Exploring preconditions for effective global responses to climate change

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Declaration of authorship

I, Jeremy Winston Webb, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Abstract

The global response to climate change depends on you… and everyone else. The decisions we make, for better or worse, contribute to the global response. This study explores decision making, climate change signals and responses, actors and interests, and the “conditions” under which we might limit climate change and related impacts.

Twenty-seven experts from around the world were asked to provide scenarios where the global response succeeds or fails to limit climate change and related impacts (i.e. the UNFCCC objective). From their responses, 175 scenarios were compiled forming a “searchable sample of possible futures”. Themes included social change and behaviour, political will and policy, business and economic activity. For these themes, multiple “pathways” were mapped. The study focused on pathways towards effective global responses (i.e. fulfilling the UNFCCC objective) and understanding the most important elements of the response system.

The study finds there is a “crisis of response” that risks becoming a “crisis of impacts”. The signal that drives effective responses (i.e. impacts on people, property and livelihoods) was undetectable, is detectable now, and is rapidly strengthening. As such, timely global responses at scale are essential. Other preconditions include a mix of ambition and serendipity.

From the analysis of effective response scenarios, serendipitous preconditions include the scale of climate change and related impacts being limited and reversible meanwhile unexpected events help limit climate change or related impacts. Ambition driven preconditions include global responses being timely with adaptation, mitigation and atmospheric GHG removals at scale, and having contingencies available in case of extreme climate change or other unexpected events. The transformative scale of required responses means social permissions and leadership are essential, as are coalitions of actors with the capacity to apply technologies and practices (policies included) and power to ensure each of us are contributing towards effective global responses.

Impact statement

The future is uncertain at the best of times, but climate change threatens to push natural, managed and human systems into a temperature and climate regime not experienced since before humans evolved. As a collective action problem, the global response to climate change depends on your contributions and everyone else's, regardless of whether they consider climate change in their decisions or not. In short, your climate strategy needs to consider other actors and the contributions they might make to climate change, in addition to climate change impacts, risks and response options.

When it comes to climate action, the Intergovernmental Panel on Climate Change (IPCC) provides summaries of climate change impacts and risks as well as adaptation and mitigation actions that might be taken. This study complements IPCC assessments and provides a set of qualitative models, scenarios and preconditions for social, political or business leaders, individuals and organisations, to consider when developing response strategies including nationally determined contributions (NDCs). These models and scenarios provide a basis for exploring the contributions an individual, organisation or jurisdiction can make to the global response, comparing this with the responses other actors might make, and considering contingencies in case of other scenarios. Preconditions for effective global responses to climate change provide a checklist of things that need to be considered when developing a response strategy.

Important qualitative models developed in this study include the Climate Change National Interests International Cooperation (CCNIIC) Model and climate change signal response models. The CCNIIC Model makes it possible to identify and consider the climate change system as a whole, including how climate change and related hazards might influence actors and interests. The CCNIIC Model also addresses national interests and international cooperation, including response options made available to state and non-state actors and possible sanctions. Meanwhile, climate change signal response models provide a typology of climate change signals to consider, and types of responses actors might make including underlying decision criteria.

With regards to scenarios, the study provides a sample of possible futures addressing: climate change impacts and risks; social, political and business responses; issues of power and capacity; technologies, practices and policies; domestic and international coalitions; international cooperation; and, other scenarios. As such, a strategy can be stress tested against a range of climate change scenarios.

Importantly, the preconditions for effective global responses identified in the study provide an essential checklist of issues that response strategies and NDCs need to consider. This includes the extent to which a response strategy is willing to rely on serendipity, the coalitions they might consider, and assumptions regarding technologies, practices and policies.

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List of acronyms

AFOLU – Agriculture, Forestry and Other Land Use

AILAC - Independent Association of Latin America and the Caribbean

AR5 – IPCC's Fifth Assessment Report

ASEAN – Association of Southeast Asian Nations

BASIC - Brazil, South Africa, India and China

BAU – Business as Usual

BC – Black Carbon

BCBS – Basel Committee on Banking Supervision

BECCS – Bioenergy with Carbon Capture and Storage

BOE – Bank of England

BRICS – Brazil, India, China and South Africa

C – Celsius

C40 – Cities Climate Leadership Group

CACAM - Central Asia, Caucasus, Albania and Moldova Group

CCNIIC – Climate Change, Nation Interests, International Cooperation Model

CCS – Carbon Capture and Storage

CDR – Carbon Dioxide Removals

CfRN – Coalition for Rainforest Nations

CFS – Committee on World Food Security (Food and Agriculture Organisation)

CH_4 – Methane

CIA – Central Intelligence Agency (United States)

CMA – Conference of the Parties serving as the meeting of the Parties to the Paris Agreement

CMIP5 – Coupled Model Inter-comparison Project Phase 5

CMP – Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol

CO – Carbon monoxide

CO_2 – Carbon dioxide

COP – Conference of Parties to the UNFCCC

CSC – Civil Service College (Singapore)

CSF – Centre for Strategic Futures (Singapore)

EIG – Environmental Integrity Group

ENI – Environment and National Interests Model

EPSRC – Engineering and Physical Sciences Research Council

EU – European Union

EVs – Electric Vehicles

FAO – Food and Agriculture Organisation (United Nations)

G7 – Group of 7 major developed economies

G-77 – Group of 77

GATT – General Agreement on Tariffs and Trade

GCF – Green Climate Fund

GDP – Gross Domestic Product

GHG – Greenhouse Gas

GOS – Government Office of Science (United Kingdom)

Gt – Gigatonnes

H_2O – Water

IAEA – International Atomic Energy Agency

IAMC – Integrated Assessment Modelling Consortium

IAMs – Integrated Assessment Models

IAMs – Integrated Assessment Models

IEGL – Institute for Ethics, Governance and Law (Griffith University)

IMF – International Monetary Fund

INDC – Intended Nationally Determined Contribution

IPCC – Intergovernmental Panel on Climate Change

IRENA – International Renewable Energy Agency

LDCs – Least Developed Countries

LUC – Land Use Change

LWR – Longwave Radiation

MDBs – Multilateral Development Banks

MEF – Major Economies Forum on Energy and Climate

MOC – Atlantic Meridional Overturning Circulation

N_2O – Nitrous oxide

NA – Not Applicable

NAMAs – Nationally Appropriate Mitigation Actions

NAPAs – National Adaptation Programmes of Action

NDCs - Nationally Determined Contributions

NO_x – Nitrogen dioxide and nitrous oxide

NPV – Net Present Value

O_3 – Ozone

OC – Organic carbon

OECD – Organisation for Economic Cooperation and Development

OPEC – Organization of the Petroleum Exporting Countries

PA – Paris Agreement

R&D – Research and development

RCPs – Representative Concentration Pathways

REDD+ – Reducing Emissions from Deforestation and Degradation in Developing Countries

RFCs - Reasons for Concern

SBI – Subsidiary Body for Implementation (UNFCCC)

SBSTA - Subsidiary Body for Scientific and Technological Advice (UNFCCC)

SDG's – Sustainable Development Goals (United Nations)

SIDs - Small Island Developing States

SLCP – Short-Lived Climate Pollutants

SLR – Sea Level Rise

SO_2 – Sulphur dioxide

SRM – Solar Radiation Management

SSPs – Shared Socio-economic Pathways

STEaPP – Department of Science, Technology, Engineering and Public Policy (UCL)

SWR – Shortwave Radiation

TCFD – Taskforce on Climate Related Financial Disclosures

ToC – Theory of Change

UCL – University College London

UK – United Kingdom of Great Britain and Northern Ireland

UN – United Nations

UN IOs – United Nations International Organisations

UNDP – United Nations Development Programme

UNEP – United Nations Environment Programme

UNFCCC – United Nations Framework Convention on Climate Change

UNGA – United Nations General Assembly

UNSC – United Nations Security Council

UNSG – United Nations Secretary General

UNTC – United Nations Treaty Collection

US – United States

Wm-2 – Watts per square meter

WMGHG – Well mixed greenhouse gas

WTO – World Trade Organisation

Part I: Framing the issue

Part I: Framing the issue consists of two chapters:

Chapter 1 introduces the study including background information, research questions and an outline of the thesis.

Chapter 2 consists of a literature review including climate change and related issues, a summary of options for addressing climate change, a description of the actors involved, as well as the institutions established to address climate change.

Chapter 1 Introduction

1.1 Introduction

Anthropogenic climate change is measurable and unequivocal generating risks and impacts on natural, managed and human systems, some of which are positive but many of which are negative including potentially catastrophic risks (IPCC 2014a). Furthermore, climate change is a problem of collective action (IPCC 2014a) requiring a global response (Stavins et al. 2014, IPCC 2018a) that is nothing short of transformational to limit global warming to well below 2°C (Rogelj et al. 2018). According to the United Nations Intergovernmental Panel on Climate Change (IPCC) climate change related “reasons for concern” are currently undetectable to moderate with 1°C of global warming, but will be moderate to high when there is 1.5°C of global warming, which is expected to happen sometime between 2030 and 2052 (IPCC 2018a). As such the impact of climate change on human and managed systems is expected to grow, but how this influences the global response to climate change is deeply uncertain. For example, it is not known: to what extent increased climate change impacts on human and managed systems might be a problem; the extent to which these impacts might influence the ambition levels of actors; or, the actions these different actors might take.

There is a large body of literature on climate change and related options for addressing climate change which has been assessed in successive IPCC reports (e.g. IPCC 2001, IPCC 2007, IPCC 2014a, IPCC 2018a). This includes scenarios, for example emissions pathways (Moss et al. 2010) or socio-economic pathways (O’Neill et al. 2017). Because climate change requires collective action between actors around the globe, it is important to address climate change taking a global perspective. The reason being the response of one actor can be undermined by the actions of other actors. It is also important to note that the United Nations Framework Convention on Climate Change (UNFCCC) does not represent the global response to climate change. It is only one part of the global response. The most important part of the global response are actions, and inaction, at national and subnational levels. With these things in mind, this study takes a global perspective and focuses on a gap in the literature, consisting of: the actors involved in the global response to climate change; their decision making criteria; and, the conditions under which actors would individually or collectively do what it takes to limit climate change and its impacts.

Given that climate change is an unprecedented challenge, with many actors, ambition levels, and possible responses to climate change, it would be nice to have something a bit like a crystal ball allowing us to ask questions, look into the future and explore not just one possible future, but the range of possible scenarios. Instead of using a crystal ball, the study interviewed 27 people from around the world involved in climate change and related issues, and from these interviews formed a searchable sample of 175 possible futures.

Metaphorically speaking, the searchable sample of possible futures is a bit like having a crystal ball. For any question, a keyword can be typed in and a range of relevant scenarios are identified, including success, failure and other scenarios. As such, it is possible to look at, and explore, the range of possible conditions that might lead to effective global responses to climate change including the actors involved and the actions taken.

1.2 Scope of the study

Treating climate change as a collective action problem (IPCC 2014a) means the scope of the study includes: climate change; related risks and impacts; the actors that might be affected; the actors and actions that contribute to the global response to climate change; and, the institutions that influence the global response, including international agreements.

Effective responses to climate change can only be assessed at the global level, hence, this study takes a global perspective treating the global response to climate change as a single system with many possible elements. The most relevant literature, upon which this study builds, consists of IPCC assessments, other United Nations documents, as well as articles regarding global mitigation and adaptation pathways including relevant technologies and practices, representative concentration pathways and shared socio-economic pathways.

The study also draws upon, and develops, concepts and methods from a range of disciplines including international relations, finance, economics, risk management and futures studies. In some ways each discipline is like the metaphorical blind person feeling the elephant. Individually, each person feels something different because they are exploring different parts of the same system, but taken together, they describe the elephant (Go and Carroll 2004, Evans 2006). Because this study explores the whole of the global response system, the study takes an interdisciplinarity approach drawing upon whatever concepts and methods help understand and describe the system.

Another important aspect of the study is stepping back, so the entire system can be observed and described. The parable of the blind people feeling the elephant works because those people fortunate enough to be sighted can stand back from the situation and see how each part the elephant fits to form the whole (Go and Carroll 2004, Evans 2006, Kleineberg 2013). This is analogous to the use of remote sensing, for example satellite imagery, where large features can be observed and identified that would otherwise be very difficult to identify from observations much closer to the ground (Wessman 1992, Aplin 2006). As such, the study steps back and focuses on large scale features of the global response system and broad response scenarios.

It is important to note that the term “global response to climate change” does not appear to have previously been defined, for example it does not appear in IPCC glossaries. To ensure the definition is consistent with use of the term and existing practices for assessing the effectiveness of the global response, the “global response to climate change” is defined as “all human actions and inaction that influence fulfilment of the UNFCCC objective”. Implicit within this definition is the assumption that there is such widespread awareness of climate change, that it can be considered a factor in all decisions, even if the decision involves ignoring climate change. Likewise, a “response to climate change” is “any human action or inaction that influences fulfilment of the UNFCCC objective”.

1.3 New conceptual models

Existing conceptual models address parts of the global response system, for example: climate change hazards and socio-economic systems (IPCC 2012); the interests of state and non-state actors when it comes to international cooperation (e.g. Putnam 1988, two level games); or, the range of influences from international institutions on the global response to climate change (Keohane and Victor 2011). Until now, there has not been a conceptual model of the global response system linking all these things. To fill this gap, a Climate Change National Interests International Cooperation (CCNIIC) Model is developed, providing a conceptual framework for exploring the global response system, including the influence climate change might have on actors and their interests, their contributions to the global response to climate change, and collective action at international, national and sub-national levels. The CCNIIC model sets the boundary of the system being explored and defines the elements within the system.

Other important concepts and models informing the study include: climate risk definitions from the Bank of England (BOE 2015) and Task Force on Climate-related Financial Disclosures (TCFD 2017); catastrophic risk scale from Bostrom and Cirkovic (2008); climate risk conceptions and response strategies from Grubb (2014); and, criteria for effective international cooperation and agreements from Stavins et al. (2014), Wilson (2015) as well as Bodansky and Diringer (2010).

To ensure the study is conceptually robust and can be read by people from different disciplinary backgrounds, substantive terms are defined and used consistently throughout the thesis. Where-ever possible the study uses existing definitions from the United Nations or reputable sources, but not at the expense of internal consistency. As such, definitions are modified if necessary, to ensure internal consistency within the study. A detailed glossary of terms and definitions is provided in Appendix A.

1.4 Limitations of existing scenarios

Scenarios have been widely used where there is uncertainty regarding future conditions or how these conditions might influence actors and their interests. Ramirez et al. (2015) have shown that, when using appropriate methods, scenarios can “produce ‘interesting research’ that is both usable and rigorous.” (Ramirez et al. 2015, p. 82). Scenarios have been used extensively in research related to climate change (e.g. Moss et al. 2010, O’Neill et al. 2017). However, true as these things may be, every scenario or model has limitations.

The limitations of existing scenarios and models include restricting dynamism to economic decision making and not addressing the diversity of actors and interests, possible decision criteria or related response strategies. This study explores actors, their interests, decision making criteria, response triggers and drivers, and response attitudes, addressing these shortcomings.

With regards to possible futures, the IPCC has assessed literature regarding Integrated Assessment Models (IAMs) and Shared Socio-economic Pathways (SSPs) (IPCC 2014a, IPCC

2018a). However, these models do not address the influence of climate change impacts on actors or their decision making. For example, the IPCC 1.5 Degree Report stated "The IAMs used in this report do not account for climate impacts" (Rogelj et al. 2018, p. 158) and "Although some IAMs do allow for climate impact feedbacks in their modelling frameworks… such feedbacks were by design excluded in pathways developed in the context of the SSP framework." (Rogelj et al. 2018, p. 158). According to the IPCC, "The SSP framework aims at providing an integrative framework for the assessment of climate change adaptation and mitigation." (Rogelj et al. 2018, p. 158). However, SSPs assume "consistent drivers" (Rogelj et al. 2018, p. 158) and exclude the possibility of shifts in socio-economic responses. As such, SSPs are locked pathways without the possibility of social movements, changes in political will or business interests due to climate change and related impacts or risks. Response attitudes are fixed.

With regards to the IPCC's Fifth Assessment Report (AR5), "The models do not structurally represent many social and political forces that can influence the way the world evolves (e.g., shocks such as the oil crisis of the 1970s)." (Clarke et al. 2014, p. 422). Yet these shocks can be very important when it comes to social, political and economic change, and can have a strong bearing on GHG emissions for example. In fact, unforeseen events, including low probability high impact events, can have a profound influence on individuals, groups and even civilisation (Taleb 2007).

IPCC assessments review scenarios where "The models use economics as the basis for decision making." (Clarke et al. 2014, p. 422) and as such ignore the possibility of security or other decision criteria driving the global response to climate change. Decisions in these "models tend toward the goal of minimizing the aggregate economic costs of achieving mitigation outcomes" (Clarke et al. 2014, p. 422) however, it is not clear whether in reality incentive structures for actors, including oil and gas companies or so called "petro-states", would actually result in "minimizing aggregate costs". In this regard, the IPCC noted, "factors such as non-market transactions, information asymmetries, and market power influencing decisions are not effectively represented." (Clarke et al. 2014, p. 422).

The IPCC noted that "Omitting climate impacts and adaptation responses from scenarios is likely to lead to biased results for three main reasons." (Clarke et al. 2014, p. 442), consisting of: "climate impacts could influence the effectiveness of mitigation options."; "adaptation responses to climate change could themselves alter emissions from human activities, either increasing or decreasing the emissions reductions required to reach GHG-concentration goals."; and, "mitigation strategies will need to compete with adaptation strategies for scarce investment and R&D resources, assuming these occur contemporaneously." (Clarke et al. 2014, p. 442). The possibility of climate change impacts influencing ambition levels of actors and their responses does not appear to have been acknowledged as a possibility.

Importantly, existing research on social, political and economic responses to climate change is unlikely to fill this gap in knowledge, as case studies have been undertaken in a situation where attributable climate change impacts on human and managed systems were undetectable to low in many parts of the world (IPCC 2001, IPCC 2007, IPCC 2014a, IPCC 2018a). Given that impacts on human and managed systems are expected to increase to moderate to high levels by the middle of the century (IPCC 2018a), it is questionable how representative existing research on responses to climate change will be as climate change conditions change. Having a sample of possible futures (i.e. scenarios) including low, moderate, high and very high impacts on human and managed systems, with responses by various actors, allows a more extensive exploration of global responses to climate change including sequences of conditions for success or failure fulfilling the UNFCCC objective and Paris Agreement purpose.

1.5 New research methods and scenarios

The semi-structured survey used to collect scenarios was designed using novel "reverse stress test" and "backcasting" approaches, meanwhile the compilation of scenarios was based on a "theory of change" analysis of survey responses. The semi-structured survey involved asking respondents from Africa, Asia, Europe, North America, Oceania, and South America for success scenarios where the UNFCCC objective is fulfilled, failure scenarios where the UNFCCC objective is not fulfilled, and other scenarios that might either influence climate or the global response to climate change. Follow up questions included asking who are the main actors and the reasons for their responses?

Scenarios compiled using theory of change based methods were thematically analysed and coded, helping make the scenarios searchable i.e. forming a searchable sample of possible futures. Instead of limiting the study to 4 or 5 reference scenarios, the study accepted that each scenario element is a possible future and explored the "multiverse"[1] of possible pathways between scenario elements. This included chains of events or themes leading to social change and behaviour, political will and policy as well as business and economic activity.

Analysis of the searchable sample of possible futures also identified 12 types of response triggers, drivers and attitudes, as well as decision criteria and related response strategies building off the work of Grubb 2014. Important responses to climate change included enlightened responses, emergency responses and responses relying on serendipity. Important themes included social change and behaviour, political will and policy, business and economic activity, technology and practices as well as other factors such as prices or legal arrangements.

[1] The term "multiverse" was first coined by William James in 1895, when he referred to the "moral multiverse" and the plurality of experience (James 1895). More recently, the term multiverse refers to "A collection of universes which some speculative theories suggest could exist." (Oxford 2020). The "multiverse" concept has been adopted both in scientific and popular literature and includes the possibility of "parallel universes" or "alternative universes" in which all possibilities exist (Carr and Ellis 2008, Wolfe 2007). In this study, the "multiverse of possible pathways" is akin to the "many worlds" conception of the multiverse, where all possible worlds and pathways are considered (Britannica 2020).

1.6 Research questions

The searchable sample of possible futures, made up of 175 scenarios, was used to address five questions. The primary question addressed by the study is:

> **What are the preconditions for effective global responses to climate changes?**

These preconditions can help address the question of:

> **Under what conditions would actors act on effective response options?**

Making the task of identifying preconditions for effective global responses to climate change a bit easier, there are some very likely changes in conditions going forward. For example, global warming is expected to continue along with other climate changes and related impacts, raising a subsequent question:

> **What influence might climate change have on actors and the global response to climate change?**

Given that climate change is a collective action problem requiring some degree of international cooperation (IPCC 2014a), this raises the question:

> **What are the preconditions for effective international cooperation on climate change?**

It is also very likely that more GHGs will be emitted into the atmosphere than a GHG budget would allow for (IPCC 2014a, IPCC 2018a, UNEP 2017), raising the question:

> **What are the preconditions for actors to remove greenhouse gas from the atmosphere at a scale required to limit climate change to safe levels?**

1.7 Preconditions for effective responses to climate change

From the searchable sample of possible futures, climate change signals and responses are identified, and a climate change signal response model is developed. The influence of climate change, as well as response risks and opportunities, on ambition levels are explored. The influence of ambition levels on the effectiveness of responses is analysed and the characteristics of effective global responses are identified. In addition to ambition, serendipity is identified as being very important along with leadership and socio-technical conditions.

From the sample of possible futures, preconditions for effective global responses to climate change are identified include climate change related preconditions, response related preconditions as well as other scenario related preconditions. Response related preconditions are also identified from the Paris Agreement purpose and IPCC's 1.5 Degree Report. With regards to actors acting on available response options, this is complicated and may depend on the extent to which society sees climate change as a problem versus a condition that can be lived with.

1.8 Thesis outline

This thesis uses a thematic structure to organise information and chapters. The thesis has 14 chapters reflecting the diversity of themes and scenarios addressed. Chapters are organised into four parts, consisting of:

- Part I Framing the issue
- Part II Concepts and methods
- Part III Scenarios and themes
- Part IV Analysis, discussion, and conclusions

Part I: Framing the issue

Part I includes this introduction as well as Chapter 2 which explores literature defining the issue of climate change. As such, Chapter 2 addresses: the climate change problem, including issues such as physical climate change, related impacts and risks, the global response, actors and institutions.

Part II: Concepts and methods

Chapter 3 draws upon the literature to highlight and develop concepts and frames. This includes concepts and frames related to the climate change hazards, climate risks, catastrophic risks, response strategies, and international cooperation. In addition to this, a new framework for understanding how climate change and other things might influence national interests and international cooperation is developed (i.e. CCNIIC Model).

Chapter 4 addresses methods and related methodological considerations, highlighting the issues considered while developing the methods used in this study. Considerations include: issues related to scenarios including backcasting; stress tests including reverse stress tests; theory of change analyses; and, thematic analyses.

Chapter 5 applies the lessons from Chapter 4 and sets out the methods used to study preconditions for effective global responses to climate change. This includes describing survey data collection methods and the use of backcasting and reverse stress test methodologies in the design of the semi-structured interviews; data processing methods including scenario identification using theory of change; thematic analysis of scenarios; and, the analysis of scenario themes including thematic chain analysis.

Part III: Scenarios and themes

Chapter 6 presents a summary of survey responses including scenarios and themes identified. This includes information on survey data collection, the compilation of scenarios from survey responses, a summary of scenarios collected, the themes identified, and a summary of themes in relation to the CCNIIC Model.

Chapter 7 presents scenarios and themes from the sample of possible futures regarding climate change impacts, risks and responses, including climate change impact and risk scenarios, the responsiveness of actors and preconditions for effective responses in terms of timeliness and scale. Response triggers, drivers and attitudes are also addressed.

Chapter 8 presents scenarios and themes from the sample of possible futures related to actors, interests and actions including social change and behaviour, political will and policy, as well as business and economic activity.

Chapter 9 presents scenarios and themes from the sample of possible futures related to response options including technologies and practices, greenhouse gas removals and other factors influencing the response of actors.

Chapter 10 presents scenarios and themes from the sample of possible futures regarding international cooperation including factors affecting the international regime complex such as globalism versus nationalism. The chapter also presents scenarios and themes related to geopolitical power and influence, and stringent enforced climate agreements.

Chapter 11 presents other scenarios that could either influence climate or the global response to climate change, including possible low probability high impact events.

It is important to note here that Chapters 7 to 11 include many sections and subsections. Some of these chapters, sections and subsections are short while others include more information including multiple possible scenarios related to a single theme. While it is normal practice to join short sections, this has not been done because all scenarios are treated as possible futures and joining sections with different themes implicitly links these themes. Instead, Chapter 12 analyses and links themes, developing models and mapping multiple possible pathways between the scenarios and themes presented in Chapters 7 to 11.

Part IV: Analysis, discussion, and conclusions

Chapter 12 analyses the scenarios and themes from Chapter 7 to Chapter 11. This includes developing a climate change signal response model of the global response system, mapping possible pathways including actors, interests and actions, GHG removals and international cooperation. Other possible scenarios are also addressed.

Chapter 13 discusses the results of the analysis in Chapter 12, and explores preconditions for effective global responses to climate change and the research questions from Chapter 1. This includes discussing preconditions from the Paris Agreement and IPCC’s 1.5 Degree Report, climate change signals, possible responses and the actors and interests involved. Preconditions for coalitions and international cooperation are discussed along with preconditions for GHG removals. Effective global responses are identified along with preconditions for effective responses and the chapter finishes with short discussions on preconditions for action and existential risk.

Chapter 14 concludes the study, answering the research questions from Chapter 1. Recommendations are made regarding on how to apply the findings of the study, and suggestions are made for future research.

Chapter 2 The climate change problem

2.1 Introduction

Climate change and the global response is a multifaceted system with environmental, economic, social and political elements. This chapter unpacks the climate change problem, in terms of issues (Section 2.2), options (Section 2.3), actors (Section 2.4) and institutions (Section 2.5). Issues include climate changes (Section 2.2.1), related impacts (Section 2.2.2) and risks (Section 2.2.3) and the inadequacy of the global response (Section 2.2.4). Importantly, there are a range of options for addressing climate change that have been identified and published in peer reviewed literature but, at present, these options have not been taken up at a scale sufficient to limit global warming and other anthropogenic climate changes. These include mitigation and adaptation options (Section 2.3.1), greenhouse gas removals (Section 2.3.2) as well as the possibility of solar radiation management options (Section 2.3.3). Actors are addressed in Section 2.4, including state actors (Section 2.4.1) and non-state actors (Section 2.4.2). The global response to the climate change includes institutional arrangements (Section 2.5) for example international agreements such as the United Nations Framework Convention on Climate Change (UNFCCC) (Section 2.5.1), the Paris Agreement (Section 2.5.2) which together with other agreements and institutions (Section 2.5.3) constitute a climate regime complex (Section 2.5.4).

This chapter draws heavily from IPCC assessments, because like this study, IPCC assessments take a global perspective. Furthermore, IPCC assessments provide an authoritative review the literature on climate change and global responses. This chapter also draws upon other literature with a global perspective, including for example United Nations Environment Programme Emissions Gap Reports and peer reviewed research for example regarding options for addressing climate change at the global scale. However, these documents contain a lot of information. This chapter highlights the most salient characteristics of the climate change and global response system, that provide a basis for understanding and discussing effective global responses in subsequent chapters. As such, this chapter helps set the context for the study, informing the development of models in Chapter 3, presentation of scenarios and themes in Chapters 6 to 11, analysis in Chapter 12, and discussion in Chapter 13.

2.2 Issues

An issue is "a vital concern or unsettled problem"[2]. Importantly, Kingdon (1995) noted "There is a difference between a condition and a problem.[3] We put up with all manner of conditions every day: bad weather, unavoidable and untreatable illnesses, pestilence, poverty, fanaticism… Conditions become defined as problems when we come to believe that we should do something about them." (Kingdon 1995, p. 109). Kingdon also noted, "Problems are not simply the conditions or external events themselves; there is also a perceptual, interpretive element." (Kingdon 1995, pp. 109-110).

[2] Adapted from Merriam-Webster, 2019.
[3] In the quote Kingdon thanks James Q. Wilson for highlighting this point.

And “There are great political stakes in problem definition. Some are helped and others are hurt, depending on how problems get defined. If things are going basically your way, for instance, you want to convince others that there are no problems out there.” (Kingdon 1995, p. 110). With these things in mind, important issues include the phenomenon of physical climate change (Section 2.2.1), the impacts (Section 2.2.2) and risks (Section 2.2.3) associated with climate change, and the inadequate global response to date (Section 2.2.4).

2.2.1 Climate change

The IPCC defines climate change as “a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.” (IPCC 2013). Climate characteristics (e.g. temperatures and precipitation) are typically assessed for periods of 30 years or more (Cubasch et al. 2013).

Climate extremes are important as they constitute hazards to people, their property and productive activities. Climate change related hazards include fast onset events such as extreme heat or extreme precipitation events, as well as changes in storm frequency or intensity. Other hazards include slow onset events such as a warming trend, a drying trend, sea level rise, ocean acidification, and carbon dioxide fertilisation (Field et al. 2014). Internationally there is concern that climate change is a threat to development and this is reflected in the UNFCCC objective (Section 2.5.1) as well as the Paris Agreement purpose (Section 2.5.2).

The climate change problem has been defined in a number of ways, for example in agreements between states such as the UNFCCC as well as by IPCC assessments. “Climate change” is defined by the UNFCCC as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.” (Article 1, UNFCCC 1992). It is important to note that the UNFCCC uses the term climate change to refer to anthropogenic climate change while the IPCC (and this study) uses the term climate change to refer to both natural and anthropogenic changes. “Adverse effects of climate change” are defined by the UNFCCC as “changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare.” (Article 1, UNFCCC 1992). As such, climate change is defined as being a potential problem for the environment, biota, ecosystems, socio-economic systems, human health and welfare. Article 1 also defines emissions and greenhouse gases as well as the related concepts of reservoir, sink and source (see the Appendix A for definitions).

In response to the above framing of climate change and its adverse effects, the UNFCCC objective is “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.” (Article 2, UNFCCC 1992). Article 2 goes on to state that “Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." (Article 2 UNFCCC 1992). As such, climate change is defined as being a problem of atmospheric concentrations of greenhouse gases, ecosystem adaptation, food production, and economic development.

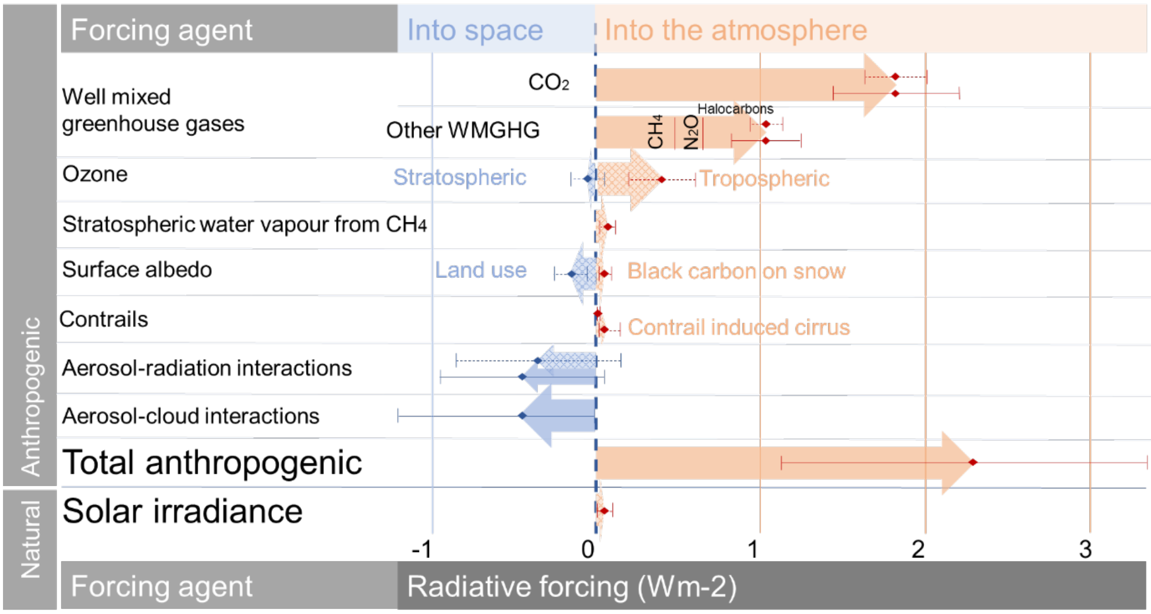

Figure 2-1: Chart for radiative forcing (hatched) and effective radiative forcing (solid) for the period 1750–2011. Uncertainties (5 to 95% confidence range) are given for radiative (dotted lines) and effective radiative forcing (solid lines). Source: Modified from Stocker et al. 2013.

While it is tempting to assume anthropogenic climate change is driven exclusively by greenhouse gas emissions, this would not be accurate. There are multiple forcing agents, greenhouse gases being the most important, that contribute to radiative forcing, influencing earth's atmospheric energy balance and climate change. Any of these forcing agents, and their sources, could become a policy focus (e.g. Prins et al. 2010). Forcing agents include well mixed greenhouse gases, ozone, stratospheric water vapour from CH_4, surface albedo, contrails, aerosol-radiation interactions, aerosol-cloud interactions as well as natural solar irradiance (Figure 2-1). Forcing agents include long-lived greenhouse gases that "have lifetimes of approximately eight years or more" and short-lived climate pollutants that "have lifetimes of approximately 20 years or less" (UNEP 2017, p. 48).

