Convention on Climate Change, 2014. *Report of the Conference of the Parties on its Nineteenth Session, Held in Warsaw from 11 to 23 November 2013. Part two: Action Taken by the Conference of the Parties at Its Nineteenth Session*. Geneva: UNFCCC.

United Nations Framework Convention on Climate Change, 2015. '*Adoption of the Paris Agreement'* (Draft decision-/CP.21) (FCCC/CP/2015/L.9/Rev.1).

United Nations Framework Convention on Climate Change, 2018. Loss and damage: Online guide. Available at: https://unfccc.int/sites/default/files/resource/online_guide_on_loss_and_damage-dec_2017.pdf [Accessed 29 September 2019].

United Nations Framework Convention on Climate Change, B.A.P. and Plan, B.A., 2007. Decision 1/CP. 13. COP13, Bali, Indonesia.

United Nations. 2020. About the Sustainable Development Goals - United Nations Sustainable Development Goals. [online] Available at: https://www.un.org/sustainabledevelopment/sustainable-development-goals/ [Accessed 13 May 2020].

United Nations., 2020. World Economic Situation and Prospects 2020, UN, New York. ISBN: 978-92-1-109181-6. Available at: https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/WESP2020_FullReport.pdf [Accessed 2 February 2020].

van Bruggen, A.H., Jones, J.W., Fernandes, J.M.C., Garrett, K. and Boote, K.J., 2015. Crop diseases and climate change in the AgMIP framework. Handbook of Climate Change and Agroecosystems: The Agricultural Model Intercomparison and Improvement Project (AgMIP) Integrated Crop and Economic AssessmentsICP Series on Climate Change Impacts, Adaptation, and Mitigation, 3.

van der Geest, K. and Warner, K., 2015. Loss and damage from climate change: emerging perspectives. *International Journal of Global Warming*, 8(2), pp.133-140.

van der Geest, K. and Warner, K., 2019. Loss and damage in the IPCC Fifth Assessment Report (Working Group II): a text-mining analysis. Climate Policy, pp.1-14.

Van Vliet, M.T.H., Van Beek, L.P.H., Eisner, S., Flörke, M., Wada, Y. and Bierkens, M.F.P., 2016. Multi-model assessment of global hydropower and cooling water discharge potential under climate change. Global Environmental Change, 40, pp.156-170.

Vanhala, L. and Hestbaek, C., 2016. Framing climate change loss and damage in UNFCCC negotiations. *Global Environmental Politics*, *16*(4), pp.111-129.

Vautard, R., Gobiet, A., Sobolowski, S., Kjellström, E., Stegehuis, A., Watkiss, P., Mendlik, T., Landgren, O., Nikulin, G., Teichmann, C. and Jacob, D., 2014. The European climate under a 2 C global warming. Environmental Research Letters, 9(3), p.034006.

Verheyen, R., 2015. Loss and damage due to climate change: attribution and causation-where climate science and law meet. International Journal of Global Warming, 8(2), pp.158-169.

Vitali, A., Segnalini, M., Bertocchi, L., Bernabucci, U., Nardone, A. and Lacetera, N., 2009. Seasonal pattern of mortality and relationships between mortality and temperature-humidity index in dairy cows. Journal of Dairy Science, 92(8), pp.3781-3790.

Vogel, M.M., Orth, R., Cheruy, F., Hagemann, S., Lorenz, R., van den Hurk, B.J. and Seneviratne, S.I., 2017. Regional amplification of projected changes in extreme temperatures strongly controlled by soil moisture-temperature feedbacks. Geophysical Research Letters, 44(3), pp.1511-1519.

Vulturius, G. and Davis, M., 2016. Defining Loss and Damage: The Science and Politics Around One of the Most Contested Issues within the UNFCCC. Discussion Brief. Stockholm Environment Institute, Stockholm.

Warner, K. and van der Geest, K., 2013. Loss and damage from climate change: local-level evidence from nine vulnerable countries. *International Journal of Global Warming*, *5*(4), pp.367-386.

Warner, K., 2012. Human migration and displacement in the context of adaptation to climate change: the Cancun Adaptation Framework and potential for future action. Environment and Planning C: Government and Policy, 30(6), pp.1061-1077.