Sources of forcing agents can be natural or due to human (i.e. socio-economic) activities. These sources may include particles and gases from volcanic eruptions, solar variations, orbital cycles, greenhouse gas and particle emissions to the atmosphere from energy and industrial processes as well as particle emissions, greenhouse gas emissions and albedo changes from land use change. The combined effect of climate forcers has been to change earth's energy balance (Figure 2-2), creating a slight imbalance with the accumulation of energy mainly in the atmosphere and hydrosphere, including oceans (Cubasch et al. 2013).

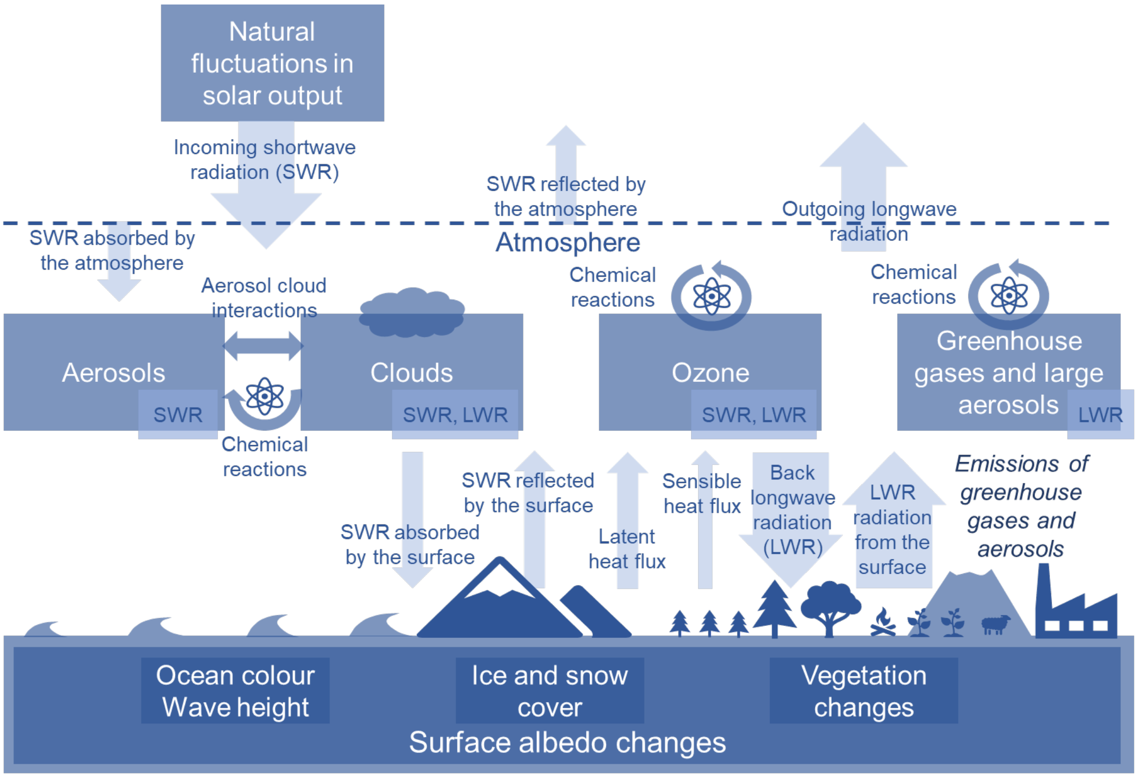

Figure 2-2: Earth's energy balance. Source: Modified from Cubasch et al. 2013.

2.2.2 Impacts

Attributable physical impacts of climate change have only recently emerged. From a review of the IPCC's five assessment reports from 1990 to 2014, three types of physical signal can be identified, consisting of: climate science; physical risks; and, physical impacts. Climate science regards "the study of relatively long-term weather conditions, typically spanning decades to centuries but extending to geological timescales." (Nature 2019). Climate risks regard "The potential for consequences where something of value is at stake" (IPCC 2014b, p. 127) and climate impacts regard "Effects on natural and human systems." (IPCC 2014b, p. 124). Representative quotes from the IPCC summaries from 1990 to 2014 are presented in Appendix B.

With regards to the three types of physical signal, climate science mainly regarded the detection of climate change and whether it was anthropogenic. Climate science showed an improvement in understanding of the physical system over time and was the most environmentally focused of all the signals. Climate risk was addressed in each of the summaries, but in most cases regarded long timeframes, decades in many cases and over 100 years in some cases. The ways which physical risk were described progressively became more refined, for example with the identification of the five reasons for concern. Assessments from 1990 to 2001 included positive and negative implications of climate but assessments from 2007 and 2014 indicated risk as being negative.

When it came to impacts, the signal went from no signal in 1990 to a clear signal 2014. No impacts were identified in the Overview from 1990 and the Summary from 1995 stated that "Unambiguous detection of climate-induced changes in most ecological and social systems will prove extremely difficult in the coming decades." (IPCC 1995, p. 6) suggesting that limited or no signal could be expected for decades. However, by 2001 there appeared to be some observation of changes particularly in physical and biological systems. In 2007, there was medium confidence of impacts while in 2014 these had become attributable including "some impacts on human systems" (IPCC 2014a, p. 6). The IPCC Fifth Assessment report included an illustration summarising impacts around the world (Figure 2-3).

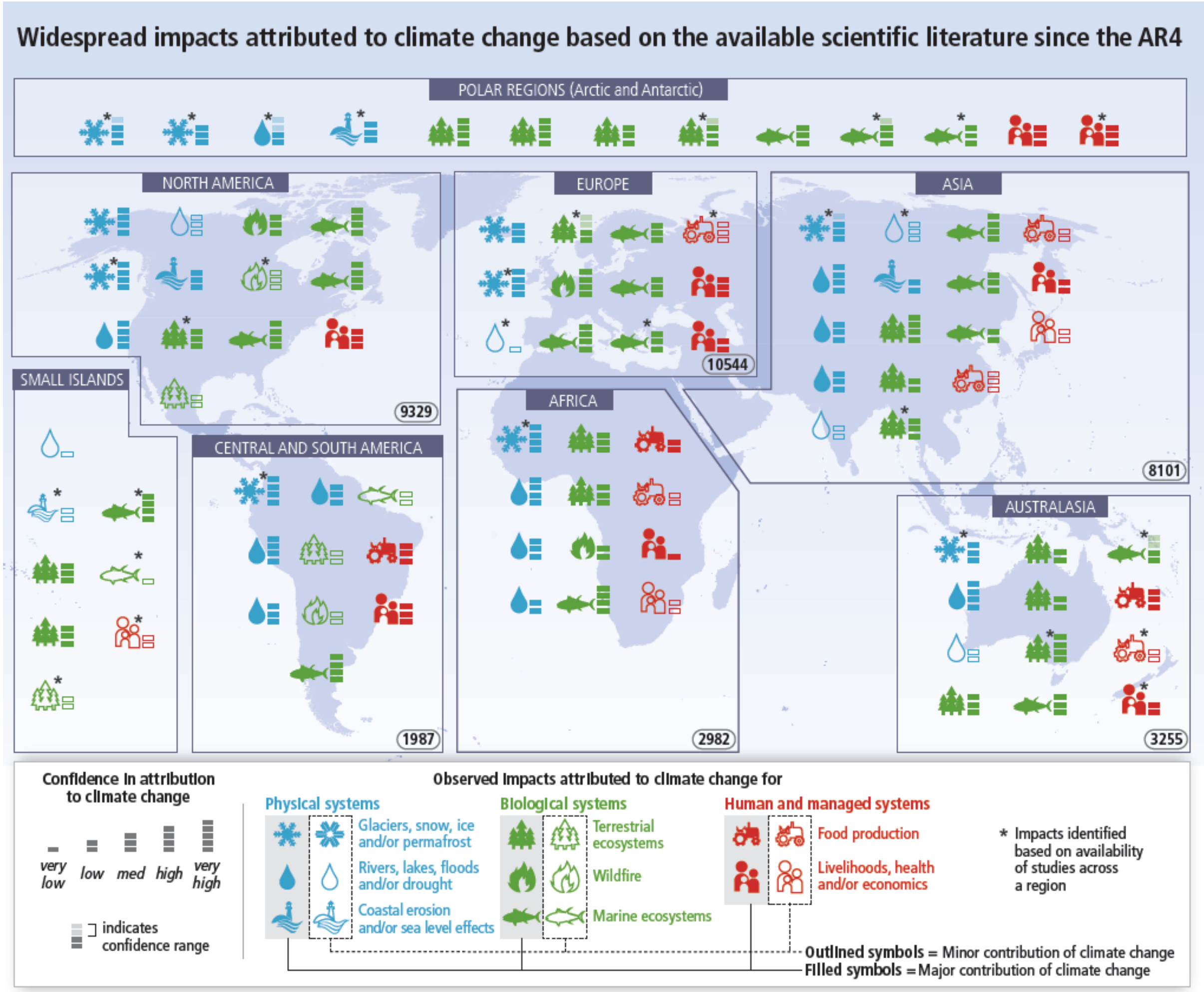

Figure 2-3: Impacts attributed to climate change from the AR5 Summary for Policy Makers. Source IPCC 2014a.

2.2.3 Risks

Climate change is a problem with long time horizons extending beyond business and political planning periods (Carney 2015) and includes the risk of feedbacks and other impacts. Long-lived greenhouse gases such as methane (CH_4) or sulphur dioxide (SO_2) remain in the atmosphere for decades (Myhre et al. 2013). Carbon dioxide (CO_2) remains in the atmosphere for over a hundred years (Myhre et al. 2013). As such, emissions today have long lasting temperature effects (Figure 2-4). However, the ultimate level of global warming and types of climate change manifested depends on feedback mechanisms that take time to reach equilibrium even after greenhouse gas concentrations stabilise in the atmosphere (Myhre et al. 2013). These feedbacks can either reinforce or limit changes in climate. Feedbacks include clouds and water vapour, emissions of greenhouse gases other than carbon dioxide from the decomposition of peat and permafrost, the emissions aerosols from biochemical processes such as wildfires, and ocean circulation for example. Each of these feedbacks are effective over different periods of time, from hours for longwave radiation and lapse rate, to as long as centuries for air-sea carbon dioxide exchange, permafrost, land ice and ocean circulation feedbacks (Figure 2-5).

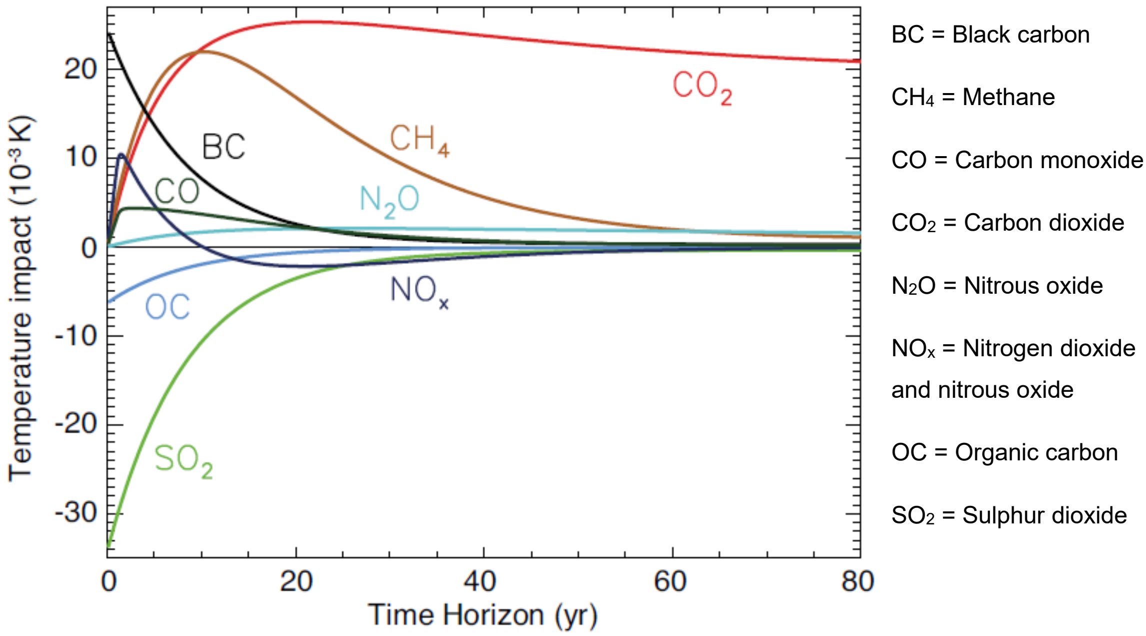

Figure 2-4: Graph of temperature response to a 1 year pulse of greenhouse gas and other climate forcers. Uncertainties are not shown. Source: Myhre et al. 2013.

A complicating factor when it comes to understanding and assessing climate change and related issues are uncertainties. For example, Figure 2-1 shows large uncertainties related to forcing agents and despite limited uncertainty around the radiative forcing of greenhouse gases there remain large uncertainties around the negative radiative forcing related to aerosols resulting in large uncertainties around total anthropogenic radiative forcing. IPCC Working Group I noted that there are large uncertainties related to the data presented in Figure 2-4 (Myhre et al. 2013). Large uncertainties can also be found in climate change projections, including levels of global warming and warming over land and sea areas. Possible effects of global warming on precipitation, storms and even sea level rise are not certain and as such this makes understanding the hazard climate change poses to development difficult to assess.

Representative Concentration Pathways (RCPs) consist of four possible future atmospheric GHG concentration scenarios. RCP scenarios were selected from the literature by an Integrated Assessment Modelling Consortium (IAMC) consisting of 45 organisations. For each RCP, time series data were published regarding possible GHG emissions levels, atmospheric concentrations of GHGs and radiative forcing (Moss et al. 2010). Importantly, most scenarios that result in the lowest atmospheric concentrations of greenhouse gases and climate forcing (RCP 2.6) assumed that greenhouse gases will be removed from the atmosphere in the second half of the 21st century although it is unclear how these removals would be achieved (UNEP 2017, van Vuuren et al. 2018).

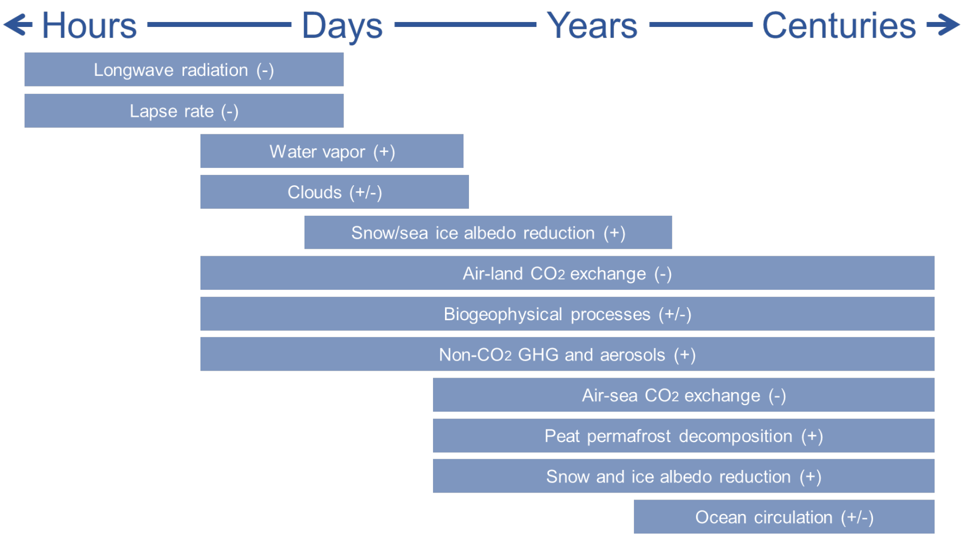

Figure 2-5: Positive and negative feedbacks and the periods of time they take to reach equilibrium. Source: Adapted from Cubasch et al. 2013.

Based on the RCPs, the Coupled Model Inter-comparison Project Phase 5 (CMIP5) made estimates of possible levels of global warming (Taylor et al. 2012). CMIP5 global warming scenarios defined a range of global warming paths and levels by 2100. As such, the plausible set of global warming scenarios for 2100 range from a minimum of 0.6°C under RCP2.6, to a maximum of 5.4°C warming (relative to the average between 1850 and 1900) under RCP8.5. However, as Table 2-1 shows, there is considerable uncertainty regarding possible global warming levels for each RCP scenario.

Based on the RCPs and related assessments of physical changes, risks to the environment, biological systems and human systems have been assessed and presented in the IPCC Fifth Assessment Report (Figure 2-6) in the same format as impacts have been presented (Figure 2-3). In each figure there are considerable uncertainties.

Further complicating the issue of scenarios and related studies, is uncertainty around physical events that might happen. For example, the figures reported in the IPCC's 5th Assessment Report for global warming up to 2035 "assumes that there will be no major volcanic eruptions or changes in some natural sources (e.g., CH_4 and N_2O), or unexpected changes in total solar irradiance" (IPCC 2014a, p. 10). Volcanic eruptions (Bethke et al. 2017) and other unexpected changes are not factored into longer term global warming estimates. For any given period of time there is a chance of volcanic activity and the longer period of time the greater the likelihood of volcanic eruptions capable of perturbing the climate locally, regionally or globally (Robock 2000, Self 2006). Most volcanic eruptions are not expected to influence long term global warming although many eruptions influence climate variability (Bethke et al. 2017).

Table 2-1: Key characteristics of the scenarios collected and assessed by IPCC Working Group III for the Fifth Assessment Report. For all parameters the 10th to 90th percentile of the scenarios is shown. Source: IPCC 2014a.

CO_2-eq Concentrations in 2100 (ppm CO_2-eq) Category label (conc. range)	Subcategories	Relative position of the RCPs	Change in CO_2-eq emissions compared to 2010 (in %)		Likelihood of staying below a specific temperature level over the 21st century (relative to 1850-1900)			
			2050	2100	1.5°C	2°C	3°C	4°C
<430	Only a limited number of individual model studies have explored level below 430 ppm CO_2-eq							
450 (430 to 480)	Total range	RCP2.6	-72 to -41	-118 to -78	More unlikely than likely	Likely	Likely	Likely
500 (480-5300)	No overshoot of 530 ppm CO_2-eq		-57 to -42	-107 to -73	Unlikely	More likely than not		
	Overshoot of 530 ppm CO_2-eq		-55 to -25	-114 to -90		About as likely as not		
550 (530 to 580)	No overshoot of 580 ppm CO_2-eq		-47 to -19	-81 to -59		More unlikely than likely		
	Overshoot of 580 ppm CO_2-eq		-16 to 7	-183 to -86				
(580 to 650)	Total range	RCP4.5	-38 to 24	-134 to -50				
(650 to 720)	Total range		-11 to 17	-54 to -21		Unlikely	More likely than not	
(720 to 1000)	Total range	RCP6.0	18 to 54	-7 to 72	Unlikely		More unlikely than likely	
>1000	Total range	RCP8.5	52 to 95	74 to 178		Unlikely	Unlikely	More unlikely than likely

The IPCC Fifth Assessment Report Summary for Policy Makers notes that “The risks of abrupt or irreversible changes increase as the magnitude of the warming increases.” (IPCC 2014a, p. 16). Abrupt irreversible changes are defined as “a large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems” (Collins et al. 2013, p. 1114). Irreversibility is defined as “A perturbed state of a dynamical system… [where] …the recovery timescale from this state due to natural processes is significantly longer than the time it takes for the system to reach this perturbed state.” (adapted from Collins et al. 2013).

Collins et al. (2013), in Chapter 12 of Working Group II’s contribution to the IPCC’s Fifth Assessment Report listed potential abrupt or irreversible changes that could affect the climate (Table 2-2). These include the loss of carbon from forests to the atmosphere due to die back, methane releases from the seafloor sediments, losses of ice affecting albedo and in the case of Greenland or Antarctic ice sheets, sea levels. There is also a possibility of climate changes resulting in long-term droughts and changes in monsoonal circulation. A shutting down of the Atlantic meridional overturning circulation (MOC) would result in cooling of Europe.

Table 2-2: Components in the Earth system susceptible to abrupt or irreversible change according to the literature. Source: Collins et al. 2013.

Change in climate system component	Potentially abrupt (AR5 definition)	Irreversibility if forcing reversed	Projected likelihood of 21st century change in scenarios considered
Atlantic MOC collapse	Yes	Unknown	Very unlikely that the AMOC will undergo a rapid transition (high confidence)
Ice sheet collapse	No	Irreversible for millennia	Exceptionally unlikely that either Greenland or West Antarctic Ice sheets will suffer near-complete disintegration (high confidence)
Permafrost carbon release	No	Irreversible for millennia	Possible that permafrost will become a net source of atmospheric greenhouse gases (low confidence)
Clathrate methane release	Yes	Irreversible for millennia	Very unlikely that methane from clathrates will undergo catastrophic release (high confidence)
Tropical forests dieback	Yes	Reversible within centuries	Low confidence in projections of the collapse of large areas of tropical forest
Boreal forests dieback	Yes	Reversible within centuries	Low confidence in projections of the collapse of large areas of boreal forest
Disappearance of summer Arctic sea ice	Yes	Reversible within years to decades	Likely that the Arctic Ocean becomes nearly ice-free in September before mid-century under high forcing scenarios such as RCP8.5 (medium confidence)
Long-term droughts	Yes	Reversible within years to decades	Low confidence in projections of changes in the frequency and duration of megadroughts
Monsoonal circulation	Yes	Reversible within years to decades	Low confidence in projections of a collapse in monsoon circulations

In addition to all the physical issues above, there is the concern related to ocean acidification due to elevated levels of carbon dioxide in the atmosphere causing more carbon dioxide to be absorbed by water in the sea or entering the sea, which in turn acidifies the water with carbonic acid (IPCC 2014a). Even without climate change, increased atmospheric concentrations of carbon dioxide would be an ocean acidification issue threatening marine life.

At the Paris Summit where the Paris Agreement was agreed, the Conference of Parties also requested the IPCC "... to provide a Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways" (IPCC 2018a, p. 4). As such, the IPCC's 1.5 Degree Report assessed risks anticipated at 1.5°C of global warming and made comparisons with risks at 2°C of global warming. This included assessing five reasons for concern along with impacts and risks for selected natural, managed and human systems (Figure 2-7).

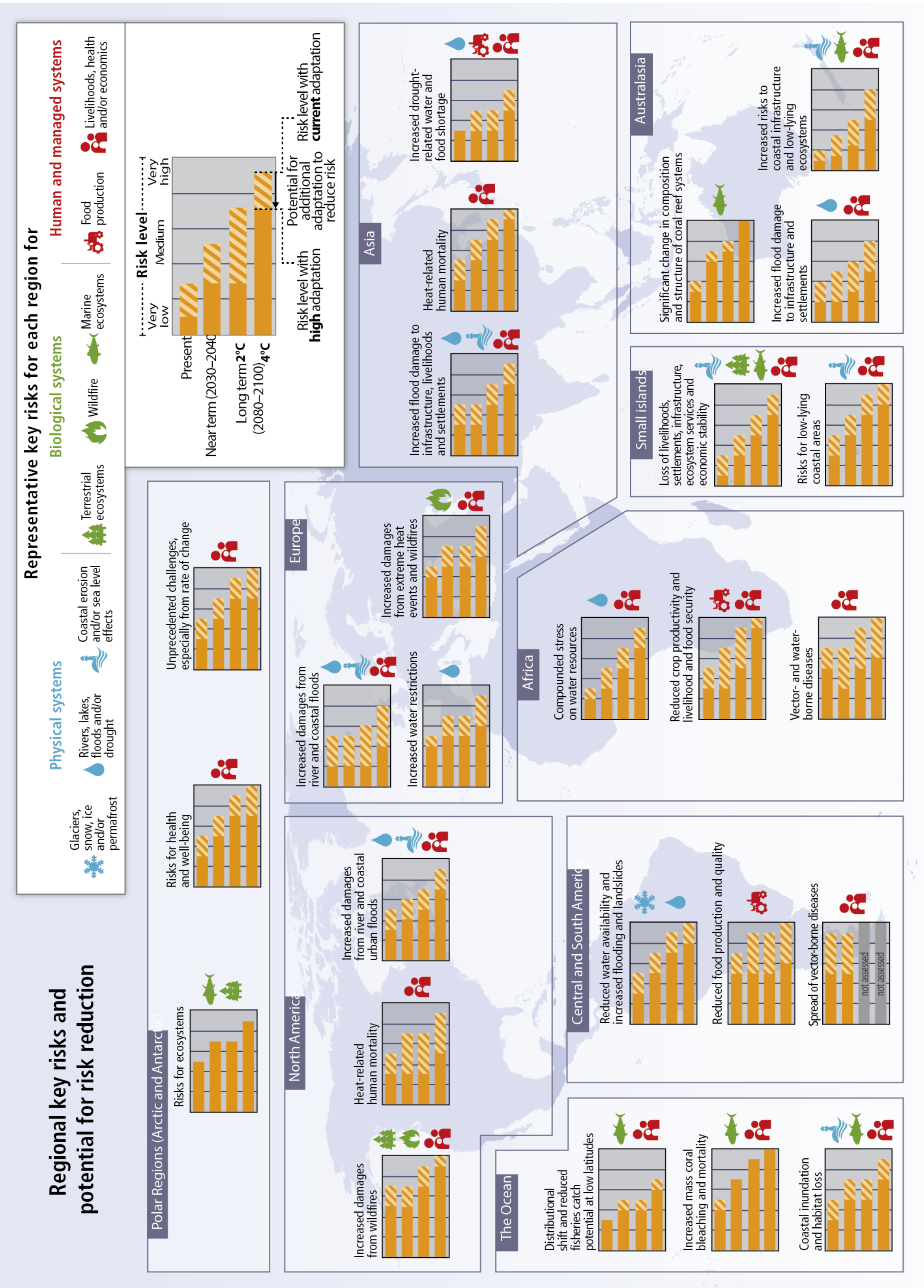

Figure 2-6: Summary of climate change related risks. Source IPCC 2014

Five reasons for concern have been reported since the Third Assessment Report and even have their own acronym (i.e. the RFCs). The five reasons for concern include unique and threatened systems, extreme weather events, distribution of impacts, global aggregate impacts, and large scale singular events (Table 2-3). The 1.5 Degree Report also assessed risk and impact levels for other categories related to natural, managed and human systems, consisting of: warm water corals; mangroves; small-scale low latitude fisheries; arctic region; terrestrial ecosystems; coastal flooding; fluvial flooding; crop yields; tourism; and, heat related morbidity and mortality.

The 1.5 Degree Report stated “Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.” (IPCC 2018a, p. 4).

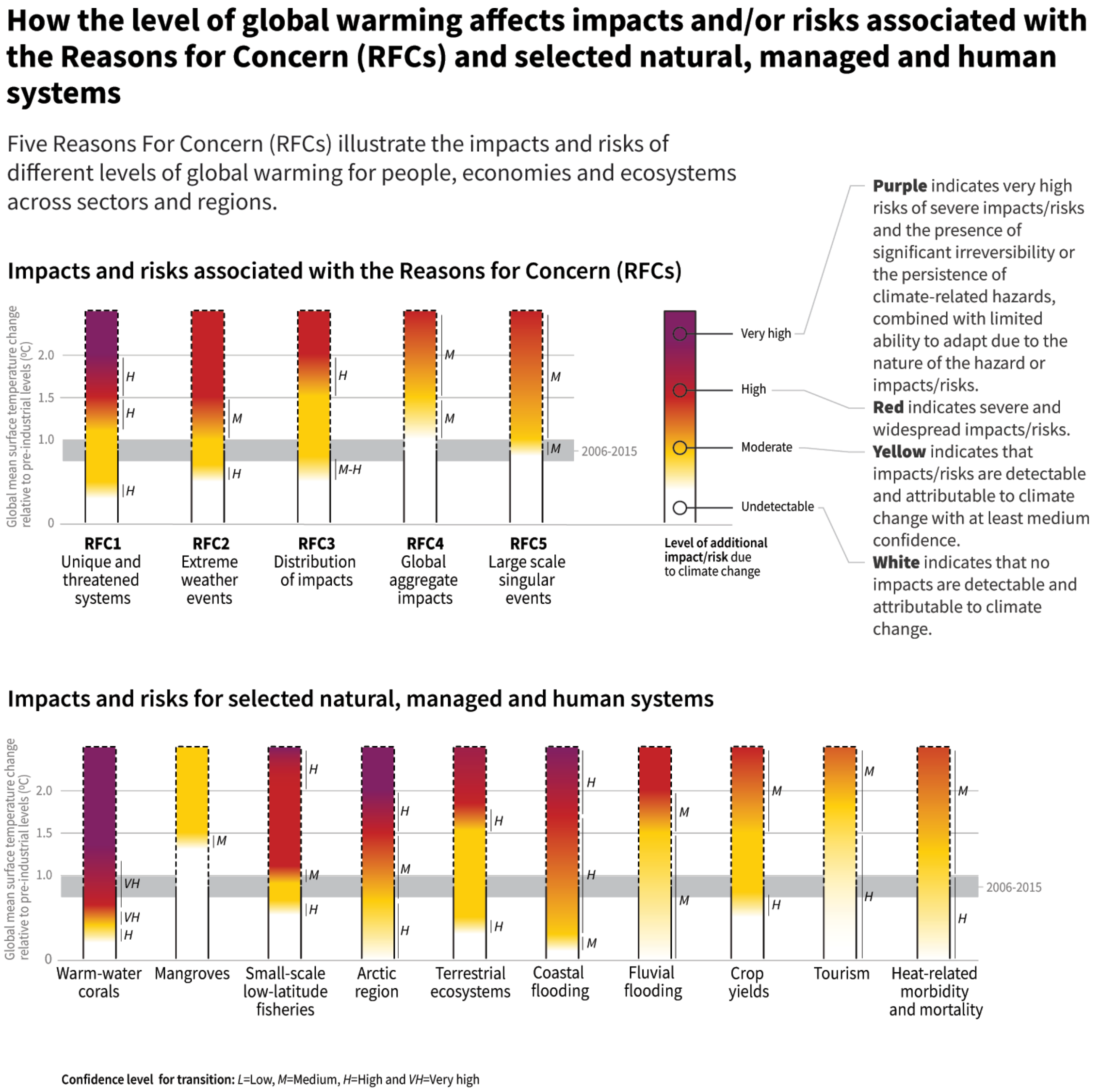

Figure 2-7: Reasons for concern presented along with impacts and risks for select natural, managed and human systems. Source: IPCC 2018a.

Table 2-3: Reasons for concern with descriptions. Source: IPCC 2018b.

Reason for concern:	Description
RFC1: Unique and threatened systems	Ecological and human systems that have restricted geographic ranges constrained by climate-related conditions and have high endemism or other distinctive properties. Examples include coral reefs, the Arctic and its indigenous people, mountain glaciers and biodiversity hotspots.
RFC2: Extreme weather events	Risks/impacts to human health, livelihoods, assets and ecosystems from extreme weather events such as heat waves, heavy rain, drought and associated wildfires, and coastal flooding.
RFC3: Distribution of impacts	Risks/impacts that disproportionately affect particular groups due to uneven distribution of physical climate change hazards, exposure or vulnerability.
RFC4: Global aggregate impacts	Global monetary damage, global-scale degradation and loss of ecosystems and biodiversity.
RFC5: Large-scale singular events	Relatively large, abrupt and sometimes irreversible changes in systems that are caused by global warming. Examples include disintegration of the Greenland and Antarctic ice sheets (see Table 2-2).

With the exception of warm water corals, the levels of risk and impacts expected at current levels of global warming are undetectable to moderate (Figure 2-7). For warm water corals it is high. However, as global warming levels increase, from 1°C to 1.5°C, impact and risk levels become moderate to high, and very high in the case of warm water corals. At 2°C impact and risk levels increase again, ranging from moderate to very high. As such, the next period of global warming looks set to have much more noticeable impacts and risks, while up until this point, there appears to have been limited impact and risk, and in some cases, undetectable levels of impact and risk.

While the RFCs indicate the risk of climate change impacts are currently undetectable to moderate, the United Nations (UN 2020), United States Congress (US Congress 2019) and others (e.g. Crist 2007, Davidson et al. 2020) have described climate change as a “climate crisis”. According to the Oxford Dictionary, a crisis is “a time of intense difficulty or danger”, meanwhile, danger refers to “the possibility of suffering harm or injury” i.e. risk. It is unclear whether the UN or US Congress are referring to immediate impacts or the risk of climate change. Stating there is a “climate crisis” might give the impression of intense difficulty (i.e. immediate impacts) or could refer to the risk of dangerous climate change. The extent to which climate change is a crisis, and the extent to which the climate crisis regards impacts versus risks or the global response to climate change is an important question which is addressed in Section 14.2.

2.2.4 Global response

An important part of the climate change problem is the lack of an adequate global response. The global response to climate change is tracked by the United Nations Environment Programme (UNEP) and its Emissions Gap Report series. The UNEP Emissions Gap Report has stated that “The overarching conclusions of the report are that there is an urgent need for accelerated short-term action and enhanced longer-term national ambition, if the goals of the Paris Agreement are to remain achievable — and that practical and cost-effective options are available to make this possible.” (UNEP 2017, p. XIV). Figueres et al. highlighted the same risk in their commentary titled “Three years to safeguard our climate" published in Nature (Figueres et al. 2017). They noted that "When it comes to climate change, timing is everything" and "should emissions continue to rise beyond 2020, or even remain level, the temperature goals set in Paris become almost unattainable." (Figueres et al. 2017, p. 593) due to the steep reduction in GHG emissions that would be required (Figure 2-8). Figueres et al. (2017) also highlighted goals and steps that could be taken to address climate change (Section 2.3).

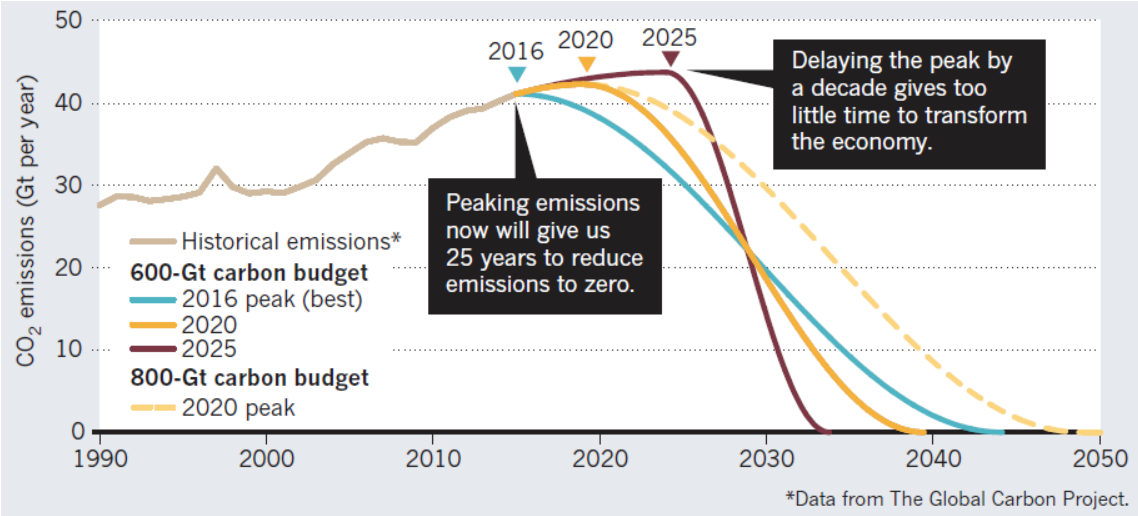

Figure 2-8: Timing and emissions paths required to limit global warming well below 2 degrees Celsius from pre-industrial times. Source: Figueres et al. 2017.

Emissions budgets help give a sense of scale to the climate change problem and response required. Figueres et al. (2017) noted that "After subtracting past emissions, humanity is left with a 'carbon credit' of between 150 and 1,050 gigatonnes" (Figueres et al. 2017, p. 594) reflecting different ways of calculating the carbon budget and uncertainty. The UNEP Emissions Gap Report series also uses a budget to assess the gap in emissions reductions required to limit global warming to well below 2 degrees from pre-industrial times (UNEP 2017). This includes an assessment of current progress as well as what progress would be made if Parties fulfilled their unconditional Nationally Determined Contributions (NDCs) and conditional NDCs[4]. The UNEP Emissions Gap Report (2017) found that "The NDCs that form the foundation of the Paris Agreement cover only approximately one third of the emissions reductions needed to be on a least cost pathway for the goal of staying well below 2°C. The gap between the reductions needed and the national pledges made in Paris is alarmingly high." (UNEP 2017, p. XIV). UNEP goes on to state, "it is clear that if the emissions gap is not closed by 2030, it is extremely unlikely that the goal of holding global warming to well below 2°C can still be reached." (UNEP 2017, p. XIV). Furthermore, "Given currently available carbon budget estimates, the available global carbon

[4] Nationally Determined Contributions (NDCs) to the global response to climate change are efforts volunteered by states, towards fulfilling the Paris Agreement purpose, including unconditional NDCs as well as conditional NDCs requiring the support of other states. NDCs are at the heart of the Paris Agreement and are periodically reviewed in global stocktakes and new NDCs submitted every five years by parties to the Paris Agreement (UNFCCC 2019).

budget for 1.5°C will already be well depleted by 2030." (UNEP 2017, p. XIV). As such, the current policy trajectory is diverging from the pathways required to limit global warming to well below 2°C. Figure 2-9 shows that conditional and unconditional NDCs are better than the current policy trajectory but are far from sufficient to put the global response to climate change on path towards achieving the UNFCCC objective or Paris Agreement purpose.

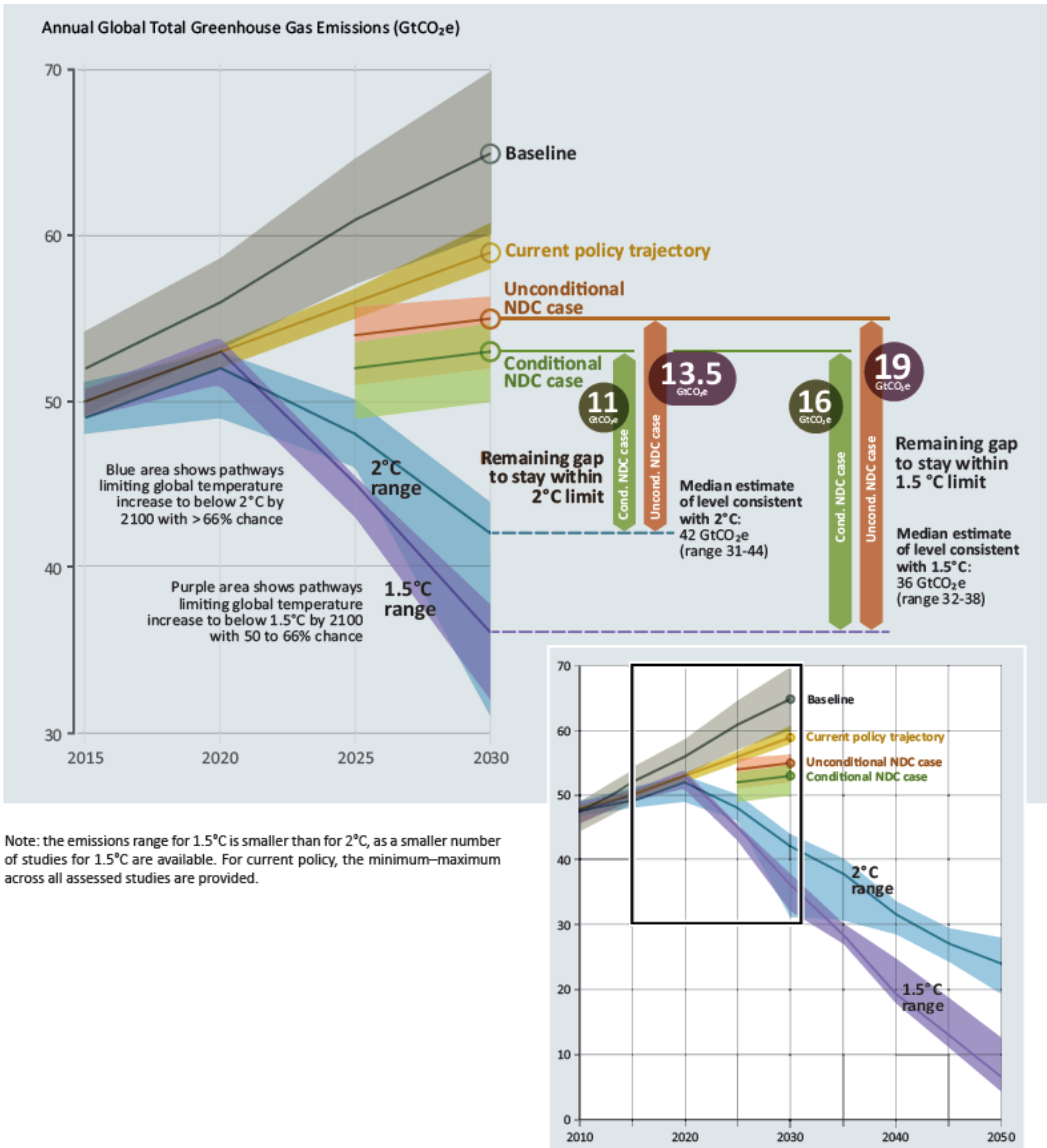

Figure 2-9: Summary of UNEP Gap Report findings. Source: UNEP 2017.

Further complicating the situation, most scenarios that limit global warming to well below 2°C also require carbon dioxide removals from the atmosphere (UNEP 2017, van Vuuren et al. 2018, IPCC 2018a). It is not clear which technological options could become cost effective or would be practical “at scale”[5] as there is limited experience in this area. Section 2.3 discusses these options further. Other organisations have conducted similar assessments and come up with similar findings (e.g. van Vuuren et al. 2018, Shell 2018a).

Likewise, the 1.5 Degree Report found carbon dioxide removals need to be at scale by 2050, if global warming it to be limited to 1.5°C of global warming. Furthermore, the 1.5 Degree Report indicated overshoot scenarios are a real possibility where global warming levels have to be brought down after exceeding 1.5°C (Figure 2-10).

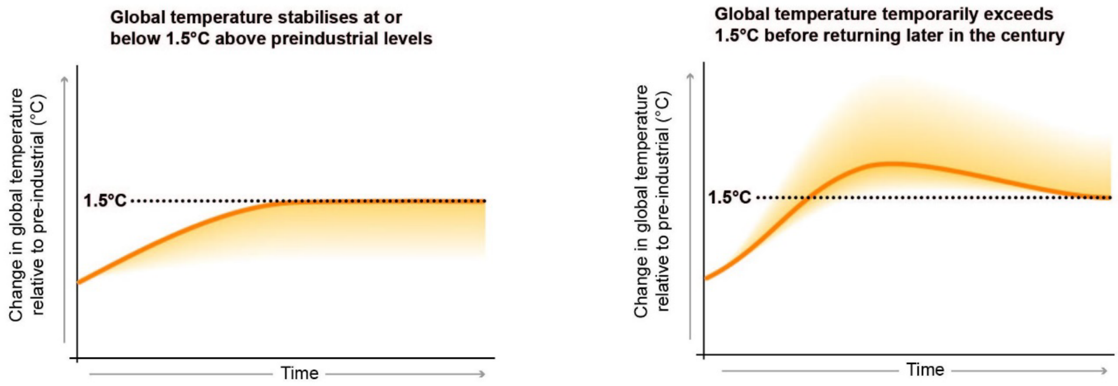

Figure 2-10: Two main pathways for limiting climate change from the IPCC’s 1.5 Degree Report. Source: IPCC 2018a.

The measurement of progress using carbon, carbon dioxide, carbon dioxide equivalent and any other type of budget tends to simplify issues. As noted by Figueres et al. (2017), the actual budget is uncertain and as noted in Section 2.2.3, there are large uncertainties around the level of global warming that might happen given a particular concentration of greenhouse gases in the atmosphere in combination with other climate forcers and feedbacks.

Further complicating the assessment of the global response to climate change, is the fact that emissions are recorded by territory from which they are emitted (i.e. sovereign states and their territorial jurisdictions) (Goodwin et al. 2019), however, only a fraction of emissions are from the government activities. Emissions inventories also include emissions from the activities of economic and social actors within a territory. National governments can influence greenhouse gas emissions and other climate forcers through policies for example, legislation, regulations, investments and plans as well as the extent to which legislation, regulations and plans are applied and enforced. In many cases there will be sub-national government bodies and governance processes that also have an influence on social and economic activities (Farber 2012). There are many other influences on social and economic activities including, for example, the availability of technology, knowledge and practices, culture and history, prices, costs and benefits as well as legal, security and other considerations (Dryzek et al. 2011). Furthermore, international trade and issues of supply and demand may also influence economic activities and their emissions within a sovereign state (Keohane and Victor 2011).

[5] “At scale” means “at the required size to solve the problem” (PCMag Encyclopedia 2020), typically involving large volumes.

Hence, the entity for which emissions are measured, i.e. the sovereign state, has limited direct and indirect influence on the greenhouse gas emissions being emitted from its territory (Farber 2012). There are many actors with competing interests that have an influence on the social and economic activities within a sovereign state as well as the policies and plans that the government of a sovereign state may adopt (Putnam 1988, Kingdon 1995, Farber 2012).

To help with understanding how social and economic factors might influence the global response to climate change, O'Neill and others have developed shared socio-economic pathways (SSPs) that "describe plausible alternative changes in aspects of society such as demographic, economic, technological, social, governance and environmental factors" (O'Neill et al. 2017, p. 170). The first iteration of the five SSPs emerged from a workshop held in 2012 (O'Neill 2012), consisting of SSP1 sustainability, SSP2 middle of the road, SSP3 fragmentation, SSP4 inequality and SSP5 conventional development. In 2017, O'Neill et al. published updated "narratives for shared socioeconomic pathways describing world futures in the 21st century". The five SSPs in O'Neill et al. (2017) were similar to the five published by O'Neill et al. (2012) and consisted of: SSP 1 sustainability, SSP 2 middle of the road, SSP 3 regional rivalry, SSP 4 inequality and SSP 5 fossil fuelled development (Figure 2-11). For each SSP, short and detailed narratives were produced, addressing: population and human resources; economic development; human development; technology; lifestyles; environment and natural resources; and, policies and institutions.

O'Neill et al. (2017) mapped the SSPs relative to the socio-economic challenges for mitigation as well as the socio-economic challenges for adaptation. SSP 3 regional rivalry was indicated as being the greatest challenge for mitigation and adaptation while SSP1 sustainability had the least challenge for mitigation and adaptation (Figure 2-11).

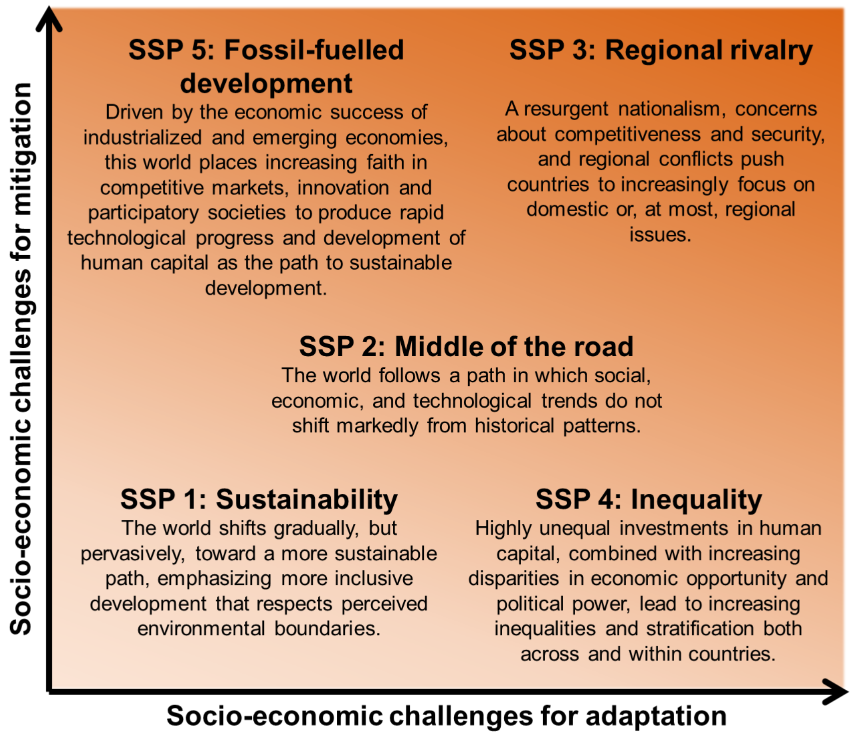

Figure 2-11: Shared Socio-economic Pathways (SSPs) in relation to levels of socio-economic challenge for mitigation and adaptation. Source: Modified from O'Neill et al. 2017.

2.3 Options

While climate change is a problem, there are options for addressing climate change. These including widely discussed mitigation and adaptation options (Section 2.3.1), greenhouse gas removals (Section 2.3.2) as well as controversial solar radiation management options (Section 2.3.3).

2.3.1 Mitigation and adaption

Mitigation regards options and actions for avoiding climate change meanwhile adaptation regards options and actions in anticipation of, or response to, physical climate change (see Appendix A for definitions). Global assessments of mitigation options include IPCC Working Group III's 5th Assessment Report, the 2017 edition of the UNEP Emissions Gap Report, a cooperative assessment of options by researchers around the world culminating in a book titled Drawdown, a scenario from Shell, as well as studies by researchers (e.g. Blok et al. 2018 or van Vuuren et al. 2018) and more recently the IPCC's 1.5 Degree Report. Likewise, there is a growing body of literature on adaptation including IPCC Working Group II's contribution to the 5th Assessment Report.

IPCC Working Group II addressed adaptation along with climate change impacts and risks. In its Fifth Assessment Report the IPCC (2014c) stated that "Adaptation options exist in all sectors, but their context for implementation and potential to reduce climate-related risks differ across sectors and regions." (IPCC 2014c, p. 95). As such, there is no one adaptation solution, but rather there are many possible options, and appropriate options depend on the local situations. The IPCC also noted that "poor planning or implementation, overemphasizing short-term outcomes or failing to sufficiently anticipate consequences can result in maladaptation, increasing the vulnerability or exposure of the target group in the future or the vulnerability of other people, places or sectors (medium evidence, high agreement).” (IPCC 2014a, p. 20).

The IPCC Fifth Assessment Report summarised adaption options. Broad approaches included: options that reduce vulnerability and exposure to climate change related hazards, through development and planning related options; adaptation through incremental or transformative changes; and, transformation related to institutions and wider societal changes. Furthermore, the IPCC (IPCC 2014c, p. 95), noted that broad options include:

- Social, ecological asset and infrastructure development;
- Technological process optimization;
- Integrated natural resources management;
- Institutional, educational and behavioural change or reinforcement;
- Financial services, including risk transfer;
- Information systems to support early warning and proactive planning.

It should be noted that adaption options need to be taken together with mitigation. The IPCC noted that “Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change.” (IPCC 2014a, p. 19). As such, mitigation is essential if adaptation is to be effective (Pers. Comm. Youba Sokona 2011). Furthermore, climate change interventions may help with both adaptation and mitigation, for example the installation of solar electricity systems can mitigate greenhouse gas emissions while at the same time powering air-conditioning and refrigeration during extreme heat events (Anand et al. 2015).

IPCC Working Group III addressed mitigation and noted that “Mitigation options are available in every major sector.” (IPCC 2014c, p. 98). These sectors include energy, transport, buildings, industry (i.e. manufacturing) as well as human settlements and infrastructure. The IPCC also identified policy options including economic instruments (e.g. taxes and subsidies as well as tradable allowances), regulations, information, and the provision of goods and services by government institutions. The IPCC Fifth Assessment Report also showed how these policy options can be applied to various sectors. The IPCC did not provide a definitive list of options or the emissions that could be mitigated, but rather demonstrated that there are a variety of options available to governments.

Project Drawdown provided a comprehensive inventory of mitigation options, including the amount of mitigation that could be achieved, the costs and savings. Project Drawdown identified 100 options, 80 of which were ranked and another 20 were identified as being “coming attractions” (i.e. other possible solutions too early to assess). The options identified as “coming attractions” demonstrated that new climate change options may emerge over time, especially when it comes to technology, management systems and behaviours. Project Drawdown not only addressed technical options but also social options, educating girls, family planning or indigenous peoples’ land management requiring investment in people, culture and social systems.

Project Drawdown succeeded in its aim of creating an inventory, which serves as a useful resource for anyone interested in mitigation options, but it did not specify how these options might be brought together to actually address climate change. As noted by the IPCC, “Mitigation can be more cost-effective if using an integrated approach that combines measures to reduce energy use and the greenhouse gas intensity of end-use sectors, decarbonize energy supply, reduce net emissions and enhance carbon sinks in land-based sectors.” (IPCC 2014c, p. 98). Fortunately, Figueres et al. (2017) provide guidance on which options to pursue, meanwhile van Vuuren et al. (2018), Blok et al. (2018) and Shell (2018a) have identified scenarios in which global warming would likely be limited to 2 degrees or less.

In addition to noting the need to go “further, faster, together” involving the use of science to guide decisions, scaling up solutions rapidly, and encouraging optimism, Figueres et al. (2017) identified specific interventions that together would likely limit global warming to well below 2 °C. This included interventions in the sectors of energy (e.g. renewables), infrastructure (including cities), transport (e.g. electric vehicles), land (e.g. reforestation), industry (e.g. efficiency and emissions reductions) and finance (e.g. private sector and new instruments).

Ecofys (Blok et al. 2018) published a report titled “Energy transition within 1.5°C” with the subtitle: “A disruptive approach to 100% decarbonisation of the global energy system by 2050”. Blok et at (2018) prepared a scenario taking into account population and economic growth and the need for additional goods and services to meet development expectations. The scenario focused on energy options and found: “Despite the global energy system’s rapid reduction of CO_2 emissions in our disruptive decarbonisation scenario, cumulative CO_2 emissions beyond 2014 are calculated to be 680 billion tonnes, likely exceeding the carbon budget. However, combined with options such as afforestation and agricultural carbon sequestration, it looks possible to stay within a carbon budget compatible with a maximum temperature increase of 1.5°C.” (, Blok et al. 2018, p. ii of summary). As such, focusing on energy alone is insufficient to limit climate change. Importantly, Blok et al. (2018) noted “Most of the required technologies are already available and developments in some sectors go so fast that transitions become cost-competitive.” (Blok et al. 2018, p. 11). The paper also noted the need for “massive investments” and the fact that there is “no time to lose” (Blok et al. 2018, p. 11).

In 2018, Shell, the oil and gas company, released its Sky scenario which limited global warming to less than 2°C in 2100, complementing its Oceans and Mountains scenarios, both of which exceeded 2°C of global warming. The Sky scenario was backcast, and as such differed in approach from the development of Mountains and Oceans scenarios which were developed using engagement, feedback and a forward looking processes. Sky was normative. The Sky scenario recognises peoples’ need for development and that “in the context of the UN Sustainable Development Goals, several billion people are still pursuing a better life through much-needed access to clean water, sanitation, nutrition, health care, and education. Energy is a key enabler for these basic needs.” (Shell 2018a, p. 12). Shell also addressed issues of competing interests and the need for government policies and leadership. A large role is played by carbon capture and storage, carbon capture and use, as well as reforestation (Table 2-4), with the net effect of allowing more oil and gas extraction. The scenario also covered a range of sectors, greenhouse gases and related mitigation actions but adaptation was not addressed.

van Vuuren et al. (2018) published a paper in Nature titled “Alternative pathways to the 1.5 °C target reduce the need for negative emission technologies”. van Vuuren et al. (2018) had prepared a series of scenarios and assessed which scenarios, or combination of scenarios, would be likely to limit global warming to 1.5°C in 2100. Scenarios included a focus on efficiency, renewable electricity, agricultural intensification, non-CO_2 emissions reductions, lifestyle changes, and low population. Additionally, a combination of all these climate related actions were assessed and compared with SSP2 as a baseline, as well as RCP 2.6 and a 1.9 W m $^{-2}$ (i.e. 1.5°C) scenario. van Vuuren et al. (2018) noted that greenhouse gas removals are problematic and as such wanted to know if it was possible to limit global warming to 1.5°C following “deep mitigation pathways” limiting the need for carbon dioxide removals. The scenarios were “found to significantly reduce the need for CDR, but not fully eliminate it.” (van Vuuren et al. 2018, p. 391).

Table 2-4: Summary of Shell’s Sky scenario limiting global warming to less than 2°C. Source: Compiled from Shell 2018a.

Shell Sky scenario
The Sky scenario limits global warming to less than 2 degrees of global warming in 2100 from pre-industrial times and “requires a complex combination of mutually reinforcing drivers being rapidly accelerated by society, markets, and governments.” (Shell 2018a, p. 6).
Summary
From now to 2070: 1. A change in consumer mindset means that people preferentially choose low-carbon, high-efficiency options to meet their energy service needs. 2. A step-change in the efficiency of energy use leads to gains above historical trends. 3. Carbon-pricing mechanisms are adopted by governments globally over the 2020s, leading to a meaningful cost of CO_2 embedded within consumer goods and services. 4. The rate of electrification of final energy more than triples, with global electricity generation reaching a level nearly five times today’s level. 5. New energy sources grow up to fifty-fold, with primary energy from renewables eclipsing fossil fuels in the 2050s. 6. Some 10,000 large carbon capture and storage facilities are built, compared to fewer than 50 in operation in 2020. 7. Net-zero deforestation is achieved. In addition, an area the size of Brazil being reforested offers the possibility of limiting warming to 1.5°C, the ultimate ambition of the Paris Agreement. (Shell 2018a, p. 6)

The UNEP Gap Report is a collaboration that involves many authors including Blok and van Vuuren for example, forming an assessment of the current state of knowledge of the emissions gap. The UNEP Gap Report 2017 addressed sectoral options for limiting greenhouse gas emissions. These sectors consisted of energy, industry, forestry, transport, agriculture, buildings, and, other. According to the UNEP Emissions Gap Report 2017, the largest potential contributions to the global response to climate change came from energy, followed by industry and forestry (Figure 2-12). The UNEP Gap Report also provided a breakdown of the emissions reductions by category, many of which are related to mitigation actions discussed above.

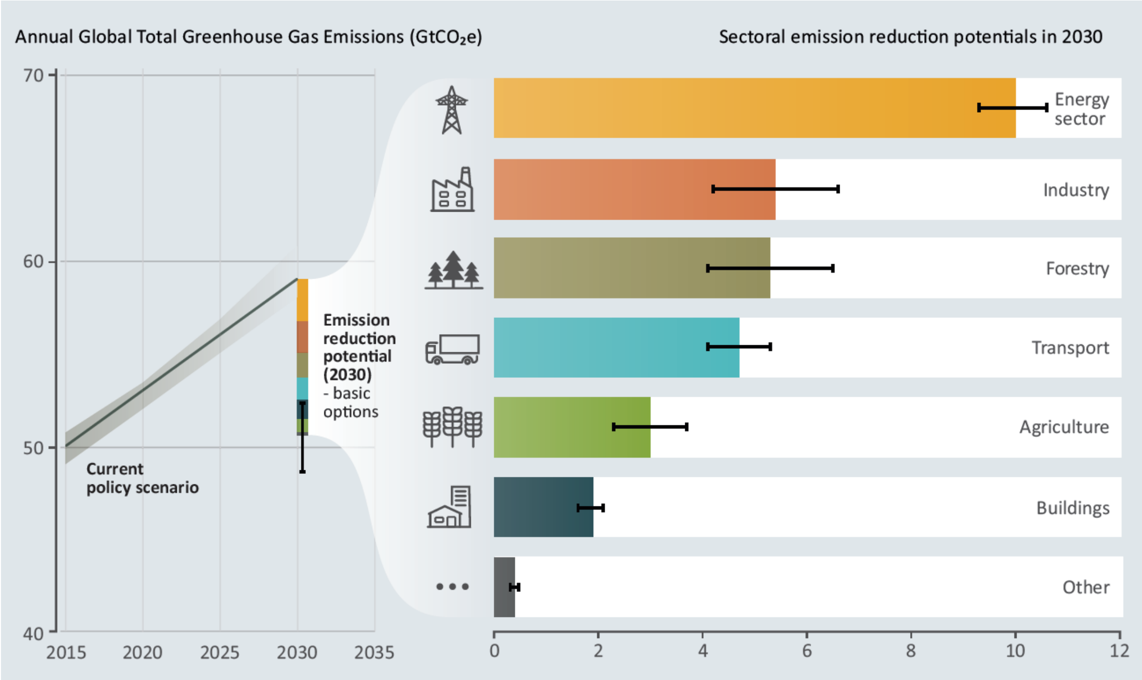

Figure 2-12: Total emission reduction basic potentials compared to the current policy scenario in 2030. Source: UNEP 2017.

With regards to limiting climate change to 1.5°C, the IPCC's 1.5 Degree Report included options and their feasibility for limiting climate change and related impacts. Options considered included options related to green infrastructure, industrial mitigation options, adaptation options, behavioural options related to mitigation and adaptation (de Coninck et al. 2018). In a section aptly titled "Disentangling the whole-system transformation", the IPCC also noted "There is a diversity of potential pathways consistent with 1.5°C, yet they share some key characteristics" (Rogelj et al. 2018, p. 129). These key characteristics (Table 2-5) are important as they represent actions (i.e. options) that need to be fulfilled if the global response is to be effective.

The feasibility of options for addressing climate change were also addressed in the 1.5 Degree Report. It was stated that "Feasibility depends on geophysical, ecological, technological, economic, social and institutional conditions for change." (Allen et al. 2018, p. 71).

Table 2-5: 1.5°C pathway characteristics from the IPCC 1.5 Degree Report. Source: Rogelj et al. 2018.

1.5°C Pathway characteristic	Supporting information
Rapid and profound near-term decarbonisation of energy supply	Strong upscaling of renewables and sustainable biomass and reduction of unabated (no CCS) fossil fuels, along with the rapid deployment of CCS, lead to a zero-emission energy supply system by mid-century
Greater mitigation efforts on the demand side	All end-use sectors show marked demand reductions beyond the reductions projected for 2°C pathways. Demand reductions from IAMs for 2030 and 2050 lie within the potential assessed by detailed sectoral bottom-up assessments.
Switching from fossil fuels to electricity in end-use sectors	Both in the transport and the residential sector, electricity covers markedly larger shares of total demand by mid-century.
Comprehensive emission reductions are implemented in the coming decade	Virtually all 1.5°C-consistent pathways decline net annual CO_2 emissions between 2020 and 2030, reaching carbon neutrality around mid-century. In 2030, below-1.5°C and 1.5°C-low-OS pathways show maximum net CO_2 emissions of 18 and 28 $GtCO_2\ yr^{-1}$, respectively. GHG emissions in these scenarios are not higher than 34 $GtCO_2$ e yr^{-1} in 2030.
Additional reductions, on top of reductions from both CO_2 and non-CO_2 required for 2°C, are mainly from CO_2	Both CO_2 and the non-CO_2 GHGs and aerosols are strongly reduced by 2030 and until 2050 in 1.5°C pathways. The greatest difference to 2°C pathways, however, lies in additional reductions of CO_2, as the non-CO_2 mitigation potential that is currently included in integrated pathways is mostly already fully deployed for reaching a 2°C pathway.
Considerable shifts in investment patterns	Low-carbon investments in the energy supply side (energy production and refineries) are projected to average 1.6–3.8 trillion 2010 USD yr^{-1} globally to 2050. Investments in fossil fuels decline, with investments in unabated coal halted by 2030 in most available 1.5°C-consistent projections, while the literature is less conclusive for investments in unabated gas and oil. Energy demand investments are a critical factor for which total estimates are uncertain.
Options are available to align 1.5°C pathways with sustainable development	Synergies can be maximized, and risks of trade-offs limited or avoided through an informed choice of mitigation strategies. Particularly pathways that focus on a lowering of demand show many synergies and few trade-offs.
CDR at scale before mid-century	By 2050, 1.5°C pathways project deployment of BECCS at a scale of 3–7 $GtCO_2\ yr^{-1}$ (range of medians across 1.5°C pathway classes), depending on the level of energy demand reductions and mitigation in other sectors. Some 1.5°C pathways are available that do not use BECCS, but only focus terrestrial CDR in the AFOLU sector

2.3.2 Greenhouse gas removals

Beyond conventional mitigation and greenhouse gas emissions abatement, there is likely to be a need for atmospheric greenhouse gas removals (Section 2.2.4), in particular carbon dioxide removals. Carbon dioxide removals can be characterised as being “restoration” of atmospheric concentrations of carbon dioxide to safe levels. The UNEP Gap Report 2017 notes that this can be done using natural or technological means. Natural means include afforestation and reforestation, biochar, soil carbon sequestration and other land use initiatives. The options are relatively low cost and can be deployed currently but are vulnerable to reversal. For example, a forest fire could eliminate a stock of carbon in days that might have taken decades to accumulate. Technological options for greenhouse gas removals include accelerated weathering, direct air capture, ocean alkalinity enhancement and carbon dioxide being converted to durable carbon materials (see Figure 2-13). The benefit of technological approaches include being much less vulnerable to reversal, however the technologies require much more research and development before they can be deployed at scale or at reasonable cost (UNEP 2017).

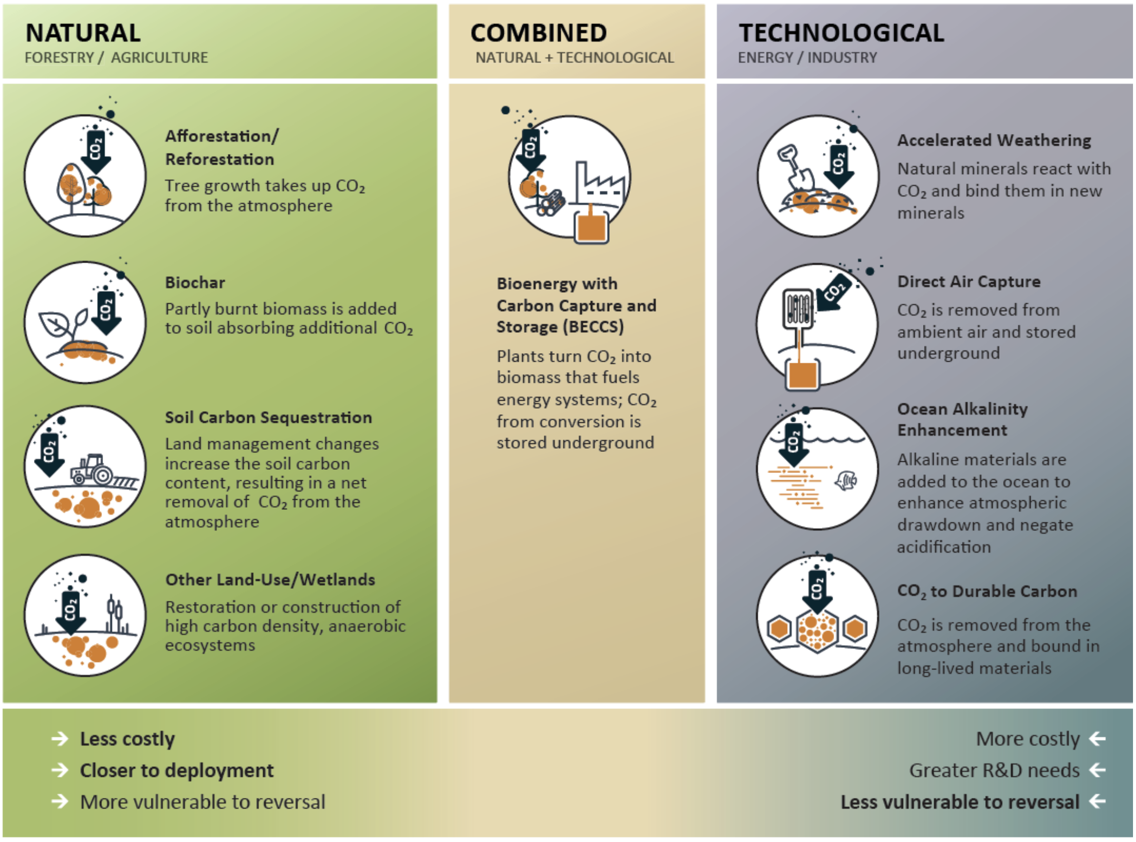

Figure 2-13: Major strategies for negative emission technologies. Source: UNEP 2017.