Warner, K., van der Geest, K., Huq, S., Harmeling, S., Kusters, K., de Sherbinin, A. and Kreft, S., 2012. Evidence from the frontlines of climate change: Loss and damage to communities despite coping and adaptation. *United Nations University-Institute for Environment and Human Security (UNU-EHS)*.

Warren, R., Price, J., Graham, E., Forstenhaeusler, N. and VanDerWal, J., 2018. The projected effect on insects, vertebrates, and plants of limiting global warming to 1.5 C rather than 2 C. Science, 360(6390), pp.791-795.

Warszawski, L., Friend, A., Ostberg, S., Frieler, K., Lucht, W., Schaphoff, S., Beerling, D., Cadule, P., Ciais, P., Clark, D.B. and Kahana, R., 2013. A multi-model analysis of risk of ecosystem shifts under climate change. Environmental Research Letters, 8(4), p.044018.

Weatherdon, L.V., Magnan, A.K., Rogers, A.D., Sumaila, U.R. and Cheung, W.W., 2016. Observed and projected impacts of climate change on marine fisheries, aquaculture, coastal tourism, and human health: an update. Frontiers in Marine Science, 3, p.48.

Webb, J.A., Schofield, K., Peat, M., Norton, S.B., Nichols, S.J. and Melcher, A., 2017. Weaving common threads in environmental causal assessment methods: toward an ideal method for rapid evidence synthesis. *Freshwater Science*, 36(1), pp.250-256.

Webster, J. and Watson, R.T., 2002. Analyzing the past to prepare for the future: Writing a literature review. *MIS quarterly*, pp.xiii-xxiii.

Webster, N.S., Uthicke, S., Botté, E.S., Flores, F. and Negri, A.P., 2013. Ocean acidification reduces induction of coral settlement by crustose coralline algae. Global Change Biology, 19(1), pp.303-315.

Wee, B.V. and Banister, D., 2016. How to write a literature review paper?. *Transport Reviews*, *36*(2), pp.278-288.

Wehner, M.F., Reed, K.A., Loring, B., Stone, D. and Krishnan, H., 2018. Changes in tropical cyclones under stabilized 1.5 and 2.0° C global warming scenarios as simulated by the Community Atmospheric Model under the HAPPI protocols. Earth System Dynamics, 9(1).

Wong, P.P., Losada, I.J., Gattuso, J.P., Hinkel, J., Khattabi, A., McInnes, K.L., Saito, Y. and Sallenger, A., 2014. Coastal systems and low-lying areas. Climate change, 2104, pp.361-409.

World Health Organisation, 2008. Protecting Health from Climate Change- World Health Day 2008. World Health Organisation, Geneva. ISBN 9789241596527.

Wrathall, D.J., Oliver-Smith, A., Fekete, A., Gencer, E., Reyes, M.L. and Sakdapolrak, P., 2015. Problematising loss and damage. *International Journal of Global Warming*, *8*(2), pp.274-294.

Yumashev, D., Hussen, K., Gille, J. and Whiteman, G., 2017. Towards a Balanced View of Arctic Shipping: Estimating Economic Impacts of Emissions from Increased Traffic on the Northern Sea Route. Climatic Change, 143(5), pp.143–155.

Zhao, C., Liu, B., Piao, S., Wang, X., Lobell, D.B., Huang, Y., Huang, M., Yao, Y., Bassu, S., Ciais, P. and Durand, J.L., 2017. Temperature increase reduces global yields of major crops in four independent estimates. Proceedings of the National Academy of Sciences, 114(35), pp.9326-9331.

Zhao, Y., Sultan, B., Vautard, R., Braconnot, P., Wang, H.J. and Ducharne, A., 2016. Potential escalation of heat-related working costs with climate and socioeconomic changes in China. Proceedings of the National Academy of Sciences, 113(17), pp.4640-4645.

Zhu, C., Kobayashi, K., Loladze, I., Zhu, J., Jiang, Q., Xu, X., Liu, G., Seneweera, S., Ebi, K.L., Drewnowski, A. and Fukagawa, N.K., 2018. Carbon dioxide (CO2) levels this century will alter the protein, micronutrients, and vitamin content of rice grains with potential health consequences for the poorest rice-dependent countries. Science advances, 4(5), pp.1012. Lehner, F., Coats, S., Stocker, T.F., Pendergrass, A.G., Sanderson, B.M., Raible, C.C. and Smerdon, J.E., 2017. Projected drought risk in 1.5 C and 2 C warmer climates. Geophysical Research Letters, 44(14), pp.7419-7428.