Natural and technological options can be combined for example to form Bioenergy with Carbon Capture and Storage (BECCS). While conceptually BECCS is possible, practical details are much less compelling, for example the large land areas that would be required (Smith et al. 2016), the possibility that forests might not be sustainably managed (Fajardy et al. 2019) or the possibility of cheating resulting in ecologically sensitive timber being harvested instead of new growth.

As noted in Section 2.2.1, it is not just long-lived greenhouse gases that are climate forcers. Short-lived climate pollutants (SLCP) are also important. Key messages emerging from the UNEP Emissions Gap Report 2017 included “Early reductions in SLCP emissions would provide substantial health benefits, limit the short-term rate of climate change, slow self-amplifying feedbacks, and facilitate the achievement of the Paris Agreement’s long-term temperature target.” (UNEP 2017, p. 57). Furthermore, the UNEP Gap Report stated that “Over the period 2018–2050, stringent SLCP reductions based on existing, demonstrated technical measures could reduce warming by between 0.3°C and 0.9°C relative to current emissions projections.” and “Roughly half of the mitigation potential is associated with methane, one third with black carbon, and the remainder with hydrofluorocarbons.” (UNEP 2017, p. 57). Some greenhouse gas mitigation actions would also have the effect of limiting short-lived climate pollutants, but for the maximum effect to be achieved, other measures would need to be taken beyond those under the Paris Agreement. Furthermore, the accounting of short-lived climate pollutants needs to be conducted separately due to the differing properties of these pollutants (UNEP 2017).

The UNEP Emissions Gap Report includes a chapter on coal and estimates the carbon dioxide emissions that would be locked in if announced coal fired power plants, pre-permitted plants, permitted plants, plants under construction and operating plants were to progress as expected. Once finance is committed and a coal fired power plant is under construction it is anticipated that there will be lock-in of the carbon dioxide emissions.

2.3.3 Solar radiation management

In addition to greenhouse gas removals, there is the possibility of solar radiation management. Solar radiation management is “the intentional modification of the Earth’s shortwave radiative budget with the aim to reduce climate change according to a given metric (e.g., surface temperature, precipitation, regional impacts, etc.).” (IPCC 2013). Working Group I, in its glossary, goes on note that “Artificial injection of stratospheric aerosols and cloud brightening are two examples of SRM techniques. Methods to modify some fast-responding elements of the long wave radiative budget (such as cirrus clouds), although not strictly speaking SRM, can be related to SRM. SRM techniques do not fall within the usual definitions of mitigation and adaptation.” (IPCC 2013). In its Summary for Policy Makers, the IPCC noted that “SRM is untested and is not included in any of the mitigation scenarios. If it were deployed, SRM would entail numerous uncertainties, side effects, risks and shortcomings and has particular governance and ethical implications.” (IPCC 2014a, pp. 25-26). Furthermore, solar radiation management does nothing to limit ocean acidification and if efforts to limit solar radiation are stopped, temperatures would rebound quickly (IPCC 2014a).

2.4 Actors

Having options to address the climate change problem is important, but it is up to actors to make decisions on whether to act on available options. With regards to climate change, important actors include sovereign states and central government as well as domestic non-state actors that may be affected by climate change and account for a majority of GHG emissions. Given that climate change is a global collective action problem, international institutions such as the UNFCCC are important too.

2.4.1 State actors

In the context of the UNFCCC and the global response to climate change, sovereign states are an important unit of analysis, because the global response to climate change is set out by states in their nationally determined contributions (NDCs).

Each state has its own national interests, but in many cases these interests will be shared with other sovereign states and as such, sovereign states that are parties to the UNFCCC form groups that cooperate on climate negotiations and climate related issues. In some cases, common interests have led to the formation of Party Groupings that are recognised by the UNFCCC and others, for example Small Island Developing States (SIDS), Least Developed Countries (LDCs), Environmental Integrity Group (EIG), or Arab Group (UNFCCC 2020).

Physical characteristics are the defining feature of SIDs and the Coalition for Rainforest Nations (CfRN). Development and economic characteristics define the G-77, LDCs and Brazil, South Africa, India and China (BASIC) groupings and their common interests. The Organization of the Petroleum Exporting Countries (OPEC) is defined by a common interest in energy, in particular petroleum production. Other groups such as the European Union (EU), Central Asia, Caucasus, Albania and Moldova (CACAM) Group or the Independent Association of Latin America and the Caribbean (AILAC) are defined by geographic proximity and varying levels of international cooperation and integration. Other interests linking countries include trade and security.

In a report titled “A New World: The Geopolitics of the Energy Transformation”, the Global Commission on the Geopolitics of Energy Transformation stated, “Fundamental changes are taking place in the global energy system which will affect almost all countries and will have wide-ranging geopolitical consequences.” (IRENA 2019, p. 12). Countries that depend on oil, gas or coal for energy or revenues will face challenges (IRENA 2019). Meanwhile, “The majority of countries can hope to increase their energy independence significantly, and fewer economies will be at risk from vulnerable energy supply lines and volatile prices.” (IRENA 2019, p. 15). Furthermore, countries that have mineral resources needed as an input to production of technologies driving the transformation, stand to benefit from increased demand (IRENA 2019). According to the report, the transformation which includes increased energy efficiency, the adoption of renewables and electrification, will “redraw the geopolitical map of the 21st century.” (IRENA 2019, p. 12). It is an interesting question as to how different states and other actors might respond to these changing circumstances.

2.4.2 Non-state actors

Non-state actors include individuals, civil society, business and local government for example. Non-state actors can be domestic or international (see Section 2.5.3 for more on international non-state actors in the form of international institutions). When it comes to non-state actors and actions outside NDCs, the UNEP Emissions Gap Report 2017 stated that “There is still limited evidence that non-state action will fill a significant part of the emissions gap, although there is significant potential for it to do so.” (UNEP 2017, p. XIV). In many cases contributions that can be made by non-state actors will be counted as part of NDC’s due to the way NDC’s are formulated and emissions reductions are accounted for using national inventories. However, the UNEP Gap Report 2017 did note that “subnational and non-state actions could possibly make a significant contribution to narrowing the gap” and “The aggregate impact of the initiatives could be in the order of a few $GtCO_2e$ in 2030 beyond the current NDCs, if the initiatives reach their stated goals and if these reductions do not displace actions elsewhere.” (UNEP 2017, p. 25). Importantly, Graichen et al. (2016) in a paper titled “Climate initiatives, national contributions, and the Paris Agreement” identified non-state mitigation actions that would be additional and would make meaningful contributions to the global response to climate change (Figure 2-14).

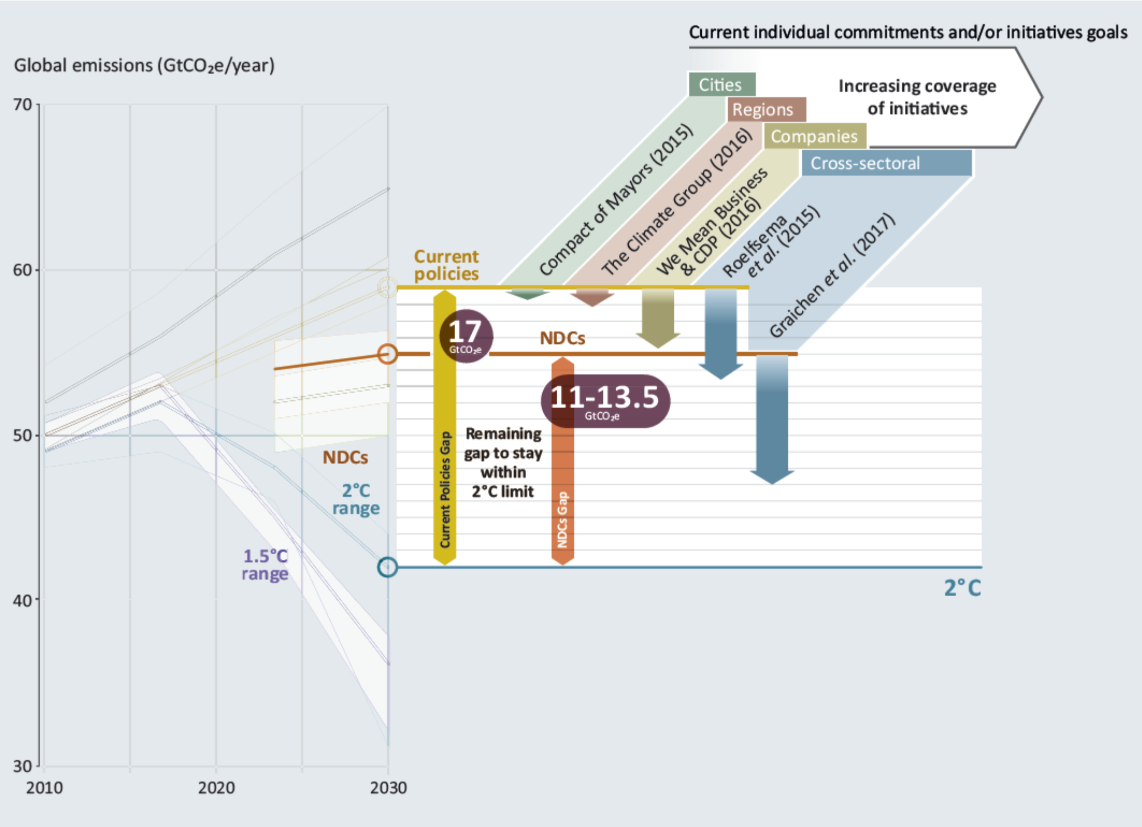

Figure 2-14: Illustration of the potential impact of international cooperative initiatives by non-state actors in 2030. Source: UNEP 2017.

2.5 Institutions

According to the IPCC, climate change is a collective action problem at a global scale. Importantly, collective action, for example towards some goal, depends on institutions (Ostrom 1990). Institutions are "systems of established and embedded social rules that structure social interactions" (Hodgson 2006, p. 18) and international institutions are "sets of rules that stipulate the ways in which states should cooperate and compete with each other" (Mearsheimer 1994, p. 8, in Simmons and Martin 2002). Some definitions also include agreements and initiatives by non-state actors as part of the international system[6].

Important institutions that form the core of the climate policy architecture include the United Nations Framework on Climate Change (Section 2.5.1) and the Paris Agreement (Section 2.5.2).

[6] Duffield defined international institutions as "relatively stable sets of related constitutive, regulative, and procedural norms and rules that pertain to the international system, the actors in the system (including states as well as nonstate entities), and their activities." (Duffield 2007, pp. 7-8). It should also be noted that "There are at least as many definitions of [international] institutions as there are theoretical perspectives" (Thomas Risse 2002, p. 605 in Duffield 2007).

It is important to note that there are other institutions that influence the global response to climate change (Section 2.5.3) and as such, climate change is part of a regime complex (Section 2.5.4).

2.5.1 UNFCCC

According to the UNFCCC "The 1992 United Nations Framework Convention on Climate Change… …provides the foundation for multilateral action to combat climate change and its impacts on humanity and ecosystems." (UNFCCC 2018a). As a framework convention, the UNFCCC simply "serves as an umbrella document which lays down the principles, objectives and the rules of governance of the treaty regime" (UNECE 2011) and leaves "more detailed rules and the setting of specific targets either to subsequent agreements between the parties, usually referred to as protocols, or to national legislation." (OPIL 2011). As such, the UNFCCC forms a framework for the global response to climate change, consisting of (UNFCCC 2018a):

- An objective;
- Broad principles;
- General obligations;
- Basic institutional arrangements; and,
- An intergovernmental process for agreeing to specific actions over time.

Essentially, the UNFCCC can be divided into two parts, the first is the objective that the international community aspires to achieve. The second part consists of the principles, obligations, institutional arrangements and intergovernmental processes which together from the "rules of the game". However, it is important to note there is a mismatch between the universal goal (i.e. UNFCCC objective) which depends on the global response to climate change, and the rules of the game which are not universally accepted or applied, for example when it comes to issues of trade, technology or land use.

The ultimate objective of the Convention is to achieve stabilisation of atmospheric greenhouse gas concentrations at safe levels (UNFCCC 1992). Safe levels mean ecosystems are able to adapt naturally to climate change, food production is not threatened and economic development is able to proceed in a sustainable manner. As such, there are four success criteria that can be taken from the UNFCCC objective (Table 2-6).

Table 2-6: Success criteria based on the UNFCCC objective. Source: Compiled from UNFCCC 1992.

UNFCCC objective (Article 2)	Key points (i.e. success criteria)
…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.	Stabilise atmospheric GHG concentrations at safe levels
Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.	Ecosystems adapt naturally
	Food production not threatened
	Economic development to proceed in a sustainable manner

The UNFCCC has many bodies and the most important of these bodies consist of: the Conferences of Parties (COP) to the UNFCCC; the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP); the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA); and the Bureau for the COP, CMP and CMA. Beneath these bodies are permanent subsidiary bodies that support the COP and CMP on technical issues related to science and technology as well as implementation. Then there are convention bodies, bodies related to the technology mechanism under the Convention, expert groups under the Convention, Kyoto Protocol bodies, bodies related to financial mechanisms, and bodies related to other financial arrangements. Lastly, there is the UNFCCC Secretariat that supports these bodies along with organisation and record keeping under the UNFCCC (see the Jellyfish model in Appendix C).

2.5.2 Paris Agreement

According to the IPCC, “The provisions of the [UNFCCC] are pursued and implemented by two treaties: the Kyoto Protocol and the Paris Agreement.” (IPCC 2018c, p. 560). While the Kyoto Protocol represents an important step in the global response to climate change, it is effectively superseded by the Paris Agreement (Savaresi 2016). Article 2 of the Paris Agreement sets out its purpose and this is summarised in Table 2-7.

Table 2-7: Paris Agreement purpose and key points summarised. Source: Compiled from UNFCCC 2015.

Paris Agreement purpose (Article 2)	Key points
Strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty	Strengthen the global response to climate change
Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change	Limit global warming to well below 2°C Efforts to limit global warming to 1.5°C (from pre-industrial levels)
Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production	Improved adaptive capacities
	Climate resilient low greenhouse gas emissions development
	Food production not threatened by the response*
Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate- resilient development	Align finance with climate resilient low carbon development
This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.	Equitable responses from sovereign states

**Note: The Paris Agreement, like the UNFCCC refers to food production not being threatened, but the Paris Agreement focuses on limiting the threat from the global response to climate change, rather than the threat of climate change itself.*

2.5.3 Other institutions

Related to the UNFCCC and the Paris Agreement are many other institutions at international, regional, national and subnational levels (Figure 2-15). This includes other environmental treaties, multilateral institutions and international cooperation between non-state actors for example city networks or between investors. As noted in the previous section, not all climate forcers are addressed under the UNFCCC. For example, ozone depleting substances that are also powerful climate forcers have been phased out under the Montreal Protocol. It is possible that short-lived climate pollutants might be addressed under its own environmental treaty or addressed by some other arrangement.

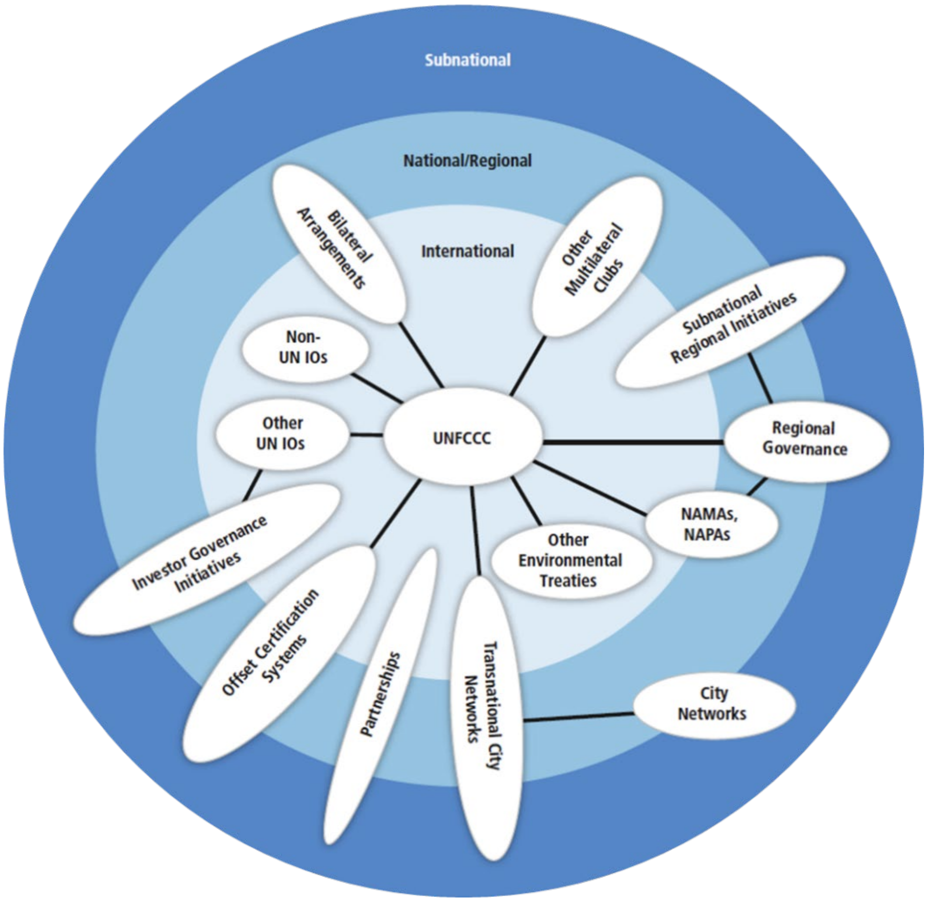

Figure 2-15: Possible institutional arrangements that could contribute to the global response to climate change. Source: Stavins et al. 2014.

2.5.4 Climate regime complex

International institutions are part of the climate policy architecture, which is defined by Alby and Stavins (2010) as "the basic nature and structure of an international agreement or other multilateral (or bilateral) climate regime" (Stavins et al. 2014, p. 1016). The climate regime can also be defined as "the set of international, national and sub-national institutions and actors involved in addressing climate change" by Moncel et al. 2011. Climate policy architecture options identified by IPCC Working Group III prior to the Paris Agreement included strong multilateralism based architectures, harmonised national policies or decentralised architectures and coordinated national policies (Stavins et al. 2014). The UNFCCC and Paris Agreement are important parts of the climate policy architecture and climate regime.

Importantly, there are other international institutions and regimes that also affect climate change, such as the World Trade Organisation, multilateral development banks and international corporations for example. As such, the UNFCCC is part of a wider climate regime complex defined as "A loosely coupled set of specific regimes" (Keohane and Victor 2011, p. 7). Importantly, "Regime complexes are marked by connections between the specific and relatively narrow regimes but the absence of an overall architecture or hierarchy that structures the whole set" (Keohane and Victor 2011, p. 8).

To explore preconditions for effective global responses to climate change, it is important to address the climate regime complex (i.e. all the agreements and rules influencing climate and the global response). Focusing on the climate regime (i.e. agreements and rules formed as part of the global response to climate change) means other influences on the global response to climate change would be ignored. Chapter 3 defines the global response system (Section 3.3) taking into account the climate regime complex. Note: For more information on the climate regime complex see Appendix C.

2.6 Summary

The global response to climate change has many elements to it, including a range of issues, options, actors and institutions. Issues including climate science, climate change impacts and risks as well as the state of the global response. Options include mitigation, adaptation, greenhouse gas removals or even solar radiation management. Actors involved in the global response to climate change include state actors as well as non-state actors. Meanwhile, institutions have formed around the issue of climate changes including the UNFCCC and the Paris Agreement but these institutions compete with other institutions. Together, these elements form a complex global response system. However, linking everything within the global response system are actors. Climate change impacts actors and creates risks for actors, meanwhile these actors make decisions on which options to take while also negotiating institutions and the "rules of the game" at local, national and international levels. As such, it is possible to explore preconditions for effective global responses to climate change by focusing on actors, their interests and the decisions they might make under changing conditions.

Part II: Concepts and methods

Part II: Concepts and methods consists of three chapters:

Chapter 3 addresses conceptual models useful for thinking about climate change and related issues. This includes a review of the literature and development of a conceptual model defining the global response system.

Chapter 4 addresses methodological considerations that are important to the design of the study, including a review of data collection, processing and analysis methods.

Chapter 5 presents the methods used in the study to collect, process and analyse data.

Chapter 3 Conceptual models

3.1 Introduction

Chapter 2 addressed the climate change problem and global response system in terms of issues, options, actors and institutions. This chapter develops conceptual models that describe the global response system elements and boundaries.

One of the questions being addressed by this study is: What influence might climate change impacts have on the global response to climate change? From the literature review no single framework or conceptual model was found that included climate change impacts and risks, the actors affected and how this might affect international cooperation on the global response to climate change. In short, there was no single model of the global response system. To fill this gap, a detailed review of climate change and related risks is made in Section 3.2, meanwhile the global response system and scope of the study are defined in Section 3.3 in terms of climate change, national interests and international cooperation.

These conceptual models provide a framework for organising information and analysing global response scenarios. As such, these conceptual models help inform the methods developed in Chapter 5, and provide a frame for organising scenarios and themes presented in Chapters 6 to 11.

3.2 Climate change and related risks

Climate change and related risks that could influence the global response to climate change consist of: physical risks including hazards, exposure and vulnerability (Section 3.2.1); the scale of risk from imperceptible to existential (Section 3.2.2); possible climate risk conceptions and response strategies (Section 3.2.3); and, other climate change and response related risks (Section 3.2.4) for example affecting finance and other sectors.

3.2.1 Physical risk including hazards, exposure and vulnerability

Chapter 19 of Working Group II's contribution to the IPCC's 5th Assessment Report (Oppenheimer et al. 2014) included a conceptual model for understanding climate change related risks (Figure 3-1). The model was modified from a similar illustration in the Special Report on "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" (IPCC 2012).

Physical risk is central to the model. It was noted that "In this report, the term risk is used primarily to refer to the risks of climate-change impacts." (Oppenheimer et al. 2014, p. 1048). Risk is defined generically as "The potential for consequences where something of value is at stake and where the outcome is uncertain" (Oppenheimer et al. 2014, p. 1048). IPCC Working Group II noted that "Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur." and "Risk results from the interaction of vulnerability, exposure, and hazard." (Oppenheimer et al. 2014, p. 1048). Vulnerability was defined as "The… predisposition to be adversely affected" (Oppenheimer et al. 2014, p. 1048) for example due to the quality of infrastructure or housing construction. Exposure was defined as "The presence of [things] that could be adversely affected" (Oppenheimer et al. 2014, p. 1048) and in the context of physical risk, this regards the physical location of people, property and livelihoods including infrastructure, housing, assets and productive activities. A hazard was defined as "The potential occurrence of a… physical event… trend or physical impact" (Oppenheimer et al. 2014, p. 1048). As such, physical risk regards the potential for, and scale of, possible climate change and related physical impacts based on the likelihood of occurrence, the presence of things of value and their predisposition to be adversely affected.

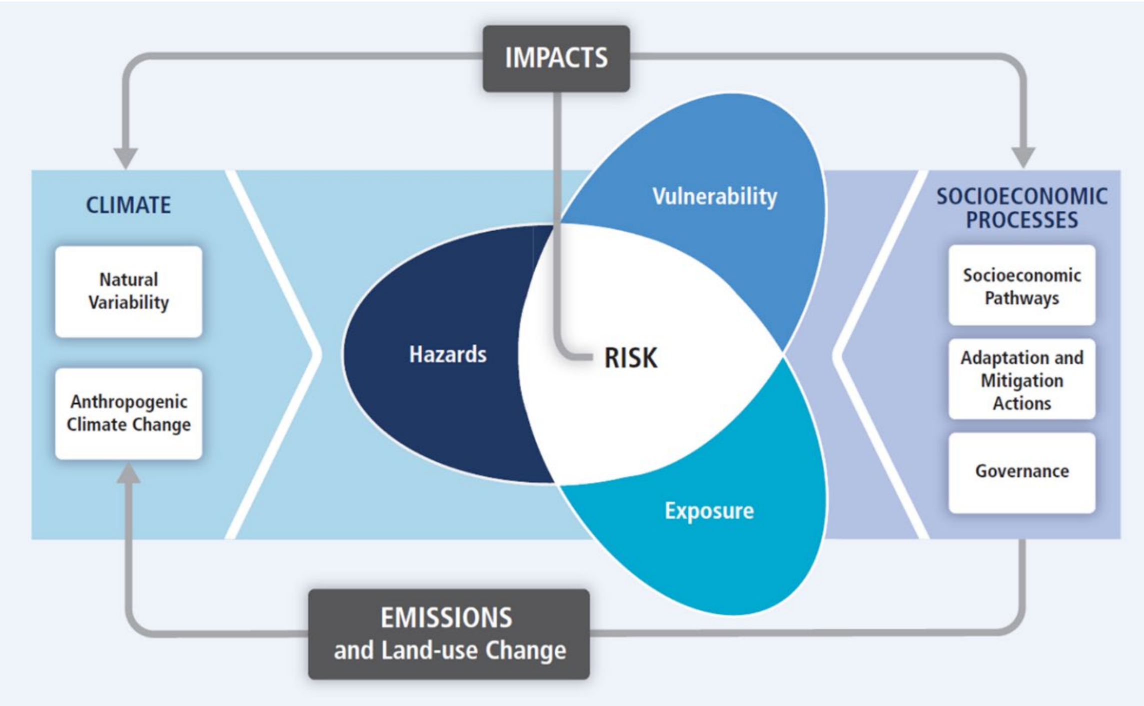

Figure 3-1: Illustration of the core concepts used by the IPCC Working Group II in its 5th assessment of climate change impacts, adaptation, and vulnerability. Source: Oppenheimer et al. 2014.

In the model, natural climate variability and anthropogenic climate change contribute to hazards, meanwhile socio-economic processes are shown to influence vulnerability and exposure to these hazards. Hazards, vulnerability and exposure together create climate risk. Feedbacks are represented in grey and include impacts, greenhouse gas emissions and land use change (Figure 3-1). Impacts are defined as "effects on natural and human systems" (Oppenheimer et al. 2014, p. 1048) i.e. risk that has become a reality. Emissions and land use change are shown as being a result of socio-economic processes and contributing to anthropogenic climate change. Importantly hazards and impacts can include "climatic" hazards and impacts (e.g. extreme heat or changes in precipitation) as well as "related" physical hazards and impacts such as sea level rise, flooding or ocean acidification.

The model in Figure 3-1 can be applied at subnational, national or international levels. Physical risks and impacts are location specific and as such will often be addressed by individual subnational or national jurisdictions, although in some cases international cooperation may be useful for example where the actions of one sovereign state can exacerbate hazards for other states or a common threat might be best addressed though cooperation (Farber 2012). Examples might include downstream flood risk where a river catchment spans more than one state, or the establishment of the European Union Solidarity Fund (Hochrainer-Stigler et al. 2017) which limits risk by sharing the cost of climate impacts. GHG emissions are reported to the UNFCCC at the national level but may be regulated by a mix of national or subnational authorities. Similarly, land use change may be regulated by national authorities or more often by subnational authorities. Of course, GHG emissions and land use change may also be influenced by wider economic trends including for example issues of behaviour, preferences and demand, technology and prices as well as international trade (Meyfroidt et al. 2013).

Note: For a more detailed analysis regarding the concepts of hazards, exposure, vulnerability and interactions with actors within a state constituting a socio-economic system, see the Environment and National Interests Model in Appendix D.

3.2.2 Scale of risk from imperceptible to existential

Without an adequate global response, climate change constitutes a dangerous to catastrophic risk (Xu and Ramanathan 2017). While the term catastrophic is used to describe anticipated impacts of unmitigated climate change, it is not altogether clear what is meant by the term. Bostrom and Cirkovic (2008) have developed a taxonomy of risks were the scale of risks (i.e. scope) range from personal to transgenerational, and the intensity of these risks ranges from imperceptible to terminal (Figure 3-2).

Scope (Cosmic?)		Global catastrophic risks	Existential risks
Trans-generational	Loss of one species of beetle	Drastic loss of biodiversity	Human extinction
Global	Global warming by 0.0001 °C	Spanish flu pandemic	Ageing?
Local	Congestion from one extra vehicle	Recession in a country	Genocide
Personal	Loss of hair	Car is stolen	Fatal car crash
Intensity (Hellish?)	Imperceptible	Endurable	Terminal

Figure 3-2: Qualitative categories of risk. Source: Modified from Bostrom and Cirkovic 2008.

The framework is useful for distinguishing different climate change impacts and risks. For example, David Attenborough's concern that climate change is a risk to civilisation (Attenborough 2018) suggests climate change could be classified as being an endurable catastrophic global and transgenerational risk, rather than a terminal existential risk. Some climate change impacts and risks will be personal including those impacts and risks that affect individuals and their property, meanwhile other climate change impacts and risks may be global or transgenerational. While evidence shows climate change being experienced is not cosmic in scope, the taxonomy from Bostrom and Cirkovic (2008) is a reminder that there are cosmic and other risks in addition to climate change related risks. For more on the need to take into account other risks see Section 4.3.5.

While Bostrom and Cirkovic (2008) addressed how bad a risk might be, Grubb (2014) addressed how a risk might be conceived and related response strategies.

3.2.3 Climate risk conceptions and response strategies

How actors respond to climate change depends in part, on how actors conceive risk and the strategies they are willing to employ (Grubb 2014). Grubb (2014) identified climate change risk conceptions and related national interests, societal processes and climate change timescales assuming progressively greater impacts. If a sovereign state and their leader's risk conception is one of indifference or disempowerment, then any options with a cost associated will likely be ignored at the international level, and the state is likely to freeride. Grubb (2014) noted that climate change risk conceptions based on tangible and attributable costs follow the so-called rational approach. To date, analyses of pathways have taken the rational approach and have assumed responses to climate change are based on "economic decision making" seeking to reduce costs of responses to economies (Section 1.4). If the risk conception is one of securitisation, then the sovereign state and their leaders are expected to mitigate as much as practical. Grubb (2014) did not address the extent to which states or other actors might be willing to coerce other actors into participating in the global response to climate change.

Table 3-1: Climate change risk conceptions and strategies over time. Source: Grubb 2014.

Risk conception	Basic belief	Typical strategy	Societal process	Timescale of climate change
Indifferent or disempowered	Not proven, or 'What you don't know can't hurt you'	'Ignorance is bliss'	Environmental group campaigns vs resistance lobbying	First few decades of climate change
Tangible and attributed costs	Weigh up costs and benefits	Act at costs up to 'social cost of carbon'	Technocratic valuation and politics of pricing	As impacts rise above the noise – next few decades
Disruption and securitisation	Personal or collective security at risk, climate change as a 'threat multiplier'	'Containment and defence'	Mitigate as much as practical and adapt to the rest	Ultimately, for all (systemic and global risk) Most vulnerable, sooner, with international spill over

In each of the models, from Grubb (2014), Bostrom and Cirkovic (2008) and Oppenheimer et al. (2014), climate change and related physical risks can impact people, their property and livelihoods. However, there are other risks beyond the physical risk of climate change.

3.2.4 Other climate change and response related risks

In a speech titled "Breaking the tragedy of the horizon – climate change and financial stability", delivered at a dinner for insurers just weeks before COP21, the Governor of the Bank of England and Chairman of the Financial Stability Board, Mark Carney (2015) highlighted three types of climate risk consisting of: physical risk; liability risk; and, transition risk (Table 3-2).

Carney's (2015) classification of climate change risks and definitions from the Bank of England Prudential Regulatory Authority (Table 3-2) were framed in the context of finance and insurance.

These definitions can be generalised to ensure the classification is comprehensive and more widely applicable. For example, physical risks can be generalised to: Potential physical impact of climate change. Litigation risks can be generalised and defined as: The potential for legal compensation claims related to climate change. Carney's (2015), and the BOE's (2015), definitions of transition risks only referred to risks related to mitigation, but it is conceivable that there may be transition risks related to adaptation as well. As such, transition risk could be generalised to: Potential disruption due to adjustment towards a climate resilient low greenhouse gas emissions economy.

Table 3-2: Types of risk identified by the Bank of England Prudential Regulatory Authority. Source: BOE 2015.

Type of risk	Description of risk to insurers
Physical risk	First-order risks which arise from weather-related events, such as floods and storms. They comprise impacts directly resulting from such events, such as damage to property, and also those that may arise indirectly through subsequent events, such as disruption of global supply chains or resource scarcity.
Liability risk	Risks that could arise for insurance firms from parties who have suffered loss and damage from climate change, and then seek to recover losses from others who they believe may have been responsible.
Transition risk	Financial risks which could arise for insurance firms from the transition to a lower-carbon economy.

In 2017, the Task Force on Climate-related Financial Disclosures (TCFD) Chaired by Michael Bloomberg, published recommendations (TCFD 2017) that identified two overarching categories of climate change related risk, specifically physical and transition risks. Liability risks were combined with policy risks to create a category titled "policy and legal risk" under transition risks. Other transition risks identified included technology, reputation and market. Physical risks were divided into acute and chronic. However, as discussed in Appendix E, liability risks run in the opposite direction from most other transition risks and as such, the author believes it would be best to keep liability risk separate from transition risks.

From the work of the TCFD (2017), BOE (2015), Carney (2015), Grubb (2014), Bostrom and Cirkovic (2008) and Oppenheimer et al. (2014), climate change and related responses poses direct and indirect risks to people, businesses, government and their interests.

3.3 Climate change, national interests and international cooperation

The IPCC's conceptual model for understanding climate change related risks (Section 3.2.1) addresses part of the climate change and global response system, specifically interactions between climate change and related hazards within socio-economic systems. An important socio-economic system is the state. Given that climate change is a global collective action problem (IPCC 2014a), it is important to understand how climate change risks and impacts on socio-economic systems might also influence the national interests of states and international cooperation between states. In the sections below, climate change, national interests and international cooperation are recognised as important parts of the global response system (Section 3.3.1), forming the basis for the Climate Change, National Interests, International Cooperation (CCNIIC) Model (Section 3.3.2). Lastly, criteria for effective international cooperation are addressed in Section 3.3.3

3.3.1 Climate change, national interests, international cooperation streams

Interactions between climate change and socio-economic systems, including sovereign states, were addressed in Section 3.2.1 (see Figure 3-1) as well as Appendix D. These interactions consist of climate and related physical hazards to socio-economic systems; of which sovereign states are especially important. Meanwhile socio-economic systems, such as sovereign states include national interests that generate greenhouse gas emissions and other changes to the environment, driving climate change (Figure 3-3). Central governments determine negotiations mandates and negotiating positions for climate negotiators (Hermwille 2018). As such, Figure 3-3 shows that the national interests of a sovereign state informing positions on international cooperation and engagement with international institutions. The UNFCCC creates obligations on central governments which affect national interests (Hermwille 2018). As such, Figure 3-3 shows international cooperation creating options and norms that sovereign states and their central governments may act on or ignore depending on their national interests (Figure 3-3).

Figure 3-3: Snapshot of interactions between climate change, national interests and international cooperation streams.

Figure 3-3 is a simple model with a central focus on the national interests of a state. However, the international community as represented by the United Nations has 193 members (UN 2018a) and the UNFCCC has 197 Parties (UN 2018b). As such, international cooperation and institutions such as the UNFCCC depend upon the national interests of many states and are the result of many positions coming together. Figure 3-4 represents a case with three states for simplicity sake (rather than attempting to represent 197 Parties to the UNFCCC). Figure 3-4 also includes relations between the states which can influence national interests and positions for example at climate negotiations. Importantly, international sanctions can be used to enforce international agreements if applied by member states.

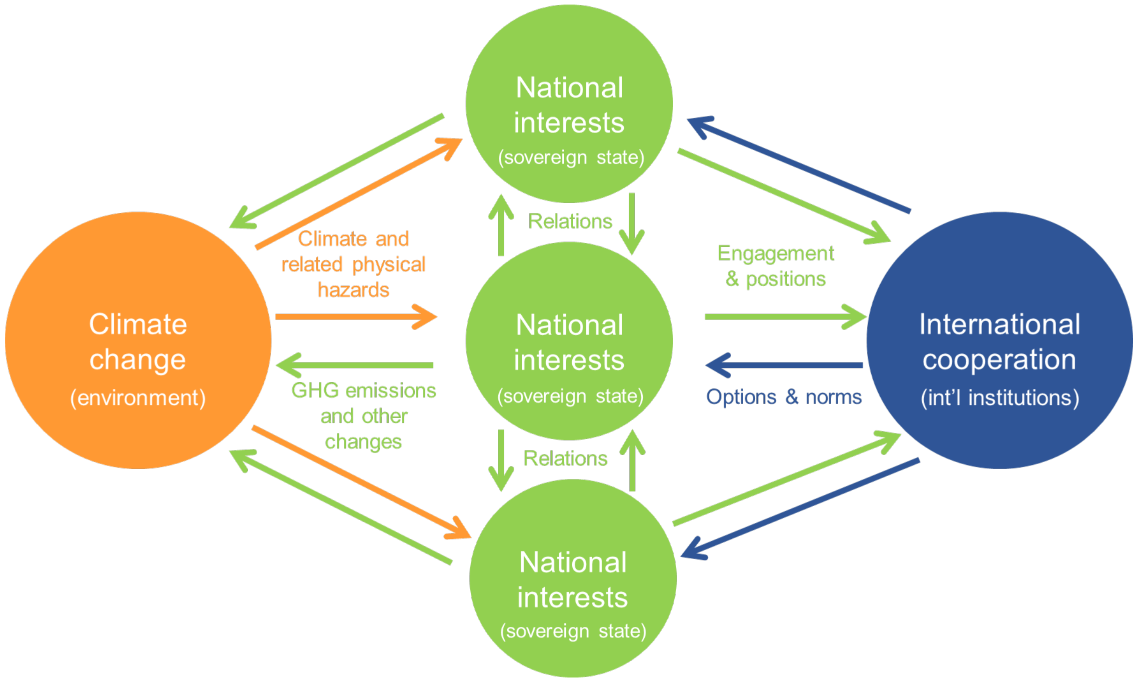

Figure 3-4: Snapshot of interactions between national interests of different sovereign states as well as climate change and international cooperation.

While Figure 3-4 includes multiple sovereign states, it lacks detail when it comes to international cooperation. For example, Keohane and Victor (2011), Stavins et al. 2014 and IEGL (2017) each refer to international cooperation by state actors as well as non-state actors such as civil society, local government and businesses. Furthermore, international cooperation includes the UNFCCC as well as other international institutions such as the World Trade Organisation, multilateral development banks and others. These other international institutions can provide options or set norms that may, or may not, be aligned with the UNFCCC objective. These things are addressed in the CCNIIC Model.

3.3.2 CCNIIC Model

From the previous section, climate change, national interests and international cooperation are important parts of the global response system These three elements can be unpacked to form the Climate Change, National Interest, International Cooperation (CCNIIC) Model (Figure 3-5). Note: CCNIIC can be pronounced “scenic”. The elements of the CCNIIC Model, and linkages between these elements, are detailed below in terms of climate change and national interests (Section 3.3.2.1), the sovereign state and national interests (Section 3.3.2.2), national interests and international cooperation (Section 3.3.2.3), and other issues (3.3.2.4).

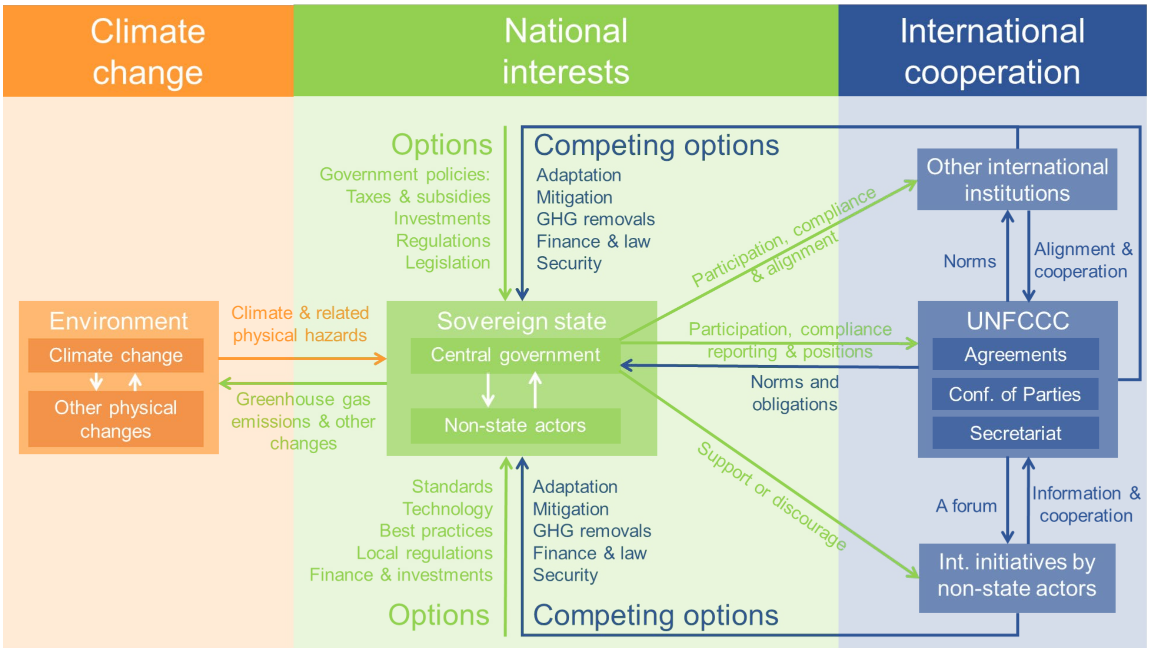

Figure 3-5: The Climate Change, National Interests, International Cooperation (CCNIIC) Model including actors and relations between these actors.

3.3.2.1 *Climate change and national interests*

The CCNIIC Model (Figure 3-5) starts on the left with climate change. Following the discussion in Section 3.2.1 and Section 3.3.1, climate change includes climate change and other related physical changes such as sea level rise, flooding or ocean acidification. Meanwhile, actors in states, through their activities create greenhouse gas emissions and other changes to the environment.

Note: Interactions between climate change and national interests can be broken down in more detail, but for the purposes of this study and defining the climate change and global response system, the level of detail is restricted in the CCNIIC Model. For a detailed description of climate change and related physical changes, or greenhouse gas emissions and other changes to the environment, see Appendix D and the Environment, National Interests (ENI) Model.

3.3.2.2 *The sovereign state and national interests*

Within the state, two actors are identified consisting of central government and non-state actors (Figure 3-5). Central government leaders have a special role in deciding what is in the national interest of a state (Putnam 1988). However, central government leaders, to varying degrees depending on their governance regime, need to take into account the interests of domestic non-state actors. Domestic non-state actors can include local government, business, civil society, researchers, the media, religious organisations, communities and individuals.

Leaders from central government decide what is in the national interest including whether to participate in, or comply with, international agreements. This includes decisions on whether or not to participate in, or comply with, the UNFCCC or Paris Agreement, what is reported to the UNFCCC when it comes to NDCs or inventories, and what positions to take at the UNFCCC or on the Paris Agreement for example regarding levels of ambition. However, the UNFCCC is not the only international institution that a state might choose to participate in or comply with. States will be a member of other international institutions and can take positions influencing whether these other international institutions align with the UNFCCC objective.

It is noted by the IPCC that "When it comes to understanding the behaviour of sovereign states, national interests are important." Furthermore, "domestic political conditions affect participation in, and compliance with, international climate policies." and "This has been addressed in the literature on 'two-level' games" (Stavins et al. 2014, p. 1010).

The term "two-level games" was coined by Robert Putnam, who stated that:

> "At the national level, domestic groups pursue their interests by pressuring the government to adopt favourable policies, and politicians seek power by constructing coalitions among those groups. At the international level, national governments seek to maximize their own ability to satisfy domestic pressures, while minimizing the adverse consequences of foreign developments. Neither of the two games can be ignored by central decision-makers… Each national political leader appears at both game boards." (Putnam 1988, p. 434).

Putnam (1988) referred to international negotiations as "Level I", and domestic negotiations as "Level II". The options (i.e. win set) available to a negotiator at Level I depends upon the options acceptable domestically at Level II (Figure 3-6). The domestic acceptability of options depends upon the preferences and coalitions within society as well as institutional arrangements within the sovereign state (Putnam 1988). The set of options available to a negotiator is referred to as a "win set". It is generally easier to reach an international agreement if a win set is larger (Putnam 1988).

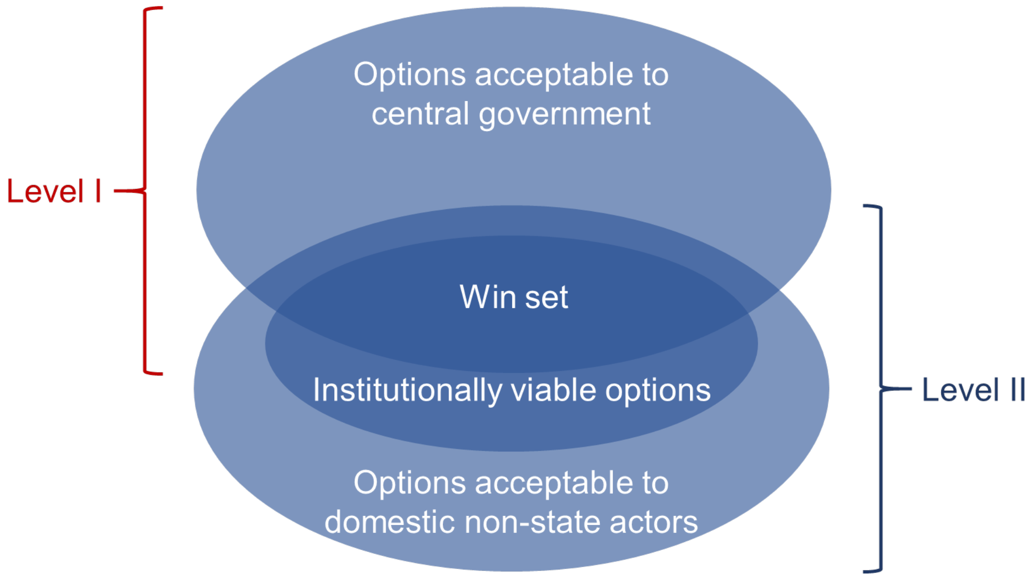

Figure 3-6: Options and the win set in a two level game. Source: Author based on Putnam 1988.

In addition to societal preferences and coalitions, institutional arrangements can limit the size of a win set (i.e. viable options). For example in the United States two thirds of the Senate need to approve international treaties, which in turn limits "institutionally viable options" and the size of the win set available to negotiators. For many other states, the win set is determined by central government leaders based on the prospect of upcoming elections, simple majorities or coalition agreements rather than a ratification process. In other states, the win set may be determined by a single party and may involve opaque coalitions of domestic interests (Putnam 1988).

From Putnam (1988), national interests and win sets reflect the interests of central government leaders and domestic non-state actors (Figure 3-7). Given the many interests, preferences and coalitions of non-state actors it can be difficult to judge Level II interests. Further complicating the understanding of national interests, it was noted by Putnam that "on nearly all important issues 'central decision-makers' disagree about what the national interest and the international context demand." Furthermore, "Even if we arbitrarily exclude the legislature from 'the state'… it is wrong to assume that the executive is unified in its views." (Putnam 1988, p. 432). As such, national interests are difficult to ascertain as there is uncertainty around interests at Level I and Level II.

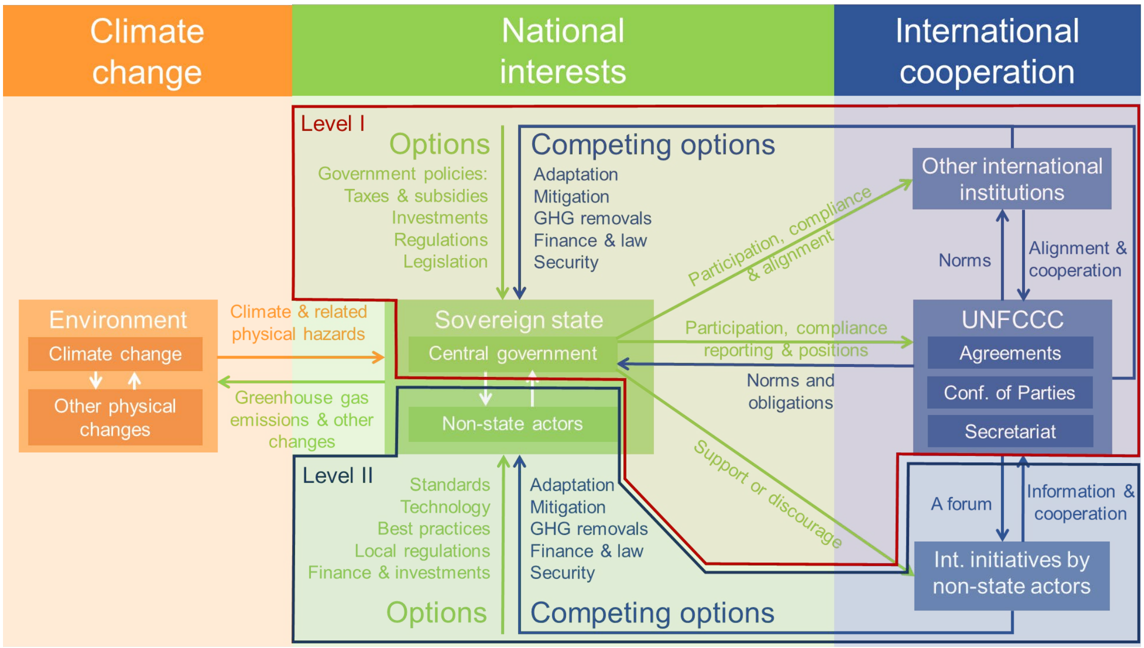

Figure 3-7: CCNIIC Model divided into Levels I and II of a two level game.

3.3.2.3 National interests and international cooperation

As discussed in Section 2.5, the global response to climate change can be characterised as a climate regime complex including the UNFCCC, Paris Agreement, state actors and non-state actors including other international institutions. The right-hand side of the CCNIIC Model presents the "International Cooperation" part of the global response system, consisting of the UNFCCC (Paris Agreement included), other international institutions and international initiatives by non-state actors.

The UNFCCC and related agreements create international norms, for example the UNFCCC objective and Paris Agreement purpose indicate that efforts should be made to mitigate greenhouse gas emissions and adapt to climate change. These norms have an influence on other international institutions, for example within the UN system and to a lesser extent international institutions outside the UN system (Keohane and Victor 2011). Other international institutions cooperate with the UNFCCC to varying degrees, for example attending the UNFCCC COP, support mitigation or adaptation through their own activities, or including climate change considerations into their own policies and practices. However, it is possible that international institutions might also support things that in effect increase global greenhouse gas emissions or reduce climate resilience.

Participation in the UNFCCC creates options for states and their central governments. This includes international cooperation on themes such as adaption, mitigation, greenhouse gas removals, finance, law or security. However, other international institutions also provide options in these areas or on issues such as trade or security for example. As such, there are competing options, some of which align with the UNFCCC objective and others do not. Furthermore, these options are also competing with other possible policy options. This includes options related to taxes and subsidies, investments (e.g. in infrastructure or utilities providing energy and water), regulations, legislation or other policies (e.g. government targets). Of course, it is possible there can be alignment between international options and national interests, but even in such situations, there will be competing interests and options when it comes to the design, modalities, and oversight of international cooperation initiatives.

There are a range of possible international initiatives by non-state actors. From IPCC Working Group III, these include: 1. Public-private partnerships; 2. Private sector governance initiatives; 3. Non-governmental organization (NGO) transnational initiatives; and, 4. Sub-national transnational initiatives (Stavins et al. 2014).

International initiatives by non-state actors provide options for domestic non-state actors related to standards, technology, best practices, examples of local regulations, as well as finance and investments. The activities of domestic non-state actors will in many cases count towards the state's contribution to the global response to climate change. However, it should be noted that options arising from international initiatives are competing with other options in the same areas. Options include options based on domestic innovation and knowledge, or competing options arising from technology transfer from other non-state actors from other states. All options, regardless of source, compete and require coalitions of actors and interests to be successful. These coalitions, at the level of non-state actors, can come in the form of businesses, local government policies, or wider societal changes.

UNFCCC COP side events provides a forum for international initiatives by non-state actors, where they can meet and discuss issues, as well as meet with delegates (e.g. negotiators) from member states, UN observers and other influencers (i.e. so called "track 2 diplomacy"). At the same time, non-state actors share information including valuable experiences that might be replicated or avoided in the future. Furthermore, some non-state actors can help the UNFCCC with ideas and cooperation towards the UNFCCC objective through their projects and activities.

Importantly, central governments can have a supportive or discouraging influence on international initiatives by non-state actors (Figure 3-7). For example, a supportive central government might include non-state actors as delegates to the COP improving access to influential people and facilitating interactions with other non-state actors (Böhmelt et al. 2014).

In Figure 3-5 and Figure 3-7, the UNFCCC is represented with three parts consisting of “agreements” including the Convention as well as the Kyoto Protocol and Paris Agreement. The “Conference of Parties” includes other conferences under the UNFCCC as well as permanent subsidiary bodies that report to these conferences. The “Secretariat” is included as it supports many of the processes related to the UNFCCC including reporting. For a more detailed representation of the UNFCCC in the context of the international regime complex, see Appendix C and the Jellyfish Model.

3.3.2.4 Other issues

It is important to acknowledge that there are many influences that are not explicitly included in Figure 3-5 and the CCNIIC Model. For example, behaviour or development goals are not highlighted in the Model. Other national interests related to security or trade are not directly addressed either. All of these can have an influence on national interests and the perceived advantages and disadvantages of addressing climate change.

Figure 3-5 highlights options but does not show how they emerge. For example, technology is widely regarded as a key issue, and while technology is included in the options in Figure 3-5, the model does not provide any insight on how technological or other options might come into existence or change incentive structures. Time series information, including scenarios, are better suited to looking at changes over time than system snapshot models.

3.3.3 Criteria for effective international cooperation

As a global collective action problem, international cooperation is widely regarded as an essential part of the global response to climate change (e.g. Stavins et al. 2014). From the literature, two sets of related criteria are identified for effective international cooperation, one for an international agreement to be effective and another for an international institution to be effective.

Barrett (2005) identified issues of compliance and participation as being central to the effectiveness of international agreements along with the issues of incentives and enforcement. Barrett (2005) noted that states are sovereign and as such, can decide whether to participate or not in international agreements and whether to comply or not with an agreement. In many cases, a state will not participate in an international agreement if they think they will not be able to comply (Barrett 2005), or in other cases will not comply unless there is an incentive to do so. Bodansky (2012) referred to

Barrett (2005) and likewise identified participation and compliance as being preconditions for effective international agreements along with stringency[7] (Bodansky 2012, Bodansky and Diringer 2010). In an independent piece of work, Wilson (2015) looked at the limits of international energy cooperation through multilateral organisations. Wilson (2015) found the effectiveness of multilateral energy organisations were limited by issues of membership (i.e. a lack of participation), design (including issues of stringency) or commitment (i.e. compliance). Specifically, Wilson (2015) found that multilateral organisations either lacked membership (i.e. participation) by key actors, the design was focused on soft law approaches and therefore lacked stringency, or there was a lack of commitment (i.e. compliance) to agreements that were stringent.

Neither Bodansky (2012) nor Bodandsky and Diringer (2010) define stringency. While the stringency of environmental agreements has been addressed at domestic levels (i.e. within a single jurisdiction, few authors have addressed the concept of stringency at the international level across multiple jurisdictions. Fortunately, Hofmann (2019) has reviewed concepts and definitions related to stringency as part of his research developing a "stringency index" for international environmental regulations. According to Hofmann, stringency in the context of international agreements and regulations is a "function of formal tightness and substantive ambition" (Hofmann 2019, p. 219). "The tightness of regulation depends on its legality, precision, and compliance system." (Hofmann 2019, p. 219). An "international regulation is tight when it is legally binding, highly precise, and endowed with strong compliance mechanisms." (Hofmann 2019, p. 220). Meanwhile, substantive ambition "results from the scope of the regulation and its requirement levels in relation to the external effect and compared with other international regulations." (Hofmann 2019, p. 220). A substantively "ambitious international regulation possesses a large scope as well as high requirement levels in relation to the external effect and other international regulation." (Hofmann 2019, p. 221).

The UNFCCC and Paris Agreement have a large scope but don't have "high requirements" instead relying on Parties to make "nationally determined contributions" to the global response to climate change. In short, the UNFCCC and Paris Agreement lack "substantive ambition" in themselves, and instead seek "voluntary ambition" from Parties. Hofmann (2019) also notes that "In case of full compliance, [substantively ambitious] regulation would virtually eliminate the external effect addressed." (Hofmann 2019, p. 221). In the case of the UNFCCC and Paris Agreement the "external effect" is climate change, meanwhile, full compliance would mean all parties complying (i.e. full participation and compliance – see Table 3-3). So, while there has been near universal membership and participation in the UNFCCC and Paris Agreement, stringency (i.e. tightness and substantive ambition) of these agreements is low. Instead, the voluntary ambition of Parties to Paris Agreement is an important precondition for success.

In a blog for the World Resources Institute, Cameron and DeAngelis (2012) defined ambition in the context of climate change as "countries' collective will—through both domestic action and

[7] Cambridge Dictionaries (2016) defines stringency as "a situation in which a law, test, etc. is extremely severe or limiting and must be obeyed".

international initiatives—to cut global greenhouse gas emissions enough to meet the 2°C goal." Cameron and DeAngelis (2012) also stated "Ambition further represents the actual steps countries are taking to meet that temperature goal." As such, Cameron and DeAngelis (2012) considers ambition in terms of "will" (i.e. determination) as well as "action" (i.e. responses).

With regards to ambition in the Paris Agreement, the concept involves Parties voluntarily making greater contributions towards the global response through their NDCs, compensating for a lack of stringency in the Paris Agreement. This is referred to as ratcheting (e.g. Meltzer 2016 and Rockström et al. 2017).

The IPCC's chapter on international cooperation in the Fifth Assessment Report identified criteria for "institutional feasibility". These criteria consisted of participation, compliance, legitimacy, and flexibility (Stavins et al. 2014). According to Stavins et al. (2014), "participation in an international climate agreement might refer to the number of parties, geographical coverage, or the share of global GHG emissions covered." (Stavins et al. 2014, p. 1010). Compliance refers to the fulfilment of an agreement's provisions (Stavins et al. 2014). Legitimacy refers to the belief by sovereign states and others, that the institution is credible with some degree of authority. Stavins et al. (2014) noted "legitimacy of substantive rules is typically based on whether parties evaluate positively the results of an authority's policies, while procedural legitimacy is typically based on the existence of proper input mechanisms of participation and consultation for the parties participating in an agreement." (Stavins et al. 2014, p. 1010). Flexibility refers to the mechanisms under the institution specifically the ability to adjust or adapt as required to new information or changes in economic situations or politics (Stavins et al. 2014).

Institutional feasibility is different from agreement effectiveness. Institutional feasibility in its most basic form is the ability of an institution to perpetuate itself (i.e. perpetuate the rules of the game). Meanwhile, agreement effectiveness is the ability of an agreement to achieve its goals. In the context of the UNFCCC, both sets of criteria are relevant. This is because the UNFCCC has the characteristics of being both an international agreement and international institution. As a framework convention, the UNFCCC depends upon additional international agreements such as the Kyoto Protocol or Paris Agreement, for its objective to be achieved (Section 2.5.1). Figure 3-8 presents the criteria for institutional feasibility along with the criteria for agreement effectiveness. Notably, participation and compliance are included in both sets of criteria. The criteria are treated as preconditions as each of them need to be fulfilled if the UNFCCC is to be an effective agreement and feasible institution (Table 3-3).

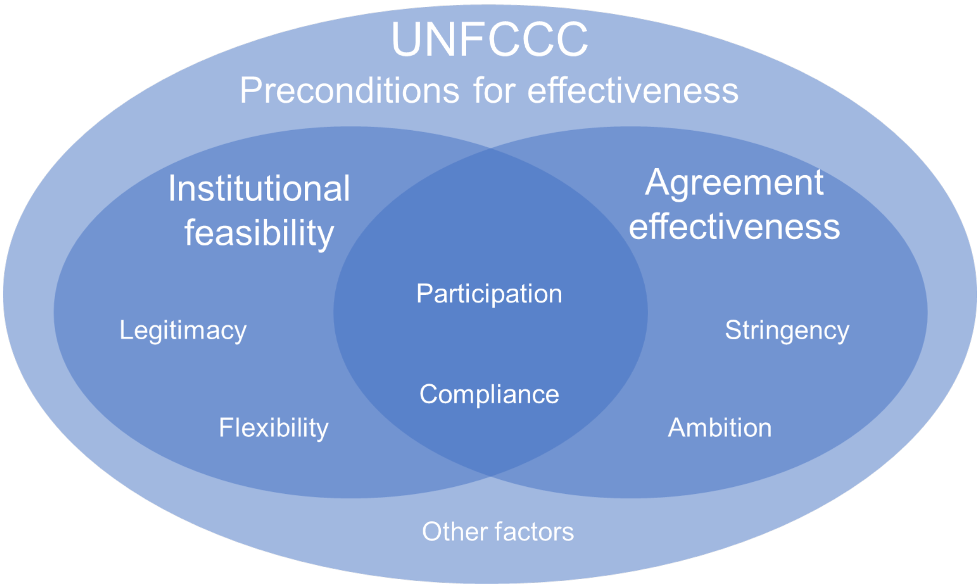

Figure 3-8: A Venn diagram of preconditions for effective international cooperation under the UNFCCC and Paris Agreement.

When it comes to collective action and the institution of the UNFCCC, one of the key issues identified by Stavins et al. (2014) was legitimacy of the UNFCCC. Without the legitimacy the institution would likely fail and ultimately cease to be recognised. As such, legitimacy was identified as a key success or failure criteria. Meanwhile, flexibility, participation, compliance and stringency are preconditions towards being able to deliver the objective of the UNFCCC.

Stavins et al. (2014) noted that "The UNFCCC is currently the only international climate policy venue with broad legitimacy, due in part to its virtually universal membership (robust evidence, medium agreement)." (Stavins et al. 2014, p. 1005). As such, Stavins et al. (2014) identified participation (i.e. membership) as a key indicator of legitimacy.

Table 3-3: Preconditions for effective international cooperation based on the preconditions for agreement effectiveness and institutional feasibility.Source: Author, Stavins et al 2014, Cameron and DeAngelis 2012.

Preconditions	Definition
Participation	When States consent to be bound by an agreement. (Source: adapted from Vienna Convention 1969). "participation in an international climate agreement might refer to the number of parties, geographical coverage, or the share of global GHG emissions covered." (Stavins et al. 2014, p. 1010)
Compliance	The fulfilment of an agreement's provisions. (Source: Adapted from Stavins et al. 2014).
Stringency	The formal tightness or substantive ambition of an agreement. Formal tightness means the agreement is legally binding, highly precise, with strong compliance mechanisms. Substantive ambition means the agreement is comprehensive in scope and has obligations sufficient to fulfil the goals, objectives, or purpose of the agreement. (Source: Modified from Hofmann 2019) Note: Agreements with formal tightness or substantive ambition require participation and compliance to be effective.
Ambition	The level of determination, and action required, to fulfil an agreement and achieve its goals, objectives or purpose. (Source: Generalised from Cameron and DeAngelis 2012)
Legitimacy	The belief by sovereign states and others, that the institution is credible with some degree of authority. (Source: Adapted from Stavins et al. 2014).
Flexibility	The ability of Parties to an agreement to adjust or adapt their actions while still fulfilling their obligations. Such adjustments and adaptations are required when there are changes in information, economic situations or politics. (Source: Adapted from Stavins et al. 2014)

Chapter 4 Review of methods and methodology

4.1 Introduction

To address the questions from Section 1.6, it would be ideal to have a representative sample of possible futures, and be able to analyse these futures, including the actors involved and the conditions that support effective global responses to climate change. This poses a challenge, specifically, how to collect and compile information that is representative of the future, given that an unprecedented combination of climatic, societal, and technological conditions are expected.

The dilemma of how to collect information on possible futures is not unique to this study. Methods, and underlying methodological justifications, have been developed for example when it comes to foresight and the use of scenarios. In this chapter, methods and underlying methodologies are discussed, including scenario methods and the extent to which scenarios can provide useful and representative samples of the future (Sections 4.2). Stress test methods are discussed including the strengths and weaknesses of such methods, along with recently developed reverse stress test methods (Section 4.3). Theory of change methods are discussed, including the identification of preconditions (Section 4.5). Given the need to process qualitative data, thematic analysis methods are also discussed (Section 4.5.2), including how these might be used to identify themes and preconditions in scenarios. The Chapter finishes with a summary (Section 4.6) highlighting methods and methodological considerations that provide a basis for the methods selected and developed in Chapter 5.

4.2 Scenarios

4.2.1 Foresight and the future

In the four years since this study started, a business and reality television personality became president of the United States and promised to leave the Paris Agreement on climate change (Chemnick 2019), the UK held a referendum to leave the European Union and political tumult ensued (Muller 2019), and a tragic terrorist attack on two mosques occurred in the author's home town of Christchurch (Graham-McLay 2019), a city which less than a decade before suffered a series of nearly 18,000 earthquakes including a magnitude 6.3 earthquake that killed 185 people, injured more than 7,000, damaging 168,000 homes 7,000 of which beyond repair, and led to cordoning off of the central business district for 858 days (New Zealand Government 2019). Meanwhile, a novel coronavirus pandemic has swept the world. None of these things were considered probable, but they happened. Due to experiences such as these, Bishop et al. (2007) noted that "the future is uncertain so we must prepare for multiple plausible futures, not just the one we expect to happen" (Bishop et al. 2007, p. 5). Kahn, an influential figure when it comes to scenario development, is widely quoted as saying "imagine the impossible" and noted that "the most likely future isn't" (Bishop et al. 2007). These observations seem especially relevant when thinking about the unprecedented mix of anticipated climate changes, social and technological conditions.