10. Appendix A

Table A.1: Text Analytics data

Term	Substitutions	Absolute Occurrence	Occurrence per paragraph
1.5°C	-	1975	1366
2°C	-	890	677
Loss	-	240	184
Damage	-	94	75
Agriculture	-	236	198
Biodiversity	-	102	85
Communities	-	181	166
Coral	-	95	66
Crop	-	146	113
Economic	GDP	415	342
Ecosystem	-	339	269
Fish	Fisheries, Aquaculture	101	64
Food	-	343	245
Forest	Rainforest	177	124
Freshwater	-	32	30
Glacier	-	17	13
Habitat	-	21	17
Health	-	157	133
Human	-	254	229
Ice	-	175	106
Infrastructure	-	192	172
Livelihood	-	81	75
Nature	-	212	183
Ocean	-	246	181
People	-	180	151
Population	-	154	125
Social	-	180	158
Species	-	86	64
Terrestrial	-	56	51
Tourism	-	59	25
Urban	Cities	356	243

11. Appendix B

DPSIR Framework References

Table B.1: Driving Forces References

Driving Forces	References
[1]Poor socio-economic conditions	McIver et al., 2015; Rosegrant et al., 2016
[2]Limited livelihood options	Fisher, 2011; Schmutter et al., 2017
[3]Population growth	Allen, 2015; Karnauskas et al., 2018
[4]Weak institutional and regulatory framework	Barnett, 2001; Betzold, 2015; Gero et al., 2015
[5]Ineffective and maladaptive policies	Gero et al., 2011; Thomas and Benjamin, 2018a; Thomas and Benjamin, 2018b
[6]Increased frequency and intensity of extreme weather events	Gard and Veitayaki, 2017; Handmer and Nalau, 2019
[7]Slow-onset events and associated threats	Mcleod et al., 2010; Mimura and Nunn, 1998; Monnereau and Abraham, 2013; Siméoni and Ballu, 2012

Table B.2: Pressures References

Pressures	References
[8]Droughts	Pearce et al., 2018; Thomas et al., 2019
[9]Cyclones	Mcleod et al., 2010; Brown et al., 2017
[10]Floods	Brown et al., 2018; Gard and Veitayaki, 2017; Siméoni and Ballu, 2012
[11]Climate change induced aridity	Karnauskas et al., 2018

[12]Temperature stress, marine and terrestrial	Bell et al., 2013b; Fabricius et al., 2011
[13]Climate change induced sea level rise	Handmer and Nalau, 2019; Mcleod et al., 2011
[14]Increased pressure on land owing to agriculture	Allen, 2015; Barnett, 2011
[15]Ocean Acidification	Fabricius et al., 2011; Munday et al., 2014; Schmutter et al., 2017

Table B.3: State References

State	References
Physical Environment	
[16]Shoreline recession	Albert et al., 2016.
[17]Temperature Stress	Bell et al., 2013b; Fabricius et al., 2011
[18]Salinization of groundwater	Terry and Chui, 2012; Nunn, 2009
Ecosystems	
[19]Change in distribution of tuna stock	Bell et al., 2013a; Bell et al., 2013b
[20]Decline in coral reefs, coastal fisheries and mariculture	Bell et al., 2013a; Rosegrant et al., 2016
[21]Increase in occurrence of extreme weather events	Handmer and Nalau, 2019; Thomas and Benjamin, 2018a
Human Settlements	
[22]Settlement encroachment	Albert et al., 2016; Giardino et al., 2018; Terry and Chui, 2012
[23]Material and intangible losses	Adger et al., 2013; Brown et al., 2018; Dannenberg et al., 2019; Janif et al., 2016; McIver et al., 2015; Nunn, 2013