With regards to most probable futures, Bishop et al. (2007) noted “Futurists often discount the expected future because it rarely occurs in its full form. In fact, they make their living pointing out that surprising developments are common and are, in fact, more likely than the expected.” (Bishop et al. 2007, p. 11). However, Bishop et al. (2007) went on to state “one of the most surprising developments to futurists, steeped in change and uncertainty, is that things do not often change as fast or as surprisingly as they anticipate.” (Bishop et al. 2007, p. 11). This poses a dilemma especially with regards to the credibility of scenarios and futures methods.

In the case of climate change, some changes are locked in for millennia, for example sea level change (Section 2.2.3), meanwhile other changes happen unexpectedly for example the collapse in Arctic sea ice extent in the summer of 2007 (Wadhams 2012, Zhang et al. 2008). As discussed in Section 2.2.3, there is deep uncertainty but at the same time there are known knowns such as long-term sea level rise, as well as unknown unknowns such as the possibility of further unexpected changes.

Scenarios are an important part of foresight and futures studies (Bishop et al. 2007, UNDP 2014). Bishop et al. (2007) noted that scenario development is concerned with creating stories about the future. Bishop et al. (2007) also noted that “A good scenario grabs us by the collar and says, ‘Take a good look at this future. This could be your future. Are you going to be ready?’” (Bishop et al. 2007, p. 5).

After reviewing climate change related scenarios, Mangalagiu et al. (2011) noted that “Scenarios are helpful in revealing, appreciating, understanding and addressing climate change.” (Mangalagiu et al. 2011, p. 11). With regards to being ready for the future, Mangalagiu et al. (2011) noted that “their value is not in enhancing prediction but in revealing and testing critical assumptions about the future, in enabling more shared and systemic understanding and in providing a means for identifying more and better options.” (Mangalagiu et al. 2011, p. 11). Similarly, Steenmans (2019) highlighted scenarios as being an important method for getting useful intelligence on the future to help with policy decision making. Steenmans (2019) noted that traditional decision-making processes focused on reducing uncertainty by agreeing on assumptions about current and future conditions and then selecting a preferred pathway towards achieving some objective or goal. The problem with this approach is that it gambles on predictions of future conditions, which in many cases are not correct. Furthermore, the path chosen may be sensitive to any deviations from expected conditions. An alternative approach, that is especially useful when there is deep uncertainty, is to analyse the robustness of options and pathways under multiple scenarios, and test these options for robustness (Steenmans 2019, Swart et al. 2013).

4.2.2 Imagining the future

According to GOS (2016), the future can be visualised as several components consisting of the probable future, plausible future, the possible future, and of course the preferred future (Figure 4-1). The probable future would often include business as usual and related projections. The plausible future is the set of futures that are consistent with results from a range of accepted models. The wider "possible" future includes many possible but improbable futures. While possible futures are often represented as a cone, with a circular cross section, Ramirez and Selin (2014) noted that there is no particular reason for assuming this and instead a plot of probable futures might just as well have a Teddy Bear shape, tetrahedral or some other form (Ramirez and Selin 2014).

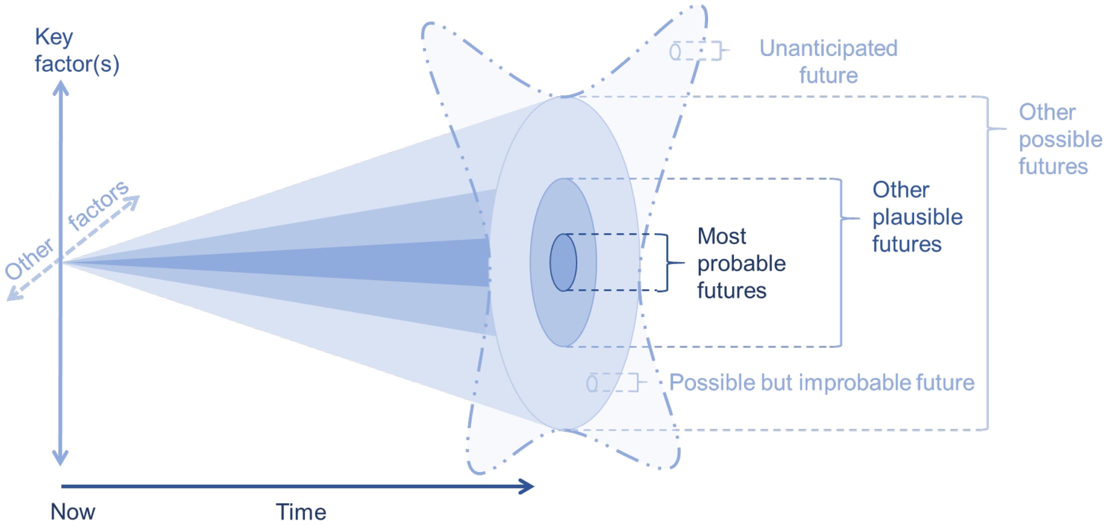

Figure 4-1: The cone of possible futures and different types of futures considered in foresight processes Source: Modified and adapted from GOS 2016.

4.2.3 Actors, situations and system conditions

A scenario with a focus on specific actors can be defined as "A possible situation or path between situations" (modified from Kosow and Gaßner's (2008) definition[8]). Two types of information might be collected as part of a scenario exercise, consisting of snapshots and chains. Snapshots regard a situation at a point in time, for example a "day in the life" or "end state" (Bishop et al. 2007). Chains regard a series of situations. This often includes a focus on the chain of events that change situations (Bishop et al. 2007).

A scenario with a focus on a system, rather than a specific actor within a system, is defined in this study as "A possible set of system conditions or succession of system conditions". Actors may have very different situations depending on where they are within a system. As such, their interests and incentives may be affected differently, and their potential to influence the system may differ too.

[8] The term "scenario" can be defined as "a description of a possible future situation, including the path of development leading to that situation" (Kosow and Gaßner 2008, p. 1). However, there are many other definitions in use (Kosow and Gaßner 2008). In the context of climate change, "…scenarios describe plausible trajectories of climate conditions and other aspects of the future" (Moss et al. 2010, p. 748) according to Moss et al. (2010). However, Parson et al. (2007) define a scenario as "…a description of potential future conditions produced to inform decision-making under uncertainty" (Parson et al. 2007, p. 1). Moss et al's (2010) and Parson et al.'s (2007) definitions capture both elements of the Kosow and Gaßner's (2008) definition of scenario, specifically the path in the case Moss et al., and the situation in the case of Parson et al.

4.2.4 Chains, pathways and other scenario elements

This study is interested in understanding system conditions, and sequences (i.e. chains) of conditions, with the aim of identifying the “pre-conditions” for effective global responses to climate change. This is similar to the concept of nodes including critical nodes, which are said to “have an impact on multiple trajectories.” (CSF and CSC 2012, p. 8). With regards to critical nodes, “If they are not reached, the scenario in question may not arise.” (CSF and CSC 2012, p. 8). Critical nodes are essentially set of “critical conditions” or “pre-conditions” for a scenario to arise. Critical nodes are differentiated from waypoints and signposts (CSF and CSC 2012). Waypoints are “milestones…. …between a given future and the present day.” (CSF and CSC 2012, p. 41). Meanwhile signposts are the “Indicators that mark milestones” (CSF and CSC 2012, p. 41). Waypoints and signposts can include “discrete events or thresholds, but they can also be much more loosely defined, such as trends or patterns.” (CSF and CSC 2012, p. 41).

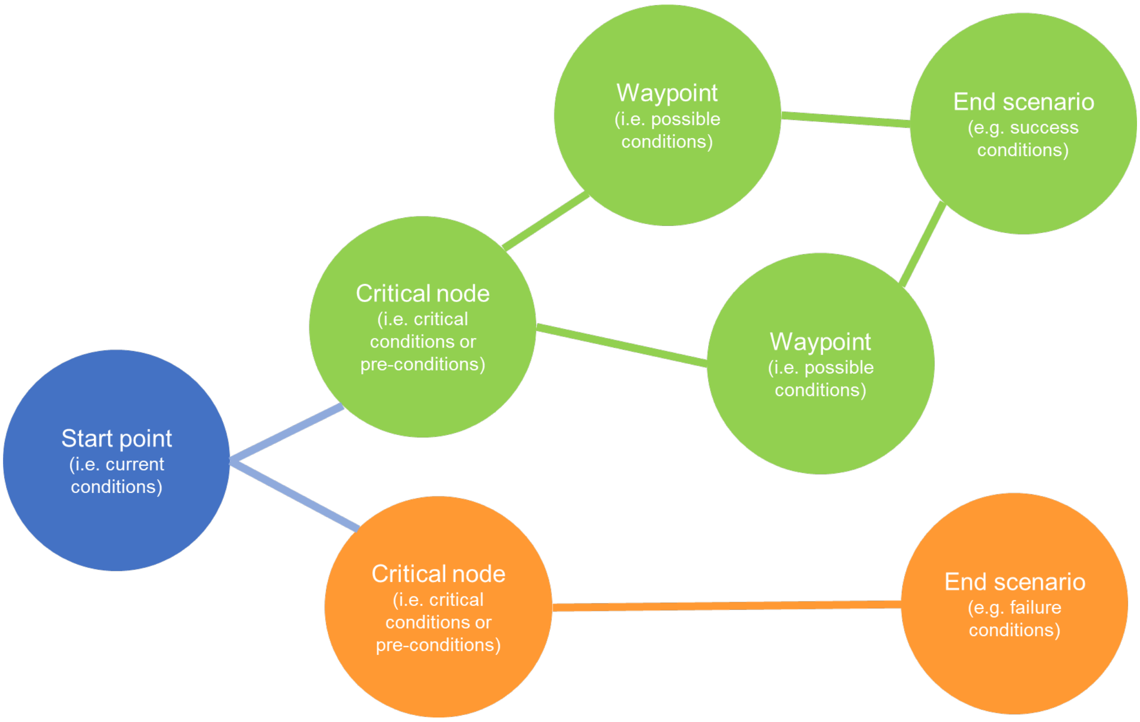

Figure 4-2: Critical nodes and waypoints. Modified from CSF and CSC 2012.

The IPCC’s 1.5 Degree Report illustrated the past and future including broad global response pathways following temperature curves, but with multiple pathways within, according to the experience of different groups of actors (Figure 4-3). The visualization also includes chains of “abrupt events” that have happened and decision points in the future highlighting the potential influence of actors going forwards.

An important part of the study is understanding how conditions might affect actors within the system, their interests and how these actors might influence the system towards, or away from, the UNFCCC objective. This means being aware of the situations actors might find themselves in as well as the options available to these actors.

Other scenario elements include trends, projections, drivers, influences, structures and constraints that might help guide the imagination of future conditions, scenario storylines, chains of events or pathways (Popper 2008). At the same time, the possibility of disruption should be taken into account (CFS 2012, Steenmans 2019) including the possibility of black swans (i.e. unanticipated low probability high impact events) or wildcards (i.e. low probability high impact opportunities or threats) (Oura and Schumacher 2012, CSF and CSC 2012). In the context of climate change, Comes et al. (2013) and Nadim (2017) noted the need to be aware of possible triggers, feedback mechanisms, tipping points and cascade effects (Section 4.3.5 and Appendix F).

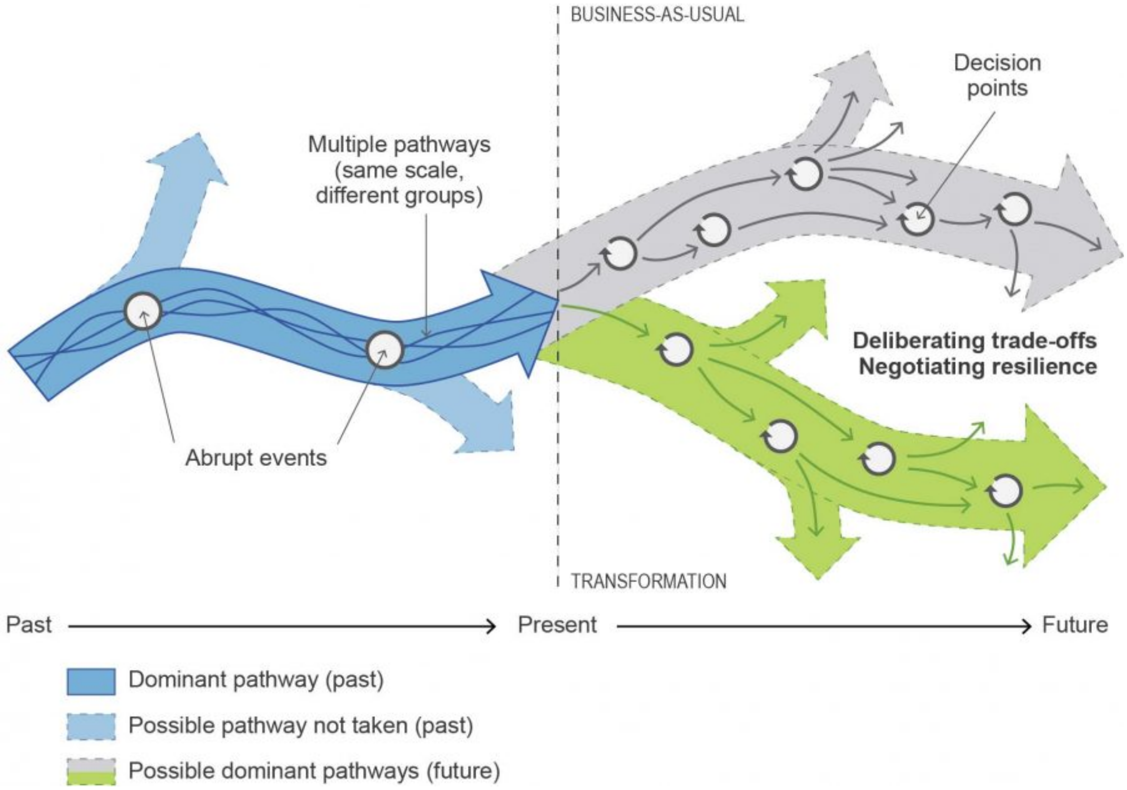

Figure 4-3: Pathways into the future, with path dependencies and iterative problem-solving and decision making while also showing business as usual versus a transformation. Source: After Fazey et al. 2016 in Roy et al. 2018.

It is important to note, scenarios can be detailed or restricted to essential details only. Detailed scenarios with many elements may seem richer, more salient and plausible, but the more conditions included in a scenario the less likely it is that the scenario will actually be realised. This is due to the conjunctive rule of probability theory, where “adding a detail to a hypothesis must render the hypothesis less probable” (Yudkowsky 2008, 19%, p. 97 of 554). Ironically, “human psychology seems to follow the rule that adding a detail can make the story more plausible.” (Yudkowsky 2008, 19% p. 97 of 554). This study is primarily interested in the essential overarching features that describe scenarios.

4.2.5 Scenarios discussed in IPCC reports

Scenarios have been used extensively in environmental studies including in IPCC reports (e.g. IPCC 2018a). The IPCC has used scenarios since its 1st assessment report (Moss et al. 2010). For the Fifth Assessment Report scenarios were prepared outside of the IPCC but were used by the IPCC (Moss et al. 2008), forming a prominent part of its assessment. Scenarios were prepared in parallel included representative concentration pathways, global warming scenarios and socio-economic scenarios. This study uses scenarios reported by the IPCC to check the plausibility of information collected as part of this study.

4.2.6 Backcasting

According to Bishop et al., one of the drawbacks of scenario development using extrapolation is that “the future then carries the ‘baggage’ of the past and present into the future. The baggage limits creativity and might create futures that are… not as bold as the actual future” (Bishop et al. 2007, p. 13). Bishop et al. go on to state that “An antidote to carrying too much baggage is to leap out into the future, jab a stake in the ground, and then work backward on how we might get there.” (Bishop et al. 2007, p. 13). This method is called backcasting (Robinson 1990, Bishop et al. 2007, Rounsevell and Metzger 2010).

For backcast scenarios, “The storyline itself is a description of the series of events and causal relationships that lead from the current world condition to the desired future world.” (Rounsevell and Metzger 2010, p. 608). Furthermore, “Inherent to this type of thinking is that very different pathways may exist that converge on the same desired outcome.” (Rounsevell and Metzger 2010, p. 608). As such, backcasting can produce multiple scenarios with equifinal outcomes (Rounsevell and Metzger 2010). Bishop et al, noted that backcast scenarios can be developed for the “plausible or fantastical, preferred or catastrophic” (Bishop et al. 2007, p. 13). Backcasting can be used to identify “signposts” and critical nodes, for example technological breakthroughs or the breaching of thresholds that have a bearing on options, contingencies and how the future is likely to unfold (Bishop et al. 2007).

Backcasting, like many other scenario development exercises, uses intuitive logic, which “aims to provide understanding of broad trends and processes” (Rounsevell and Metzger 2010, p. 608). Intuitive logic is similar to judgement techniques that “rely primarily on the judgement of the individual or group describing the future.” (Bishop et al. 2007, p. 11). Rounsevell and Metzger noted that “most scenario storylines use the expert judgement of scenario analysts” (Rounsevell and Metzger 2010, p. 610).

4.3 Stress tests

A stress test is an assessment with the purpose of understanding how something responds under difficult conditions, informing risk management and decision making (see Appendix G regarding stress test definitions).

4.3.1 Climate change stress tests and lessons from financial stress tests

Climate change stress testing emerged following the great financial crisis, as a set of methods for assessing climate change related risks, including physical, transition and liability risks (Carney 2015). Brown and Wilby (2012), Stern et al. (2013), Swart et al. (2013) and Carney (2015) have each made the case for using stress tests to investigate climate change related risks. Between them, they noted that history and precedent may not be a reliable guide to the future and stress tests may help with understanding future risks arising from the interaction of climate change and human systems.

The influence of financial stress tests on climate change related stress tests is found both in the area of physical stress testing (e.g. Stern et al. 2013) as well as transition[9] stress testing (e.g. Battiston et al. 2017). In fact, finance and insurance related climate change stress tests is an area of continued interest to large financial institutions and groups working on climate change related financial disclosures (e.g. Colas et al. 2018).

There are important differences between financial institutions and the global response to climate change. For example, the chances of a shock in the case of financial institutions are low for any given year (Oura and Schumacher 2012), while in the case of climate change the chance of significant stress occurring, including shocks, increases with the accumulation of GHG emissions in the atmosphere (IPCC 2014a). Another difference between the global response to climate change and financial institutions is failure. Failure is the Business as Usual (BAU) scenario in the case of climate change and is likely to be irreversible. For financial institutions, failure is the exception to BAU and is usually considered reversible[10], although it can be expected to happen occasionally over the long term.

These differences between financial institutions and the UNFCCC means important adjustments to stress test design are required. For example, instead of just stress testing the global response to climate change for failure, it also makes sense to test for success fulfilling the UNFCCC objective.

4.3.2 Stress test criticisms

No documents were found making the case against climate change stress testing. However, there have been criticisms of financial stress tests that may be relevant to climate change stress tests. For example, the Basel Committee on Banking Supervision (BCBS 2009) criticised financial stress tests conducted prior to the global financial crisis as not being severe enough, relying too much on historical precedent, being unaware of linkages that had emerged due to new financial products, and a lack of awareness of the interlinked nature of risks. Prior to the financial crisis, stress tests often focused individual parameters rather stressing all parameters at once. Furthermore, stress tests failed to include prolonged systemic stresses in part because this had

[9] See Section 3.2.4 for more information on transition risks and related definitions.
[10] If managed effectively, financial systems can recover; however, it should be noted that the people impacted by a financial crisis, including those who had nothing to do with the creation of the crisis, may or may not recover.

never happened before. New financial products created new risks that made historical precedents much less relevant (BCBS 2009). The climate change problem has similar issues, for example past precedent is of limited value and there are deficiencies in knowledge regarding the interlinkages across the environment and development system (Levin et al. 2012).

Borio et al's (2014) criticism was much deeper than the BCBS (2009) and stated that "stress tests failed spectacularly when they were needed most: none of them helped to detect the vulnerabilities in the financial system ahead of the recent financial crisis." (Borio et al. 2014, p. 12). Furthermore, Borio et al. found that "macro stress tests are ill-suited as early warning devices, i.e. as tools for identifying vulnerabilities during seemingly tranquil times and for triggering remedial action." (Borio et al. 2014, p. 3). However, Borio et al. (2014) did find that "stress tests can be quite effective as crisis management and resolution tools." (Borio et al. 2014, p. 3).

Borio et al. (2014) found behaviour differed in times of tranquillity versus times of crisis and this influenced the effectiveness of stress tests. This observation is important given that attributable climate change impacts have only recently been experienced (Section 2.2.2) but are anticipated strengthen (Section 2.2.3). Borio et al. (2014) noted that in tranquil times, the inherent contradiction in defining "severe but plausible" scenarios tended to limit the effectiveness of stress tests. To start with, plausibility is assessed relative to historical precedent. Secondly, the inability of models to model risk amplification means that stresses need to be exaggerated to create an effect, which in turn reduces the perceived plausibility of a scenario or shock. Furthermore, in tranquil times it was said that there is less interest in taking stress tests results seriously and making interventions based on these results. However, in times of crisis, people were said to be much more accepting of scenarios with severe shocks that exceed historical precedent. Borio et al. (2014) stated that people are more willing to make interventions based on the results of such stress tests, giving an example where "the macroeconomy is suffering, balance-sheet quality has overtly deteriorated and financial institutions are incurring losses. Hubris has given way to prudence. The balance of power has shifted from business areas to risk controllers, and from the financial industry to the official sector. In such an environment, the technical shortcomings of the tests are less of an issue." (Borio et al. 2014, p. 9).

While plausibility is central to scenario development, plausibility is subjective and often judged according to historical experience (Borio et al. 2014), limiting the exploration of possible futures which may be probable or improbable (GOS 2016), fantastical (Bishop et al. 2007) or unprecedented (Borio et al. 2014). As such, plausibility is not a particularly useful concept and it would be better to use scenario methods that do not rely on this concept. Importantly, Borio et al. (2014) noted an alternative approach to using "severe but plausible" scenarios is to instead conduct a "reverse stress test" to see what it would take for the system to fail; an approach similar to that used in engineering.

4.3.3 Reverse stress tests

Reverse stress testing is a relatively new variant of stress testing with a limited body of literature (Grundke and Pliska 2017) that is growing. Reverse stress tests have been conducted at the financial systems level, for example testing interbank networks in Europe (Grigat and Caccioli 2017) and at the institution level (e.g. Grundke 2011). The literature includes qualitative or quantitative methods and examples (e.g. Kilavuka 2013, Grundke 2011) driven in part by authorities increasing oversight following the global financial crisis of 2008. Reverse stress testing had not been applied to the global response prior to this study.

In finance, reverse stress tests aim to find scenarios that cause an institution to fail (Grundke 2011) with the purpose of identifying potential vulnerabilities (BOE 2018) and helping risk management (Füser et al. 2012, Kilavuka 2013). The method involves backcasting from a failure state, to derive scenarios. An important part of reverse stress testing is understanding and setting the conditions that define success or failure. A reverse stress test scenario must satisfy these conditions (Kilavuka 2013).

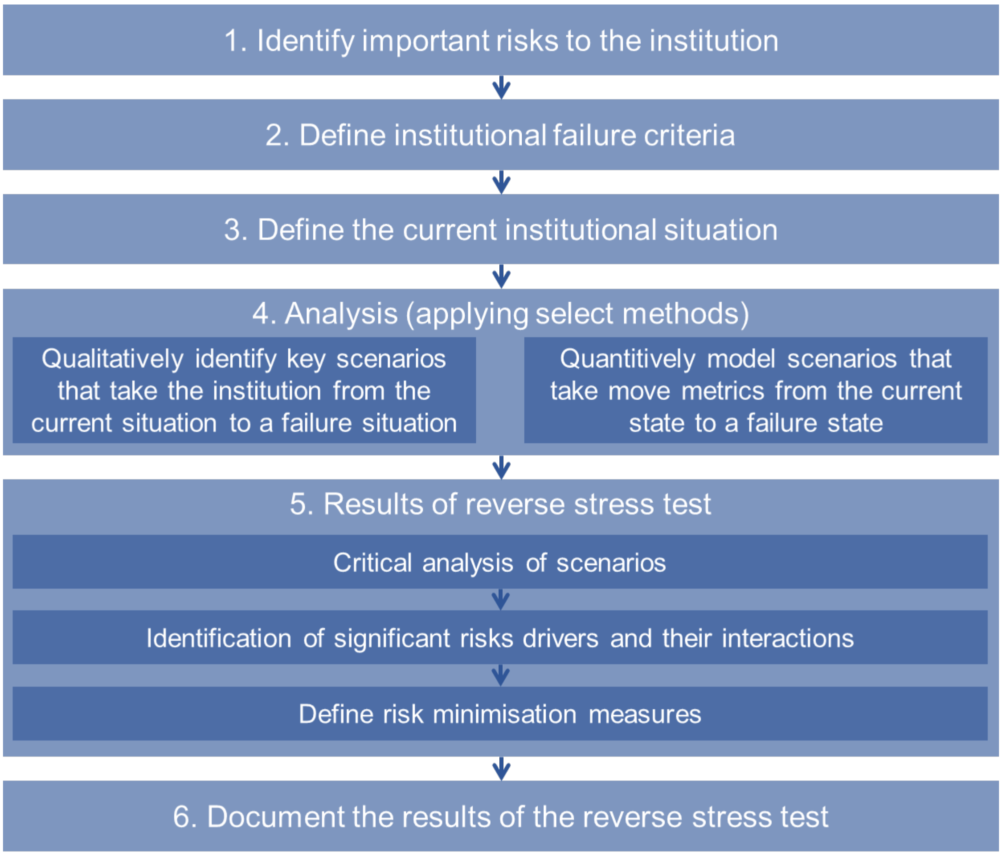

Figure 4-4: Reverse stress test method. Source: Modified from a translation of Füser et al. 2012.

Füser et al. (2012) addressed reverse stress tests for financial institutions and set out a generalised reverse stress test method (Figure 4-4). This starts with identifying key risks to be addressed and defining failure conditions. After this, an assessment is made of the current situation and then scenarios are backcast from a failure situation back to the current situation. These scenarios can be developed using quantitative or qualitative methods. The results of the reverse stress test need to be critically analysed, with key risks and drivers identified, including critical interactions between elements of the scenario. Based on this, risk minimisation measures are identified. Lastly, the reverse stress test should be documented. Füser et al. (2012) also provided guidance on the results that should be documented from a reverse stress test including for example the scenarios developed along with key causes of failure and the consequences of various possible events. The identification of early warning indicators (i.e. signposts) was recommended, as was assessing the likelihood of a scenario happening for example using quantitative analyses or expert judgement. Lastly, connections between scenarios and alternative scenarios should be elaborated according to Füser et al. (2012).

4.3.4 Reverse stress testing the global response to climate change

Reverse stress tests could potentially be applied to the global response to climate change at the system level. Importantly, according to Füser et al. (2012), qualitative reverse stress tests take a “birds eye view” and tend to focus on actors and strategies that are generally overlooked by quantitative stress tests. In this regards, qualitative reverse stress tests appear to be a promising method for collecting information for this study, especially when it comes to system conditions and the situations actors might find themselves in or identifying possible chains of events and understanding the roles, incentives and motivations various actors might have in each scenario.

4.3.5 Stress test principles

Oura and Schumacher (2012), Comes et al. (2013), and Nadim (2017) provided guidance that could be used as principles to help in the design of stress tests and the analysis of stress tests results. Based on IMF experiences and research, Oura and Schumacher (2012) identified 7 principles for macroprudential stress tests. Comes et al. (2013) provided guidance for climate change stress tests with the purpose of supporting decisions on the design of critical infrastructure. Nadim (2017) provided guidance for physical climate change stress tests based on practices from traffic, financial and nuclear stress tests.

Table 4-1 summarises stress test principles from Oura and Schumacher (2012), Comes et al. (2013), and Nadim (2017). These principles consist of: 1. Clearly define the scope and boundaries of the stress test taking into account geopolitical, institutional, social, economic boundaries and relevant timeframes; 2. Identify all channels of risk propagation that create the possibility of cascade failures; 3. Include all material risks and buffers in the model and analysis, although the extent to which this is possible is debatable; 4. Identify vulnerability especially those that could result in fundamental shifts in state, for example triggers, tipping points or cliff edge events; 5. Seek multiple perspectives and use experts from different disciplines and backgrounds when conducting a stress test; 6. Address all possible risks including extreme event scenarios and external factor shocks; 7. Make recommendations on risk minimisation and resilience; 8. Communicate results of the stress test in meaningful and smart ways that will reach people that could benefit from the information; 9. Consider follow up activities including iterative processes. Note: for a complete discussion on stress test principles see Appendix F.

Table 4-1: Stress test principles derived from Oura and Schumacher 2012, Comes et al. 2013 and Nadim 2017.

Stress test principles
1. Clearly define the scope and boundaries of the stress test
2. Identify all channels of risk propagation especially interconnections that create the possibility of cascading failures
3. Include all material risks and buffers in the model and analysis
4. Identify vulnerabilities especially those that could result in fundamental shifts in state
5. Seek multiple perspectives and use experts from different disciplines and backgrounds when conducting a stress test
6. Address all possible risks (including implausible but possible risks)
7. Make recommendations on risk minimisation and resilience
8. Communicate the results of the stress test in meaningful and smart ways
9. Consider follow up activities

4.4 Scenario and stress test data collection

Stress tests and scenario development exercises can use a range of data collection techniques including published materials, interviews, surveys, workshops, role playing and simulations for example (Popper 2008, UNDP 2018).

Rounsevell and Metzger (2010) highlighted participatory approaches, for example using workshops and groups of stakeholders, that can raise scenario legitimacy especially among the stakeholders involved in developing the scenarios (Rounsevell and Metzger 2010). The credibility of scenarios developed using participatory methods depends upon the diversity of stakeholders involved as well as issues of social learning and group dynamics. From a practical perspective, the use of participatory approaches for scenario development, including workshops, is a very efficient way of creating scenarios, as only minimal data compilation is required after conducting the data collection exercise.

In related research, McEvoy et al. (2018) compared participatory stress testing of climate change adaptation with other participatory methods when it came to learning effects and shared understanding in groups. These effects were assessed by observation of workshops and analysis of the outcomes from the workshop. The most effective method, in terms of group learning effects and shared understanding was found to be group model building followed by the participatory application of stress test guidelines. The adaptation support tool was also found to be useful meanwhile the tool-free approach was least effective.

McEvoy et al. (2018) found that participatory application of stress test guidelines resulted in the "Most technical and narrow designs, without strategic approach or holistic planning, but highest satisfaction with designs and technical quality." (McEvoy et al. 2018, p. 330). As such, McEvoy cautioned, "careful consideration should be given to ensuring that 'going through the steps' does not replace thorough reflection and analysis by the group" (McEvoy et al. 2018, p. 330). It is uncertain how relevant the results of McEvoy et al. 2018 are to other climate change stress test methods but at a minimum it suggests that stress test design is important, and the focus of a stress test may result in narrow focus on some risks while neglecting others.

With regards to data collection methods, workshops are an efficient way of collecting and processing information, where participants generate scenarios through discussion and various exercises. Simulations depend on facilitators setting context and managing some scenario elements while participants respond to this context and each other. Multiple simulation runs can generate a set of scenarios, each of which are grounded in the context provided by the facilitator. The use of surveys or survey interviews requires more work from the scenario analyst but can capture information that would otherwise be discarded by workshop participants.

4.5 Theory of change and thematic data analysis

Theory of change is defined as “The description of a sequence of events that is expected to lead to a particular desired outcome” by Davies 2012 in Vogel 2012. At its core, theory of change analyses follow a logic of “if… then” (Stein and Valters 2012), using this logic to map “pathways” (Taplin and Rasic 2012) or “outcome chains” (Harries et al. 2014) where “A pathway is the sequence in which outcomes must occur to reach long-term goal.” (Taplin and Rasic 2012) such as the UNFCCC objective. Importantly, it is possible to have “multiple outcomes chains” (Harries et al. 2014, p. 15) towards a specified goal and these outcomes constitute “preconditions because they are conditions that must exist… …for the next outcome in the pathway to be achieved.” (Taplin et al. 2013, p. 21). As such, theory of change analysis is a uniquely suited as a method for exploring preconditions while also being akin to backcasting and reverse stress testing.

Importantly, in the context of the global response to climate change, a theory of change analysis can take a “systemic or network perspective that reflects the complexity of change processes and shows the actors, chains, linkages and learning loops.” (James 2011, p. 7). Similarly, Vogel noted that theory of change should include “critical thinking about the contextual conditions that influence the programme, the motivations and contributions of stakeholders and other actors, and the different interpretations (assumptions) about how and why that sequence of change might come about.” (Vogel 2012, p. 3). The “programme” in this study is the global response to climate change. As such, theory of change methods can also help address the research questions from Section 1.6 related to actors, interests, and collective responses to climate change.

4.5.1 Theory of change methods

Vogel (2012) reviewed theory of change methods and identified a set of six basic elements, consisting of: context, long-term change, sequence of change, assumptions, and the use of diagram and narrative summaries. James (2011), along with Stein and Valters (2012), also highlight the use of narratives and diagrams in theory of change analyses. However, Stein and Valters (2012) suggested diagrams should only be used as part of the analysis then removed from final documentation, due to their complexity. With regards to diagrams, James (2011) along with Taplin and Rasic (2012) present outcome chains vertically in the form of a hierarchy, meanwhile Harries et al. (2014) presented chains horizontally from left to right giving a sense of being a time series.

According to Taplin and Rasic, “The narrative is a summary of the group’s theory that explains the pathways of change, highlights some of their major assumptions, rationales, and interventions” (Taplin and Rasic 2012, p. 9). Taplin and Clark have noted, “The purpose of the narrative is twofold: (1) to convey the major elements of the theory easily and quickly to others; (2) to better understand how the elements of the theory work as a whole.” (Taplin and Clark 2012, p. 8). Importantly, “Writing a narrative theory of change can help draw out causal links and organise your thinking.” (Harries et al. 2014, p. 14). At the same time, assumptions should be made clear and themes identified.

4.5.2 Thematic analysis

Thematic analysis is a flexible method used “for identifying, analysing and reporting patterns (themes) within data.” (Braun and Clarke 2006, p. 79). Importantly, “A theme captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set.” (Braun and Clarke 2006, p. 82). Thematic analysis is a qualitative method that can be used to identify commonalities between qualitative scenarios, for example commonalities at the level of chain elements and system conditions, pathways, dynamics or the situations actors might find themselves in.

Braun and Clarke (2006) identify six phases of thematic analysis, starting with familiarizing oneself with the data collected, then generating codes and searching for themes, reviewing themes, naming and defining themes and lastly producing a report (Table 4-2).

Table 4-2: Six phases of thematic analysis. Source: Braun and Clarke 2006.

Phase		Description of the process
1	Familiarizing yourself with your data	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2	Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3	Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
4	Reviewing themes	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic ‘map’ of the analysis.
5	Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6	Producing the report	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Thematic analysis can be applied to qualitative data sets such as transcripts. For this study, thematic analysis is of interest as a method for analysing themes in scenarios, including themes within chain elements. By thematically analysing and coding scenarios including chain elements, it is possible to analyse chains from different scenarios that have the shared themes. Thematic analysis also helps ground the analysis in the data collected.

4.5.3 Unpacking assumptions

The unpacking of assumptions and use of evidence is something theory of change emphasises more strongly that scenario or stress testing literature, which are satisfied with scenarios being plausible or possible. Given that theory of change analyses are practitioner driven, with practitioners relying on a theory of change as a basis for making interventions, the stakes surrounding each scenario are higher, and as such, there is greater demand for assurance that a given theory of change is robust and related interventions are justifiable. Hence the question, "Why do we think a given precondition, or short term outcome, will lead to (or is necessary) to reach the one above it?" (Taplin and Rasic 2012, p. 1). To answer this question it is necessary to unpack assumptions.

According to Vogel, "Assumptions are important because they are the 'theories' in theory of change thinking." (Vogel 2012, p. 26). Ortiz noted in an interview with Vogel, that "Theory of change is about generating better assumptions, better hypotheses of change to strengthen our work" (pers comm Alfredo Ortiz in Vogel 2012, p. 26). Vogel (2012) found that all people interviewed on theory of change mentioned "making your assumption explicit". However, Stein and Valters noted that "it is problematic that assumptions are always seen as central to ToC processes" as this would mean "ToC processes are simply about uncovering common beliefs, rather than critically interrogating them." (Stein and Valters 2012, p. 11). As such, "Assessing the plausibility of an assumption, either using strong theory or good evidence, remains a key challenge" but "one way of making ToCs more robust is to link them to evidence" (Stein and Valters 2012, p. 11).

With regards to evidence Coffey (2012) stated that an "evidence base would consist of a combination of quantitative and qualitative data focused on testing and proving a plausible theory of change." (Coffey 2012, p 12, in Stein and Valters 2012, p. 11). Vogel takes a pragmatic perspective and states that "The role of evidence is to check and challenge assumptions, broaden the range of strategic options that may be relevant to the context, and strengthen the quality of the hypotheses to provide a confident basis for action." (Vogel 2012, p. 40). Triangulation between different types of data from different data sources was noted as being important in this regard (Stein and Valters 2012, Vogel 2012). As noted in Section 4.2, climate change being experienced now is unprecedented in human history. As such there is limited data with which to draw evidence regarding the plausibility of global responses. However, it is possible to triangulate with IPCC assessment reports and climate change and development related literature including scenarios reviewed in Chapter 2.

Lastly, the quality of theory of change narratives, scenarios and stress tests depend on the quality of analysis and understanding of how the world works. In this regard, Stein and Valters note, "At its best, ToC requires an engagement with wider social science theory and research-based evidence. Such work is ultimately an attempt to describe and understand how change happens in the world" (Stein and Valters 2012, p. 9). However, they also caution that "The extent of practitioner engagement with… social science theory and research, may well reflect whether ToC approaches ultimately reveal or oversimplify the complexity of processes of change." (Stein and Valters 2012, pp. 9-10). This is poignant in the case of climate change, where social processes and responses to climate change are not yet adequately addressed or understood (Section 1.4).

4.6 Summary

Climate change is an unprecedented challenge to development (Section 2.2.3), and from the scenario literature, is likely to be one of many challenges, including other unexpected events (Section 4.2.1). To explore preconditions for effective global responses to climate change, it would be ideal to have a representative sample of possible futures, from which preconditions for effective responses to climate change could be identified. Scenario and stress test methods could be used to generate a sample of possible futures, but these methods rely on severe but plausible scenarios. Unfortunately, plausibility is judged using historical precedent and severity is subjective, hence these methods disregard many possible scenarios. As such, the concepts of severity and plausibility are of limited value (Section 4.3.2), and alternative methods are needed to collect and compile a representative sample of possible futures. Promising alternative methods include backcasting and reverse stress test methods that can be used to elicit scenarios that either succeed or fail to fulfil some objective or goal (Section 4.2.6 and Section 4.3.3). Meanwhile, theory of change methods provide a basis for compiling scenarios and exploring preconditions (Section 4.5). It is also important to address multiple possible futures rather than limiting possible futures to just a few reference scenarios (Section 4.2.1). With these things in mind, Chapter 5 presents the methods used in this study to generate a representative sample of possible futures and analyse preconditions for effective global responses to climate change.

Chapter 5 Methods used

5.1 Introduction

This chapter presents the methods used in this study (Figure 5-1), building on the methods and methodology reviewed in Chapter 4. The purpose of the data collection is to get information on possible futures (i.e. a sample of possible futures) so that the questions identified in Chapter 1 can be addressed. The structure of this chapter follows the process illustrated in Figure 5-1. Data collection is addressed in Section 5.2, and focuses on how the study collected information on possible futures including success, failure and other scenarios. Data processing is addressed in Section 5.3 and focuses on how the study compiled a sample of possible futures. Data analysis is addressed in Section 5.4 including the methods used to analyse themes in the sample of possible futures and preconditions for effective global responses to climate change.

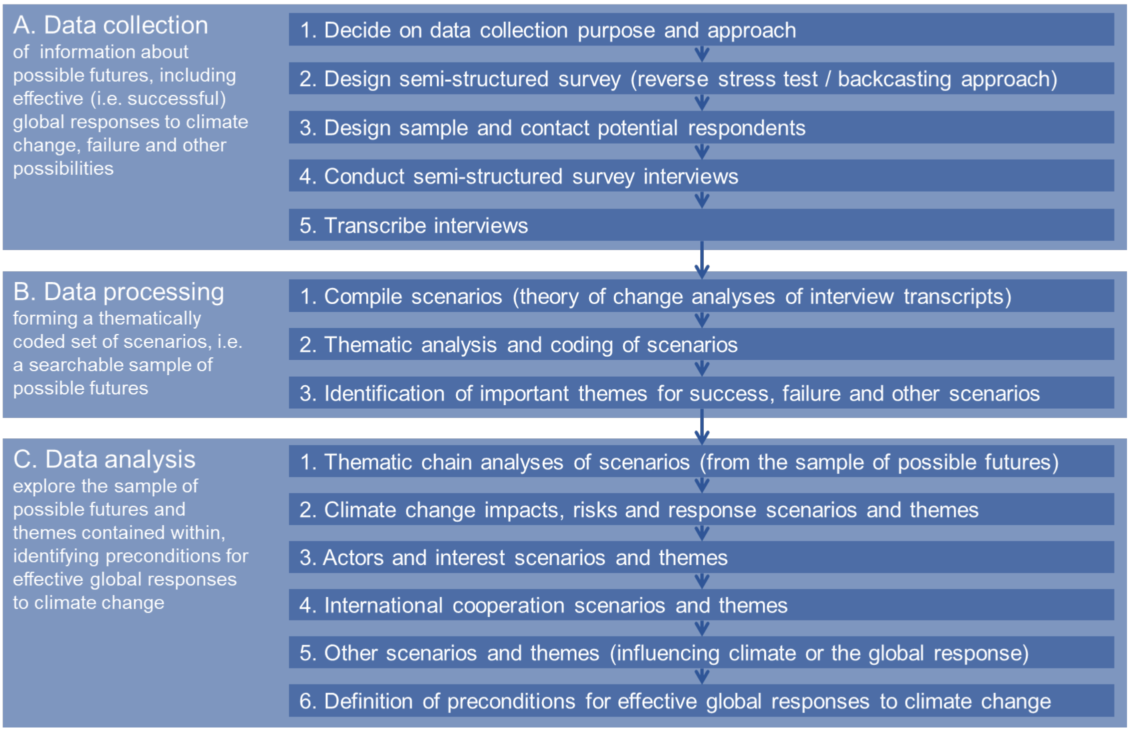

Figure 5-1: Summary of methods used in the study to collect and compile information about possible futures and analyse preconditions for effective global responses to climate change.

5.2 Data collection

Data collection had five key steps, consisting of deciding the data collection purpose and approach (Section 5.2.1), followed by semi-structured survey question design (Section 5.2.2), sample design (Section 5.2.3), conducting interviews (Section 5.2.4), and transcription of interviews (Section 5.2.5).

5.2.1 Data collection purpose and approach

The purpose of data collection was to get information on possible futures (i.e. scenarios). By having a broad sample of possible futures, keywords can be searched, themes identified, and chains of conditions explored. Together, these methods make it possible to identify preconditions for effective global responses to climate change.

The possibility of conducting structured scenario workshops, online simulations and surveys were each investigated. However, these methods involved varying levels of framing. The concern was that with more framing there would be more bias introduced into the sample of possible futures.

It was decided to use backcasting and reverse stress test methods as they allow respondents to backcast their own scenarios with little influence from the interviewer or anyone else. There is very little framing, beyond defining success and failure criteria. Meanwhile, respondents define system conditions and situations that could contribute towards success or failure, while also elaborating on groups of actors involved, the issues, options and interests that are important to the scenario.

With regards to the mode of data collection, it was decided to use semi-structured interviews. Semi-structured interviews are flexible, can be conducted in 30 minutes or an hour, and whenever a respondent is available. Workshops were considered impractical given the difficulty of organising participants from around the world many of whom have very limited time available.

5.2.2 Semi-structured survey question design

The first step in designing the survey was defining success and failure criteria (Section 5.2.2.1). The survey also included background questions (Section 5.2.2.2), backcasting and reverse stress test related questions (Section 5.2.2.3), and reflective questions (Section 5.2.2.4) (Figure 5-2).

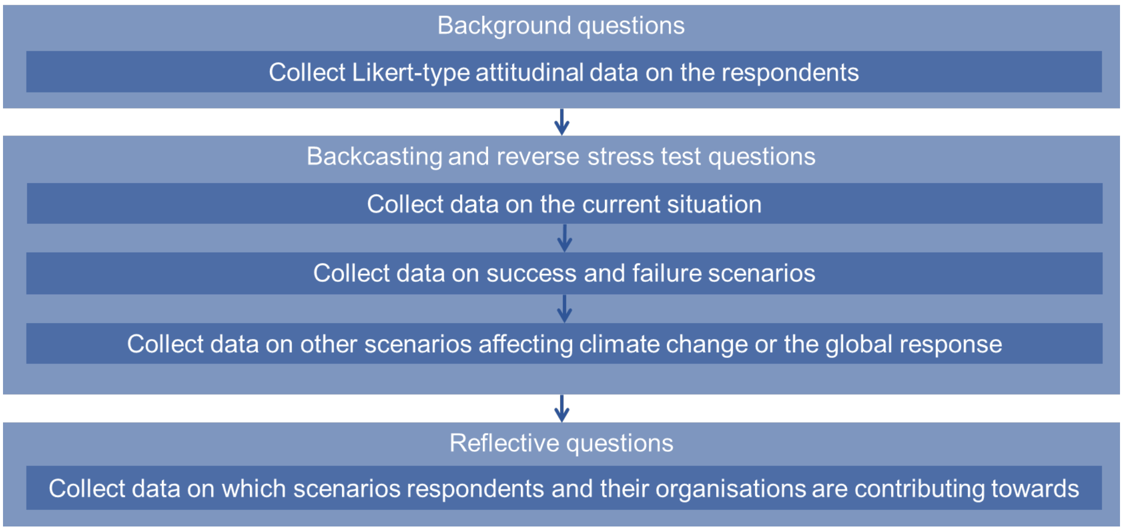

Figure 5-2: Reverse stress test survey design.

As discussed in Sections 4.2.6 and 4.3.3 respectively, backcasting and reverse stress testing are methods for eliciting success and failure scenarios. Like in the method outlined by Fuser et al. (2012), the questions addressed current conditions, possible success and failure scenarios. The interview followed the semi-structured interview guide in Appendix H. During the early stages of the survey data collection process, respondents were asked about other people that should be interviewed, applying the snowballing method of finding respondents.

5.2.2.1 Success and failure criteria

An important part of backcasting and reverse stress testing is defining success and failure conditions. For this study it was important to define what an effective global response (i.e. success) would look like. Given that there are 197 Parties to the UNFCCC accounting for the vast majority of global GHG emissions, the UNFCCC objective serves as an important reference, as does the Paris Agreement.

The UNFCCC objective (Section 2.5.1) and Paris Agreement purpose (Section 2.5.2) are interrelated. The Paris Agreement is "In pursuit of the objective of the Convention" and is "guided by its principles" (Article 1, Paris Agreement) (UNFCCC 2015). The Paris Agreement aims to strengthen the global response to climate change and puts in place a system where countries make contributions to the global response (i.e. NDCs) and progress is measured (i.e. global stocktakes) (UNFCCC 2015). As such, the Paris Agreement is an important step towards operationalising the global response to climate change. The Paris Agreement purpose (Article 2) includes a series of intermediate outcomes that if achieved, would help fulfil the ultimate outcomes of holding the increase in the global average temperature to well below 2°C above pre-industrial levels (Article 2, Paris Agreement), stabilising GHG concentrations, allowing ecosystems to adapt naturally, ensuring food production is not threatened, and economic development can proceed in a sustainable manner (Article 2, UNFCCC) (Table 5-1 and Appendix I).

Table 5-1: Ultimate outcomes and intermediate outcomes from the UNFCCC objective and Paris Agreement purpose. Source: Compiled by the Author.

Context	Source	Text from Article 2
Ultimate outcomes	UNFCCC	Stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system
	PA	Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels
	UNFCCC	Allow ecosystems to adapt naturally to climate change
	UNFCCC	Ensure that food production is not threatened
	UNFCCC	Enable economic development to proceed in a sustainable manner
Intermediate outcomes	PA	Strengthen the global response to the threat of climate change*
	PA	Pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels
	PA	Increasing the ability to adapt to the adverse impacts of climate change
	PA	Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate- resilient development
	PA	Climate resilience and low greenhouse gas emissions development
	PA	Response does not threaten food production
	PA	Equity in the light of different national circumstances**

PA = Paris Agreement purpose
UNFCCC = United Nations Framework Convention on Climate Change objective
Footnotes:
* …in the context of sustainable development and efforts to eradicate poverty.
** This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

The ultimate outcomes identified in Table 5-1 and Appendix I, largely come from the UNFCCC objective, with the only ultimate outcome from the Paris Agreement being "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels" (Article 2, Paris Agreement) which essentially provides a goal and metric for assessing progress towards "Stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (Article 2, UNFCCC) (Randalls 2010). As such, the UNFCCC objective provides success and failure conditions for the global response to climate change. Success is considered to be stabilising atmospheric concentrations of greenhouse gases at safe levels, where safe levels means ecosystems are able to adapt naturally, food production is not threatened and economic development is able to proceed in a sustainable manner. Failure is simply failure to achieve one, or more, of the conditions specified in the UNFCCC objective.

Another approach for assessing the effectiveness of the global response to climate change is to avoid binary success failure determinations and instead analyse the nature of success or failure along a spectrum of possible conditions. This could include achieving the UNFCCC objective or being on path towards achieving the UNFCCC objective, through to being on path towards failure, actual failure to achieve the UNFCCC objective and having a plan B, or failure without any alternative plans (see column headings in Table 5-2).

International cooperation is widely regarded as being essential for effective global responses to climate change (Stavins et al. 2014). As discussed in Section 3.3.3, participation in international agreements and international institutions is essential for these agreements and institutions to be effective. Participation also serves as an important indicator of institutional legitimacy (Stavins et al. 2014). As such, the level of membership (ranging from universal to no members) is an important indicator (see the row headings in Table 5-2).

Table 5-2: Degrees of success (white) and failure (orange) relative to the UNFCCC objective and UNFCCC legitimacy (i.e. universality of membership).

Membership of the UNFCCC as an indicator of legitimacy		UNFCCC objective				
		Achieved	On path towards being achieved	On path towards failure	Failed (i.e. either emissions have not been stabilised or ecosystems unable to adapt naturally, food production threatened or economic development unable to proceed in a sustainable manner)	
					There is plan B	The is no plan B
Legitimacy	Universal membership					
	Almost universal membership					
	Majority membership					
	Around 50% membership					
	Minority membership					
	No members					

These success and failure criteria informed the design of backcasting and reverse stress test questions (Section 5.2.2.3).

5.2.2.2 Background questions

The semi-structured survey started with background questions designed to get a sense of general optimism regarding the future and faith in the institution of the UNFCCC. Each respondent was asked to fill in a form with background questions, either online or on hardcopy. These background questions asked respondents to indicate whether they strongly disagreed, disagreed, neither disagreed or agreed, agreed or strongly agreed with the following statements:

- The world is worse place to live today than it was in the past;
- The world will be a better place to live in the future;
- The UNFCCC should be abandoned; and,
- The UNFCCC is essential for an effective global response to climate change.

Respondents were also asked if they had attended the UNFCCC conference of parties.

From these background questions, the aim was to verify that the sample of respondents included participants across the spectrum of optimism to pessimism, and levels of faith in the UNFCCC. For more information on survey sample design see Section 5.2.3.

5.2.2.3 Backcasting and reverse stress test questions

Backcasting and reverse stress test questions are the most important questions in the survey. These are the main questions used to elicit possible futures from respondents. Backcasting and reverse stress test questions were supplemented, if necessary, by follow up questions to ensure responses were sufficiently detailed and coherent to allow analysis and comparison with other responses. Backcasting and reverse stress test questions were numbered 3 to 11 (see Appendix H) and addressed the current situation, failure scenarios, success scenarios and other scenarios (Figure 5-3).

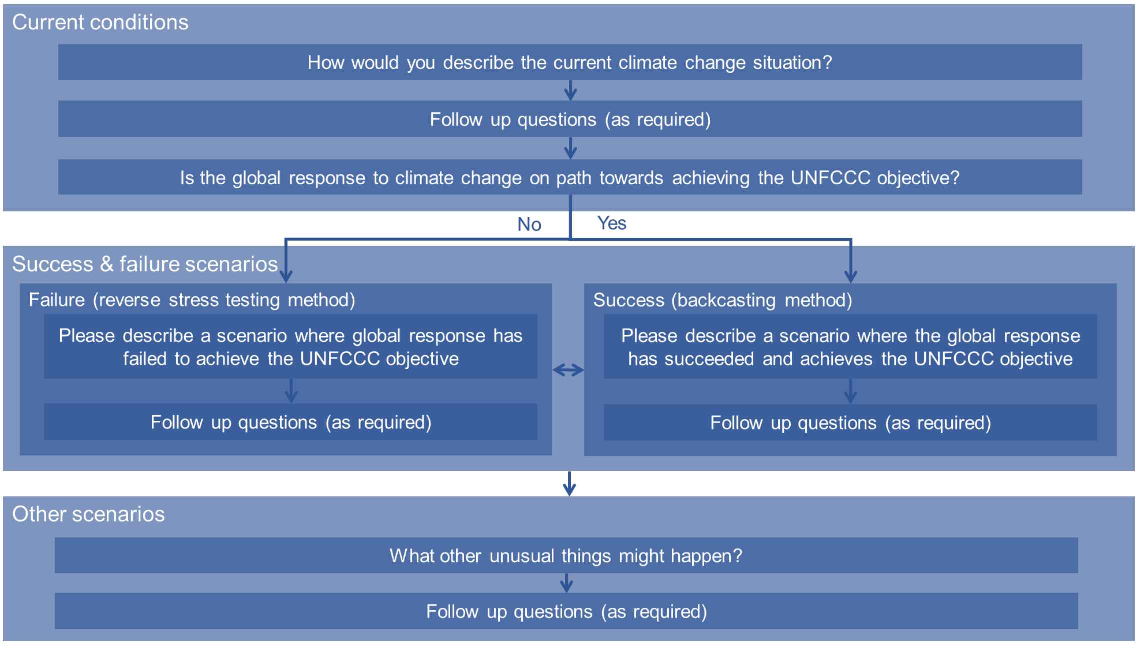

Figure 5-3: Reverse stress test question order in the semi-structured interview.

To get information on each respondent's perceptions of current climate change and development system conditions, they were asked:

How would you describe the current climate change situation?

Responses to this question allowed comparison of the respondent's perceptions with IPCC assessments and peer reviewed literature on current climate change and development conditions summarised in Chapter 2. General follow up questions were asked if required, to get more information (Section 5.2.2.4). The respondent's description of current conditions also helped provide a starting point for the compilation of scenarios (Section 5.3.1).

The last follow up question, regarding current conditions, asked whether the respondent thought the global response was on path towards achieving the UNFCCC objective. In all cases respondents indicated that the global response was not on path towards achieving the UNFCCC objective[11]. Hence, the next question regarded failure scenarios, with respondents asked to:

> **Please describe a scenario where the global response has failed to achieve the UNFCCC objective.**

Some respondents indicated they knew Article 2 of the UNFCCC and as such did not need to have it described to them. However, in most cases failure to fulfil Article 2 was explained to the respondent for clarity sake, as being atmospheric greenhouse concentrations have not been stabilised or ecosystems are unable to adapt naturally, food production is threatened or economic development is not able to proceed sustainable manner.

General follow up questions were asked as required (Section 5.2.2.5). In addition, two specific follow up questions related to ineffective global responses were asked if the respondent had not already addressed the issues. These specific follow up questions consisted of:

- **Please describe a scenario where the UNFCCC objective (Article 2) is amended by the Conference of Parties to the UNFCCC.**
- **Please describe a scenario where Parties withdraw from the UNFCCC.**

The question on amending the UNFCCC objective helped address the possibility of failing to achieve the UNFCCC objective and having a so called "plan B" as illustrated in Table 5-2 from Section 5.2.2.1. It is important to note that Article 15 of the Convention set the conditions for amending the UNFCCC (see below). This information was shared with respondents.

> 1. Any Party may propose amendments to the Convention.
>
> 2. Amendments to the Convention shall be adopted at an ordinary session of the Conference of the Parties. The text of any proposed amendment to the Convention shall be communicated to the Parties by the secretariat at least six months before the meeting at which it is proposed for adoption. The secretariat shall also communicate proposed amendments to the signatories to the Convention and, for information, to the Depositary.
>
> 3. The Parties shall make every effort to reach agreement on any proposed amendment to the Convention by consensus. If all efforts at consensus have been exhausted, and no agreement

[11] If the respondent had responded "yes" the global response is on path towards fulfilling the UNFCCC objective, then the next question would have regarded success scenarios (Figure 5-3).

reached, the amendment shall as a last resort be adopted by a three-fourths majority vote of the Parties present and voting at the meeting...

(Article 15, UNFCCC 1992)

Legitimacy of the UNFCCC is widely regarded to be a function of its near universal membership (Section 3.3.3 and Section 5.2.2.1). The question on UNFCCC Parties withdrawing from the UNFCCC could be a situation where only a few parties withdraw, or a situation where many parties withdraw from the UNFCCC. As such, responses could fall across the vertical axis of Table 5-2 from Section 5.2.2.1.

To get information on effective global responses to climate change, respondents were asked to:

Please describe a scenario where the global response to climate change succeeds in achieving the UNFCCC objective.

Those respondents that indicated they knew Article 2 of the UNFCCC did not need to have it described. However, for the sake of clarity achieving the UNFCCC objective was described to most respondents, as being atmospheric concentrations of greenhouse being stabilised at levels that allow ecosystems to adapt naturally, food production not being threatened and economic development being able to proceed in a sustainable manner.

General follow up questions were asked as required (Section 5.2.2.5). In addition, two specific follow up questions related to effective global responses were asked if the respondent had not already addressed the issues in their responses. These specific follow up questions consisted of:

- **Please describe a scenario where a stringent international climate change agreement is enforced.**
- **Please describe a scenario where greenhouse gas removals successfully stabilise atmospheric concentrations of greenhouse gases at safe levels.**

These two questions focus on dilemmas around how the UNFCCC objective might be fulfilled. The question on a stringent enforced agreement helps elicit responses related to possible institutional arrangements including the possibility of a protocol (i.e. a legally enforced agreement under a pre-existing agreement) (Appendix J). The question on GHGs removals directly addressed a research question from Section 1.6 regarding preconditions for effective GHG removals.

Following Principle 6 from the stress test principles listed in Table 4-1 (Section 4.3.5) which is to address all possible risks, questions were included on other scenarios that might affect climate change or the global response. These other scenarios were elicited with two questions:

What other unusual things might happen?

What other scenarios can you imagine for the UNFCCC?

As experience developed in the delivery of the survey, the interviewer would clarify these questions, asking: what other things might influence climate or the global response to climate change? The aim of these questions was to extend the range of scenarios collected, while also fulfilling the principle of addressing all possible risks (Section 4.3.5), including low probability, high impact scenarios, or more mundane extreme scenarios for example a year of drizzle in the United Kingdom (pers. comm. Adam Cooper). Other UNFCCC related scenarios were also explored.

5.2.2.4 Reflective questions

At the end of the survey reflective questions were asked, to help understand the respondent's role in relation to current climate change conditions and possible scenarios. The main question consisted of:

> **What role do you and the organisation you are with have in relation to climate change?**

Specific follow up questions consisted of:

- **How would you describe your organisations contribution towards the global response to climate change?**
- **Which scenario would you say your organisation contributing towards?**

As experience developed in the delivery of the survey, respondents were asked: With regards the scenarios described, which scenario is your organisation contributing towards? And, which scenario are you personally contributing towards?

5.2.2.5 General follow up questions

General follow up questions were asked if a response was: unclear; did not fully address the key question being asked; or, if there was some interesting element to be further explored. Follow up questions were designed to ensure the responses to each question included enough information for a robust analysis and that all elements of the UNFCCC objective were addressed. Follow up questions also addressed actors and the reasons for their actions in each scenario.

General follow up questions included:

- How would you describe the situation?
  For example, in relation to:
  - the ability of ecosystems to adapt naturally
  - food production
  - economic development
  - society, politics and other things
- Who are the main actors?
  - Countries
  - Groups of countries
  - Businesses and business groups
  - Civil society and civil society groups

        - The UNFCCC and other international organisations
        - Individuals and households
    - How do they influence the situation and for what reasons?
    - How would you describe the UNFCCC's role?
    - Outside of climate change processes, what are the key things driving the situation?

5.2.3 Semi-structured survey sample design

It is important to note, the aim of the survey was to get a representative sample of possible futures rather than responses representative of people in the sample. However, to collect information on possible futures it was important to have a sample of experts from which to collect information on possible futures. As such, a survey sample was designed (Section 5.2.3.1) and respondents recruited (Section 5.2.3.2).

5.2.3.1 Survey sample

The survey sample was designed to get a broad sample of possible futures (i.e. scenarios) by eliciting global response scenarios from a diverse group of people with different backgrounds, experiences and views on climate change and the global response.

Sample selection criteria are presented in Table 5-3 and included nationality, gender, level of engagement with the UNFCCC, and institutional affiliations. In addition to these criteria, climate change sceptics (i.e. people sceptical of the scientific basis for anthropogenic climate change) were excluded from the sample because the study is focused on collecting evidence based global responses to climate change rather than interrogating climate science, which is accepted as being unequivocal (IPCC 2014a).

Table 5-3: Sample selection criteria.

Development and geographic distribution	Gender	Engagement with UNFCCC	Current institutional affiliation
Nationality(s) including developed and developing country nationalities	Female Male	Secretariat staff member Representative on a UNFCCC body Negotiator and delegate to COP Other delegate to COP Observer to COP IPCC Distant observer (never attended COP)	**UNFCCC:** UNFCCC IPCC **Other international organisations:** Multilateral Development Bank Other international organisations **Sovereign States:** National government policy National security **Non-state actors:** Local Government Business Civil Society Research Media Religious

The level of engagement respondents had with the UNFCCC was considered important because it was essential to have respondents with a knowledge of the UNFCCC, its institutional arrangements and how this affects the global response to climate change. At the same time, only selecting people deeply engaged with the UNFCCC could bias the sample towards those that see value in the institution. As such, some people who have not been deeply engaged were wanted in the sample, for example people involved in climate related interventions in the field. Furthermore, the study deliberately sought people sceptical of the global response to climate change and the UNFCCC for inclusion in the survey sample. Background questions regarding faith in the UNFCCC (Section 5.2.2.2) were included in the survey, making it possible to verify the survey sample included global response sceptics.

A key issue of concern in the 5th IPCC Assessment Report chapter on international cooperation was competing international institutions, the possibility of forum shopping and whether this enhances or weakens the global response to climate change (Stavins et al. 2014). As such, it was important to have people in the sample with a range of institutional affiliations, including people from potentially competing and complementary institutions and organisations. The right-hand column of Table 5-3 has a list of the institutional affiliations of interest.

5.2.3.2 Recruitment of respondents

A list of potential respondents was compiled based on the sample selection criteria discussed above. However, once interviews began, snowballing was also used to recruit new participants as well, although this only resulted in a couple actual interviews.

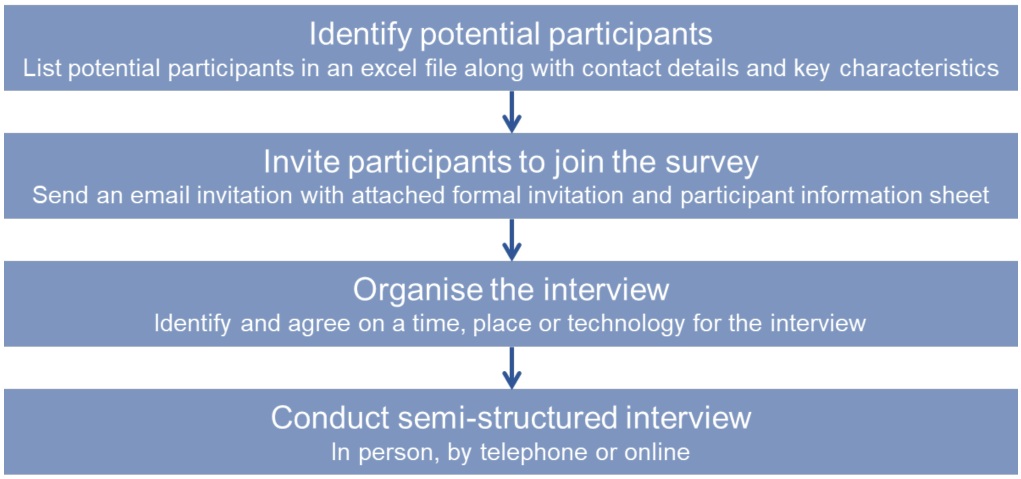

Figure 5-4: Survey data collection process.

Prior to being interviewed, each respondent was sent an email with an invitation letter (Appendix K) and a participant information sheet (Appendix L). They were also asked if there is a particular time or place that would be best for the interview to take place. In some cases, the invitation was for an in-person interview and in other cases it was for an interview by telephone, via skype or some other online communication provider.

Data collection and recruitment stopped once theoretical saturation was achieved i.e. when interviews stopped yielding new information.

5.2.4 Semi-structured survey interviews – sample and response rate

Invitations to participate in the survey were sent to 44 people, of which 18 were women and 26 were men (Table 5-4). Of these, 27 people responded and participated in the survey, of whom 8 were women and 19 were men. Of the 27 interviews conducted, 19 were conducted in person and 8 were conducted by telephone or over the internet. Before starting the interview, each respondent was asked to go through the participant information sheet (Appendix L) and consent to the interview (Appendix M). They were also provided with a copy of the participant information sheet. Interviews took between 30 and 85 minutes and were recorded for transcription purposes.

Table 5-4: The number of female and male invitees and respondents along with response rates.

	Invitees	Respondents	Response rate
Female	18	8	44%
Male	26	19	73%
Total	**44**	**27**	**61%**

With regards to primary national and regional affiliations (Table 5-5), 3 respondents were from Africa, 2 from Asia, 11 from Europe, 3 from North America, 7 from Oceania, and 1 from South America. As such there is a developed country bias in the sample, however, responses were not markedly different from developed or developing country respondents, for example, global response scenarios focused on powerful actors regardless of whether the respondent was from developed or developing countries. Many of the developed country respondents had spent time working in or with developing countries.

Table 5-5: Primary national affiliations of invitees and respondents along with response rates.