Table B.4: Impacts References

Impacts	References
[24]Reduced availability of freshwater	Karnauskas et al., 2018; Terry and Chui, 2012
[25]Declining well-being	Fisher, 2011; Pearce et al., 2018
[26]Human health impacts, stress and psychological problems, access to health facilities	Dannenberg et al., 2019; Schwerdtle et al., 2018
[27]Loss of culture, identity, community cohesion and sense of place	Adger et al., 2013; Allgood et al., 2017; Roberts and Andrei, 2015.
[28]Damages associated with flooding, financial costs associated with economic losses, emotional impacts associated with non-economic losses	Birk et al., 2014; Brown et al., 2017; Dannenberg et al., 2019; Schwerdtle et al., 2018; Siméoni et al., 2012
[29]Loss of livelihoods, difficulty in sustaining traditional coastal livelihoods	Handmer and Nalau, 2019; Nunn, 2013; Pearce et al., 2018; Thomas et al., 2019
[30]Degraded ecosystems	Bell et al., 2013a; Fabricius et al., 2011; Mcleod et al., 2010; Ortiz et al., 2014

Table B.5: SDG linkages with DPSIR Framework on slow-onset events

	SDG	Target
Pressures	**1.5**	By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters
	13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
	13.2	Integrate climate change measures into national policies, strategies and planning
	13.3	Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
	13.a	Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to

		address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
	13.b	Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities
	14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
	14.3	Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels
	14.5	By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
	15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
State	**3.d**	Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks
	9.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
	9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
	11.3	By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries
	11.5	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
	13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
	14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
	14.5	By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information

	14.6	By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiationc
	14.7	By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism
	14.a	Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries
	14.b	Provide access for small-scale artisanal fishers to marine resources and markets
	14.c	Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"
	15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
	15.2	By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally
	15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
	15.5	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
	15.9	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
	15.a	Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
Impacts	**1.4**	By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance

	3.3	By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases
	3.8	Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all
	3.c	Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States
	3.d	Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks
	6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
	6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
	6.5	By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
	6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
	8.9	By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products
	8.10	Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all
	9.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
	9.3	Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets
	9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
	9.a	Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States
	11.4	Strengthen efforts to protect and safeguard the world's cultural and natural heritage
	11.5	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses

		relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
	11.b	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
	11.c	Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials
	12.2	By 2030, achieve the sustainable management and efficient use of natural resources
	12.b	Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products
	13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
	13.2	Integrate climate change measures into national policies, strategies and planning
	13.3	Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
	13.a	Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
	13.b	Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities
	14.b	Provide access for small-scale artisanal fishers to marine resources and markets
	15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
	15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
	15.5	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
	15.6	Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed

	15.9	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
	15.a	Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
	17.6	Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism
	17.7	Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed
	17.9	Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation
	17.18	By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts
	17.19	By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries

Table B.6: SDG linkages with DPSIR Framework on extreme weather events

	SDG	Target
Pressures	**2.4**	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality
	13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
	13.2	Integrate climate change measures into national policies, strategies and planning
	13.3	Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
	13.a	Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to

		address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
	13.b	Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities
	15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
State	**1.5**	By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic
	3.d	By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters
	9.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
	9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
	11.3	By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries
	11.5	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
	13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
	14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
	14.5	By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
	14.a	Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of

		developing countries, in particular small island developing States and least developed countries
	14.c	Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"
	15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
	15.5	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
Impacts	**1.4**	By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance
	3.3	By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases
	3.8	Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all
	3.c	Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States
	3.d	Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks
	6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
	6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
	6.5	By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
	6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
	8.9	By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products
	8.10	Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all
	9.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic

		development and human well-being, with a focus on affordable and equitable access for all
	9.3	Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets
	9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
	9.a	Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States
	11.4	Strengthen efforts to protect and safeguard the world's cultural and natural heritage
	11.5	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
	11.b	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
	11.c	Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials
	12.2	By 2030, achieve the sustainable management and efficient use of natural resources
	12.b	Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products
	13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
	13.2	Integrate climate change measures into national policies, strategies and planning
	13.3	Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
	13.a	Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
	13.b	Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small

		island developing States, including focusing on women, youth and local and marginalized communities
	14.b	Provide access for small-scale artisanal fishers to marine resources and markets
	15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
	15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
	15.5	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
	15.6	Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed
	15.9	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
	15.a	Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
	17.6	Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism
	17.7	Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed
	17.9	Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation
	17.18	By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts
	17.19	By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries

12. Affirmation

I certify, that the master thesis was written by me, not using sources and tools other than quoted and without use of any other illegitimate support.

Furthermore, I confirm that I have not submitted this master thesis either nationally or internationally in any form.

Vienna, 20th of May 2020

Mrinalini Cariappa