	Invitees	Respondents	Response rate
Africa:	4	3	75%
Ethiopia	1	1	100%
Mali	1	1	100%
South Africa	1	0	0%
Sudan	1	1	100%
Asia:	3	2	67%
India	1	0	0%
Japan	1	1	100%
Philippines	1	1	100%
Europe:	19	11	58%
Austria	1	0	0%
Denmark	1	1	100%
France	1	0	0%
Germany	2	1	50%
Hungary	1	1	100%
Ireland	1	0	0%
Italy	1	1	100%
Sweden	1	0	0%
United Kingdom	10	7	70%
North America:	7	3	43%
United States of America	7	3	43%
Oceania:	9	7	78%
Australia	1	1	100%
Fiji	1	0	0%
New Zealand	7	6	86%
South America:	2	1	50%
Argentina	1	1	100%
Costa Rica	1	0	0%

With regards to primary institutional affiliations, 1 was primarily affiliated with a United Nations related climate change institution, 4 were affiliated with other international organisations, 5 with sovereign states and their governments, and 17 were primarily affiliated with non-state actors such as research organisations or civil society (Table 5-6). As such, there is a bias in the types of respondents (i.e. survey sample), with high numbers of researchers and civil society respondents and no business, local government or religious respondents. The extent to which “survey sample” bias is a problem depends on the extent to which this biases the “sample of possible futures” collected. As noted in Section 5.2.1, the survey attempts to collect a representative sample of possible futures i.e. a set of scenarios broadly representing the range of possibilities. However, the sample of possible futures might lack global response scenarios involving business, local government or religion as key drivers for change.

Table 5-6: Primary institutional affiliations of invitees and respondents along with response rates.

Primary institutional affiliation	Invitees	Respondents	Response rate
United Nations Climate Change Institutions:	2	1	50%
UNFCCC	1	0	0%
IPCC	1	1	100%
Other international organisations:	6	4	67%
Multilateral Development Bank	2	1	50%
Other UN or international organisation	4	3	75%
Sovereign States:	9	5	56%
National government policy	8	4	50%
National security	1	1	100%
Non-state actors:	27	17	63%
Local Government	0	0	NA
Business	0	0	NA
Civil Society	13	7	54%
Research	13	9	69%
Media	1	1	100%
Religious	0	0	NA

Individually, the respondents have a wealth of experience and in many instances have had multiple roles in life, for example in the United Nations system, for their government or at the community level (Table 5-7).

Table 5-7: Summary of respondents including respondent numbers.

Respondent number	Information regarding the respondent
1	The respondent has a background in history and has published on issues of climate change.
2	The respondent comes from a security background and has been involved in climate change issues internationally.
3	The respondent has worked in international development, climate change and rural development both for their government as well as in civil society.
4	The respondent is a recently retired senior UN official with international development experience in Asia, Africa and Europe including dealing with international crises.
5	The respondent has been involved in the IPCC at a high level as well as energy research and civil society.
6	The respondent has worked on geopolitical and security related climate change scenarios with governments from around the world.
7	The respondent has held science diplomacy roles with a developed country government interacting with large developing countries and has also been involved in climate change research.
8	The respondent has been an IPCC author and researches issues related to land and agriculture.
9	The respondent works for an international civil society organisation engaged in issues of climate change in developing countries.
10	The respondent works in a multilateral development bank, has extensive experience supporting developing countries, and has supported climate negotiators in the past.
11	The respondent works in a faith based non-profit organisation working in developing countries on issues related to ecosystems and agriculture.
12	The respondent has worked on issues of disaster response in a developing country for government and civil society.
13	The respondent is a former politician and diplomat who has been active in climate change, foreign affairs and the United Nations.
14	The respondent has been involved in environmental consulting in developed and developing countries, environmental policy and national politics in a developed country.
15	The respondent is a prominent researcher on economics, climate change and other global issues.
16	The respondent has worked in civil society and international organisations supporting governments in Africa on issues related to climate change, development and the environment.
17	The respondent is involved in energy modelling and planning for an international energy system including stakeholder engagement.
18	The respondent is employed by an organisation that works on renewable energy, and the respondent has been a part of international initiatives related to climate change and sustainable development.
19	The respondent is a senior figure involved in energy policy in a developed country.
20	The respondent has a background in paleoclimate and hazards related research.
21	The respondent is an academic involved in modelling energy systems and related greenhouse gas emissions as well as GHG balances.
22	The respondent has a background in media and communications including in government (agriculture related) and consulting roles.
23	The respondent works for an international humanitarian organisation and has been involved in issues of climate change and development.
24	The respondent has advised senior figures in the United Nations and has a leadership role in civil society and research on issues related to climate change.
25	The respondent has been involved in civil society, the promotion of renewable energy and government delegations to climate negotiations.
26	The respondent is a researcher with a legal background, teaching climate change law.
27	The respondent has advised governments and cities on issues related to climate change and development.

5.2.5 Transcription of interviews

The 27 interviews were transcribed verbatim including time tags making it possible to go back to relevant sections of audio files. Transcripts were imported into excel where each paragraph became a row. The 27 imported transcripts consisting of over 13,500 rows and just over 238,000 words. Each transcript was checked for quality, against the recorded response and any errors in transcription were corrected. A copy of each response was made and edited removing stutters, repeated words, and words such as "um" or "uh". These clean transcripts of responses were then used as a basis for scenario identification. The data set was read in its entirety and notes were made (see Appendix N).

5.3 Data processing

Data processing had 2 key steps, consisting of scenario compilation using theory of change (Section 5.3.1), and thematic analysis including the coding of scenarios (Section 5.3.2). It should be noted that the division between data processing and data analysis is somewhat arbitrary, as thematic coding is a form of analysis and contributes to the definition of themes that are further analysed. However, for the purposes of presenting the methods used in this study, data processing stops at the point where the sample of possible futures is compiled and coded, ready for "thematic chain analysis" and the exploration of preconditions.

5.3.1 Scenario compilation using theory of change analysis

From the 27 survey responses, over 145,000 of the respondents' own words were analysed in detail using a theory of change approach, resulting in 175 scenario plots with 37,000 words of respondent quotes within.

While the current situation is not the main focus of this study, the survey started with the current situation to get a sense of what each respondent thinks about the climate change as an issue, and also to get a sense of the extent to which responses and scenarios provided were consisted with published literature. In many interviews respondents deferred to, and repeated, IPCC and related research on climate change.

For each respondent, the clean transcript of their response was analysed using theory of change. The theory of change analysis included reading transcripts looking for statements and quotes that had a logical flow from one set of conditions to another set of conditions. Statements that indicated "if… then" were identified and highlighted. These quotes were then taken from the transcript and plotted as "scenario elements" on a 2-dimensional plot, with time running left to right. With regards to the vertical axis, localised issues were plotted lower while overarching or international issues were plotted higher. In most cases scenario elements were based on quotes from a respondent (in quotation marks) but in some cases scenario elements consisted of short summaries based on an analysis of the respondent's responses (presented without quotation marks).

For each scenario, distinctions were made between essential and other information. Orange boxes were used to plot quotes deemed essential to the scenario, green boxes presented quotes related to, or of interest, but not essential to the scenario, and blue boxes were used to present related issues and assumptions (Table 5-8). However, it should be noted that the distinction between essential and non-essential elements did not appear particularly useful during the analysis of scenarios, and as such, orange and green elements were analysed in the same way.

When plotting scenarios elements, boxes were aligned with each other to indicate the extent to which they may be related, for example boxes that are parallel along the x-axis indicates these scenario elements (i.e. boxes) are relevant over the same period of time. Boxes that are parallel along the y-axis indicate that these scenario elements (i.e. boxes) are related in terms of theme. It should be noted that alignment was indicative and imperfect. In some cases, for example where there are branching follow on elements, then it may be arbitrary which element is above or below. But to the extent possible, the criteria above were used to plot scenarios. Note: see Section 6.2.1 for more on how scenarios were plotted.

Table 5-8: Scenario elements.

Descriptor	Description
Scenario element	A box with a description of something relevant to the scenario.
Essential element	Something that is necessary to the scenario, presented in an orange box.
Non-essential element	Something not necessary to the scenario but helps provide context or examples of possibilities within the scenario and is presented in a green box.
Issues and assumptions element	Things that are important to the scenario and understanding the other elements and relationships presented. These things are presented in a blue box.

When asked to describe the current situation, failure, success or other scenarios, in many cases respondents provided a series of statements, sometimes switching between the current situation, the past and the future, or switching between success and failure scenarios. At other times, respondents thought aloud about possible actors, dynamics, factors or situations that might be relevant. As such, transcripts contain discontinuous pieces of information, spread between statements and responses to different questions in some cases.

Most statements only addressed segments of chains, for example some critical node, a waypoint, an important change, or a significant event, and as such were akin to post-it notes marking out scenario pathways and storylines; which is a common approach used in scenario development workshops. The theory of change analysis was akin to taking post it notes (i.e. quotes) based on what the respondents said and organising them into logical sequences (i.e. chains) to form success and failure scenarios.

From the theory of change analysis, 175 scenarios were compiled forming a sample of possible futures. These scenarios ranged from very simple to complex, in some cases consisting of a single element, and in other cases with multiple steps through time, or layers from local to international, branching or merging elements, parallel conditions and related assumptions. Figure 5-5 is an example of a scenario with four steps and seven layers, compiled based on a theory of change analysis of a survey response.

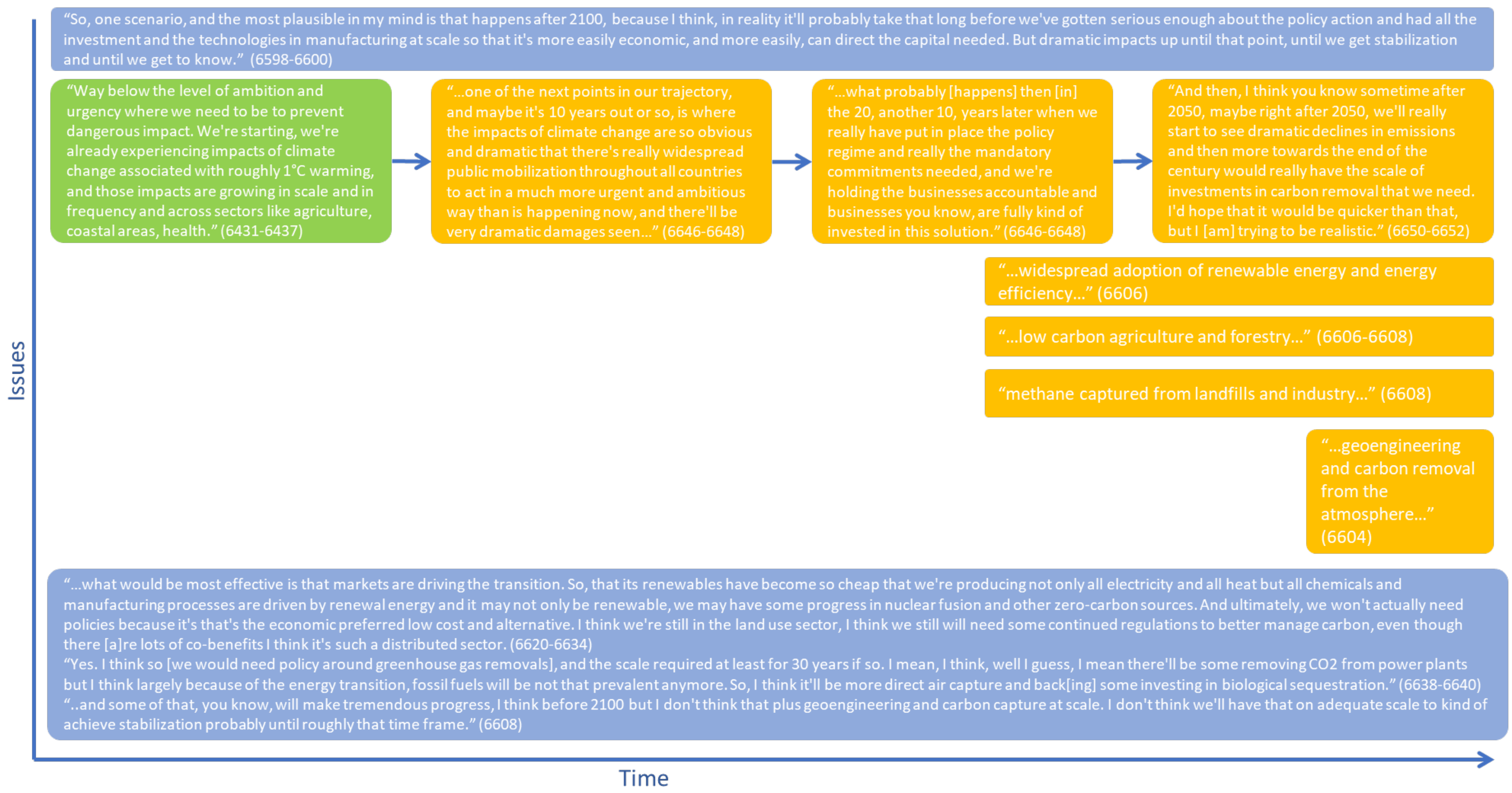

Figure 5-5: An example of a scenario compiled using theory of change, with four steps and 7 layers, including non-essential (green) and essential (orange) elements as well as assumptions (blue). The numbers in brackets refer to rows in the database of transcribed responses.

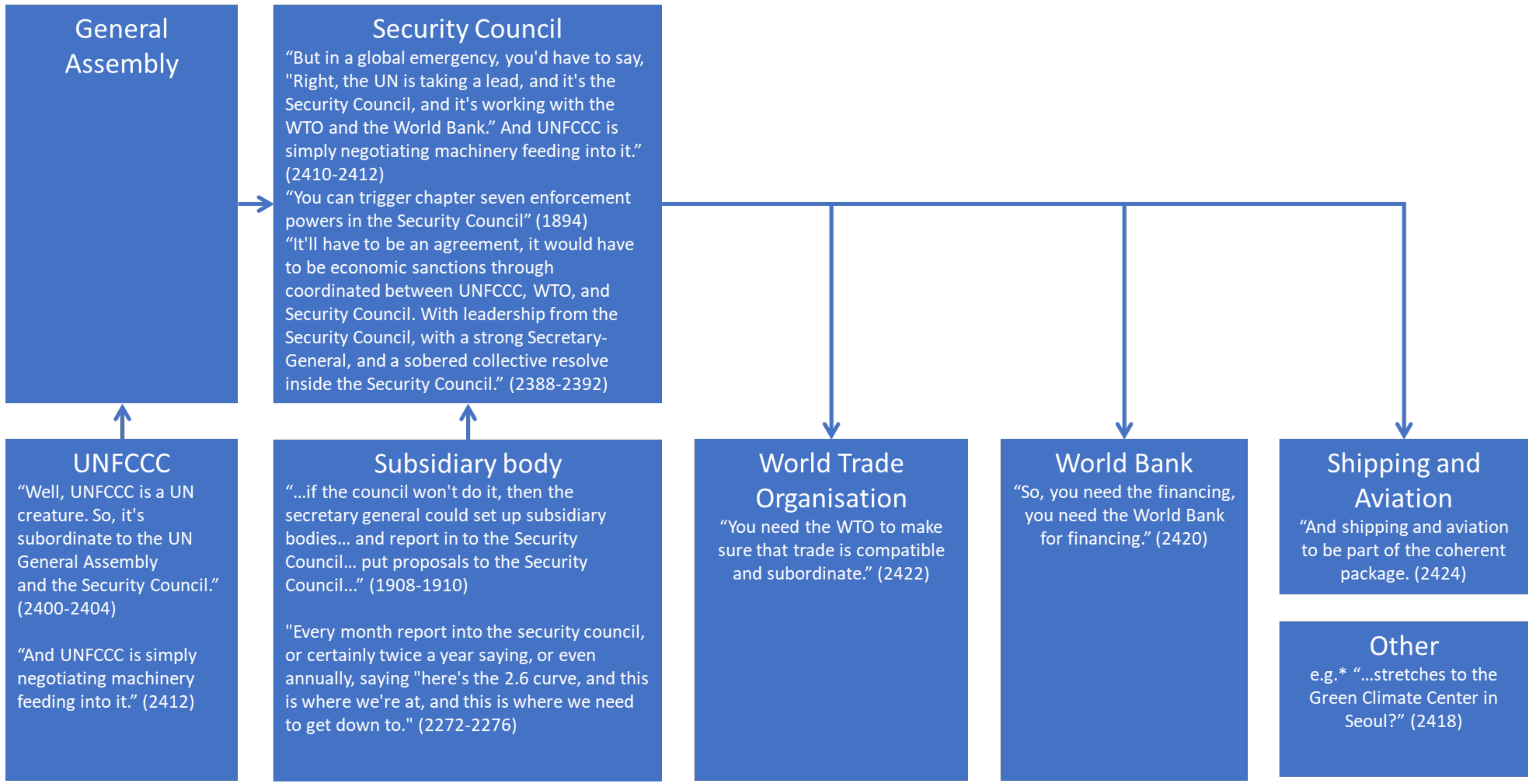

Figure 5-6: Example of a plot showing the international regime and organisation of international institutions at a point in time.

Most scenarios plotted include chains of scenario elements through time, but in 2 cases the scenario plot took the form of a snapshot of a future international regime addressing climate change. These 2 scenario plots essentially took the form of organisation diagrams showing a hierarchy of international institutions with roles in quotes. Figure 5-6 is one of the two scenarios plotted in the style of an organisation diagram.

Note: With regards to record keeping, for each survey response a theory of change analysis document was prepared consisting of: a short description of the respondent; a summary of the current climate change situation using quotes from the respondent, a summary of each scenario including scenario plots and accompanying quotes; a transcript of responses organised into sections with headings indicating the content and key points in each section.

5.3.2 Thematic analysis and coding of scenarios

Thematic analysis and coding of scenarios broadly followed the steps from Braun and Clarke (2006) which including familiarisation, initial codes, searching for themes, reviewing themes, naming and defining themes and reporting of themes (Section 4.5.2).

Familiarisation with the data collected happened over several phases including the editing and checking of transcripts to produce clean transcripts, the review of clean transcripts taking notes and highlighting “if… then” relations and the plotting of scenarios. The generation of initial codes included making concise notes on each scenario as well as concise notes on each of the scenario elements within a scenario. While generating themes (i.e. codes), it became apparent that notes could be identified as regarding outcomes, types of responses, actors and interests, issues or options, or regarded assumptions. In addition to these things, scenarios were coded according to their complexity. Any other notes were recoded under “Notes” (Table 5-9).

Table 5-9: Fields for which notes were recorded and themes developed.

Fields	Definition
Complexity	A simple description of the extent to which different parts of the scenario are shown to influence each other based on the form of scenario plots.
Assumptions	Stated (i.e. explicit) or unstated (i.e. implicit) beliefs about the system that has explanatory power with regards to the scenario.
Issues and options	**Issues** are concerns or problems in the scenario*. **Options** are actions, or inactions, that can be decided upon by actors in the scenario.
Actors and interests	**Actors** are individuals or groups with the ability to make decisions and influence the scenario. **Interests** are the issues and options that an actor cares about in the scenario.
Response	The actions of actors in the scenario (i.e. options taken by actors in the scenario).
Outcome	The extent to which conditions at the end of a scenario are said to fulfil the UNFCCC objective.
Notes	A summary of any other information important to the interpretation or understanding of the scenario.
Coding	Short (comma separated) list of most important themes in the scenario.

**Adapted from Merriam-Webster, 2019.*

The search for themes that could meaningfully reflect common and encompassing ideas with explanatory power, started with a comparison of notes (i.e. initial codes) from across all the scenarios, specifically notes related to “outcomes” and “responses” given the focus of the study on “effective global responses”. Themes were iteratively reviewed until it was considered that themes described the most important characteristics of possible futures, at the level of individual scenarios and collectively when it comes to the entire sample of possible futures. At this stage themes were named and defined. Scenarios were then coded (in the “Coding” field) according the most important themes in the scenario (i.e. the most salient themes).

Principles guiding the selection of words to name and define themes included using simple English while at the same time ensuring terms are identifiably grounded in survey responses and semantically correct. The first sentence of each definition describes the concept in the broadest possible and most essential terms while subsequent sentences may include examples or provide additional context.

Reporting of overarching themes and results of the thematic analysis is done in Chapter 6, including a summary of notes for each type of outcome (Section 0) and overarching themes organised in relation to the CCNIIC Model (Section 6.3). The results of the thematic analysis, including themes, scenarios and salient quotes are presented in Chapters 7 to 11. It is important to note: the study did not attempt to limit the sample of possible futures to four or five reference scenarios. Instead all scenarios, and scenario elements, were accepted as being possible futures. As such, the study provides a broad sample of the multiverse of possible futures. Chapters 7 to 11 present multiple possible scenarios, even for a single theme, and include many headings reflecting the diversity of themes identified.

5.4 Data analysis

Data analysis (Chapter 12) involved identifying important themes and conditions, multiple possible pathways between these conditions, and identifying the preconditions that contribute toward effective global responses. The point of departure for data analysis was the overarching themes identified in Section 6.3. Importantly, the searchable sample of possible futures included searchable text in scenario titles, scenario elements and quotes, notes and themes. As such, keywords were used to search for relevant success, failure or other scenarios.

Having a searchable sample of possible futures made it possible to conduct “thematic chain analysis” of keywords. Thematic chain analysis involved identifying a theme of interest such as social unrest, making a search for relevant scenarios, which were then reviewed and a table created, with the theme of interest in the central column, preconditions recorded in the left column and subsequent conditions (i.e. following conditions) recorded to the right (Table 5-10). Themes were highlighted in bold and quotes from respondents were recorded in quotation marks.

Table 5-10: Example of "thematic chain analysis" of the theme "social unrest".

Preconditions	Social unrest	Following conditions	Scenario ID
Insecurity: "So, first, you feel the bite just in terms of heat, cost of living, food availability" **Defence**: "when food is not available, or when temperatures become unbearable or when wealthy people are perceived to be protecting themselves behind high walls"	**Social unrest**: "social disruption" "And I think that that could happen in our cities. That could happen in different places… the risk of breakdown of law and order and of social systems"	**Institutional failure**: "So if you've got a breakdown in law and order your ability to create a new order in an intentional way is compromised"	80919b

From thematic chain analyses, and the analyses in Chapters 7 to 11, it was possible to construct maps with multiple possible pathways, including possible preconditions and possible responses for example related to social change and behaviour, political will and policy, business and economic activity, GHG removals, and international cooperation as well as possible responses and subsequent conditions (Chapter 12). These maps highlight interventions and conditions that could contribute towards effective global responses to climate change.

The analysis, including thematic chain analysis, was organised into five parts. The first part addressed the influence climate change might have on actors and the global response to climate change from Chapter 7. From the analysis of these scenarios and themes, a typology of climate change signals and responses was created along with an analysis of response criteria (Section 12.2).

The second part of the analysis addressed scenarios and themes regarding actors and their interests from Chapter 8. The analyses of overarching actor interest themes included social change and behaviour (Section 12.3.1), political will and policy (Section 12.3.2), business and economic activity (Section 12.3.3). The third part of the analysis addressed response option scenarios and themes from Chapter 9, including an analysis of GHG removal options (Section 12.4). The fourth part of the analysis addressed international cooperation themes from Chapter 10, including coalitions and issues of power and capacity (Section 12.5).

The fifth part of the analysis is the discussion in Chapter 13 which addresses the findings from Chapter 12 and the literature reviewed in Chapters 1 to 4. An important part of the analysis was the qualitative assessment of response types and the likelihood of these responses fulfilling the UNFCCC objective. If a response type is consistent with dramatic reductions in GHG emissions described in Section 2.2.4, then it was considered more likely to be effective. If a response was consistent with business as usual or limited reductions in GHG emissions, then it was considered unlikely to be effective. However, as noted in Table 2-1 from Section 2.2.3, there is a small chance that global warming might be limited to below 2ºC even if atmospheric GHG concentrations are above 450 or even 500 ppm (CO_2-eq), which complicates the analysis, requiring consideration of serendipity.

Note: Failure scenarios were identified and thematically analysed but due space constraints, these scenarios do not feature in the analysis and only “failure of international cooperation” scenarios have been presented in Appendix O. It is unclear what influence additional analysis and discussion of failure scenarios might have had on the results of this study.

Part III: Scenarios and themes

Part III: Scenarios and themes consists of 6 chapters.

Chapter 6 summarises the results of data collection and processing. This includes summarising the sample of possible futures and the overarching themes identified.

Chapters 7 to 11 present scenarios and themes identified from the searchable sample of possible futures.

Chapter 7 presents climate change impacts, risks, responses and related themes.

Chapter 8 presents actors, interests and related themes.

Chapter 9 presents domestic response options including GHG removal options and related themes.

Chapter 10 presents international cooperation options and related themes.

Chapter 11 presents other scenarios and related themes including the influence these scenarios and themes might have on climate change or the global response.

Note: All scenarios and scenario elements are accepted as being possible futures, hence there are many section headings in Chapters 7 to 11 reflecting the diversity of themes and scenarios identified. Each section heading represents a theme for which there may be multiple related scenarios. Sections have not been joined (i.e. conflated) where there are distinct themes, even if a section is very short.

Chapter 6 Survey responses, scenarios and themes

6.1 Introduction

Following the methods from Chapter 5, data was collected, processed and thematically analysed. This chapter summarises the data collected and processed from respondents. This includes information on respondent sentiment (Section 6.2), a summary of scenario complexity as well as scenario types by outcome with related notes (Section 0), and lastly a summary of overarching themes in relation to the Climate Change, National Interests, International Cooperation (CCNIIC) Model (Section 6.3).

6.2 Respondent sentiment

Respondent sentiment was sampled to help get a sense of possible respondent biases. Of the 27 people surveyed, respondent sentiment was collected from 24 respondents[12]. The results below are presented based on the sentiment of the 24 respondents from whom data was collected.

With regards to whether the world is a better place to live today than it was in the past, nearly 40% either agreed or strongly agreed, while just over forty percent disagree or strongly disagreed. Just over 20% of the sample were neutral. With regards to the world being a better place to live in the future, over 50% of the sample were neutral, nearly thirty percent agreed or strongly agreed and 17% disagreed. As such, there was a spread of sentiments.

There were only a few obviously optimistic or pessimistic individuals in the sample. For example, there were two optimistic respondents that agreed or strongly agreed that the world is a better place today and will be better in the future, meanwhile there were three pessimistic respondents that disagreed the world is better today than it was in the past, and disagreed that the world will be a better place to live in the future.

If neutral responses are ignored[13], then one respondent can be said to have indicated the world is peaking, as they agreed the world is a better place than it was in the past but disagreed that the future would be better. Meanwhile, three respondents indicated the world is as bad as it might get, as they disagree that the world is better today than it was in the past and agreed the world will be a better place in the future.

[12] The first respondent was not sampled as the sentiment question had not yet been included in the semi-structured interview, another respondent failed to press the submit button on the electronic form, hence their response was not collected, and lastly, one of the respondents from the COP24 was an impromptu interview, starting in the queue for coffee, hence the sentiment form was not filled in.
[13] Neutral responses are ignored because it's not possible to tell if the respondent is unsure of what they think, or thinks life is the same as in the past or will be the same in the future.

Interestingly, regardless of respondent sentiment being generally optimistic, pessimistic or something else, respondents universally indicated that the global response to climate change is failing during the interview (Section 5.2.2.3).

With regards to whether the UNFCCC should be abandoned, 96% of respondents disagreed or strongly disagreed with the statement. Only one respondent indicated that they strongly agreed that the UNFCCC should be abandoned, however this may have been a mistake filling in the response sheet, as they also strongly agreed that the UNFCCC is essential for an effective global response to climate change. Regardless, it can be said, respondents overwhelmingly disagreed with the idea of abandoning the UNFCCC.

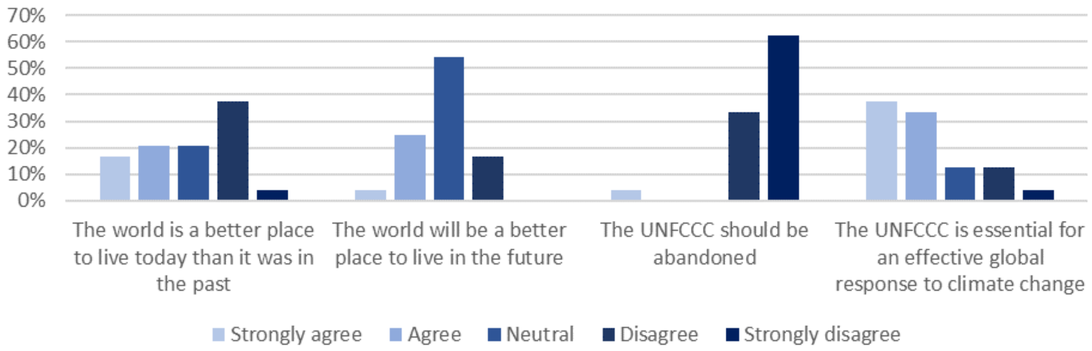

Figure 6-1: Summary of survey respondent sentiment.

A large majority (just over 70%) of respondents agreed or strongly agreed that the UNFCCC is essential for an effective global response to climate change. However, nearly 30% were neutral, disagreed or strongly disagreed. As such, the sample included a limited number of respondents that were sceptical of the UNFCCC's contribution to the global response.

From the respondent sentiment data, it can be said that there is a relatively even spread of optimists and pessimists in the sample, however, the sample lacked respondents that believe the UNFCCC should be abandoned and generally included people that considered the UNFCCC is essential for an effective global response to climate change, although nearly 30% didn't necessarily hold this view and as such may have been somewhat sceptical of the UNFCCC.

From Section 5.2.3.1 the "survey sample" is biased but it was an open question as to what extent the survey sample biases the "sample of possible futures". Sentiment analysis suggests the survey sample includes respondents with mixed levels of optimism and faith in the UNFCCC and its role in the global response to climate change. These results are encouraging as the purpose of the survey was to collect a broad sample of possible futures. Summary of scenarios (i.e. sample of possible futures)

Each scenario was analysed and coded starting with outcomes. It was anticipated that scenario outcomes would be classified as being either, "success", "failure" or "other". However, some scenario plots had branching success or failure outcomes and as such a new category of scenario needed to be included. Table 6-1 provides descriptions of scenario types according to outcome codes.

As previously noted, the scenarios compiled constitute a sample of possible futures. In total, 175 scenarios were compiled and plotted graphically. Of these, 8 were branching success or failure scenarios (Appendix P), 48 were failure scenarios (Appendix Q), 68 were success scenarios (Appendix R), and 51 were other scenarios (Appendix S). Of the 48 failure scenarios, 21 featured parties withdrawing from international agreements and 6 featured international climate agreements being amended in response to follow up questions. Of the 68 success scenarios, 24 featured greenhouse gas removals and 22 featured stringent enforced agreements mostly in response to follow up questions, but some of these scenarios were unprompted. The codes for the scenarios are provided in Appendices P to S, meanwhile the summary notes for each category of scenario can be seen in Appendix O.

Table 6-1: Scenario type by outcome.

Scenario type	Description
Branching success or failure scenario	A scenario that shows diverging chains of scenario elements, one of which goes towards fulfilling the UNFCCC objective and the other goes towards not fulfilling the UNFCCC objective. Branching success or failure scenarios include critical nodes.
Failure scenario	A scenario that does not fulfil the UNFCCC objective or contributes towards not fulfilling the UNFCCC objective.
Success scenario	A scenario that results in fulfilling the UNFCCC objective or contributes towards fulfilling the UNFCCC objective.
Other scenario	A scenario that shows other conditions or events that could affect the climate or the global response to climate change, as well as other issues or dynamics related to the global response to climate change without necessarily contributing directly to either fulfilling or not fulfilling the UNFCCC objective, including extreme events.

Each of the scenarios compiled is like a short story of the future. Some of these scenarios are very short, for example consisting of a single element, while other scenarios are much more complex consisting of multiple steps and layers. In the sub-sections below, a broad summary of scenarios is provided starting with scenario forms and complexity (Section 6.2.1), then branching success or failure scenarios (Section 6.2.2), failure scenarios (Section 6.2.3), success scenarios (Section 6.2.4) and other scenarios (Section 6.2.5). Note: The themes identified from these scenarios are presented Chapters 7 to 11.

6.2.1 Scenario forms and complexity

Each scenario had a level of complexity reflected in the form (i.e. shape) of the scenario plot. Information recorded from scenario plots included the number of steps, whether the scenario was linear, had merging elements or branching elements, the number of layers and whether there were interlinkages or parallel conditions including assumptions (Table 6-2, Figure 6-2).

Table 6-2: Scenario complexity descriptors.

Descriptor	Description
Steps	The maximum number of scenario elements in a chain from left to right, i.e. steps in time.
Linear	A simple chain of scenario elements through time, represented by horizontal arrows connecting these elements from left to right.
Merging	Two or more scenario elements joining a single scenario element in the future (to the right), represented with connecting arrows.
Branching	A scenario element that is connected to two or more scenario elements in the future (to the right), represented with connecting arrows.
Layers	The maximum number of scenario elements (including issues and assumptions boxes as well) from bottom to top (i.e. from more local to more global).
Interrelations	Scenario elements that are parallel in time and are directly connected, represented with a vertical arrow.
Parallel conditions	A condition that is parallel in time with other conditions, but not directly interrelated with other elements. In practice, this is presented as two boxes parallel in time but without connecting vertical arrows. Parallel conditions only refer to orange or green boxes, not issues and assumptions in blue boxes.
Assumptions	Stated (i.e. explicit) or unstated (i.e. implicit) beliefs about the system that has explanatory power with regards to the scenario.

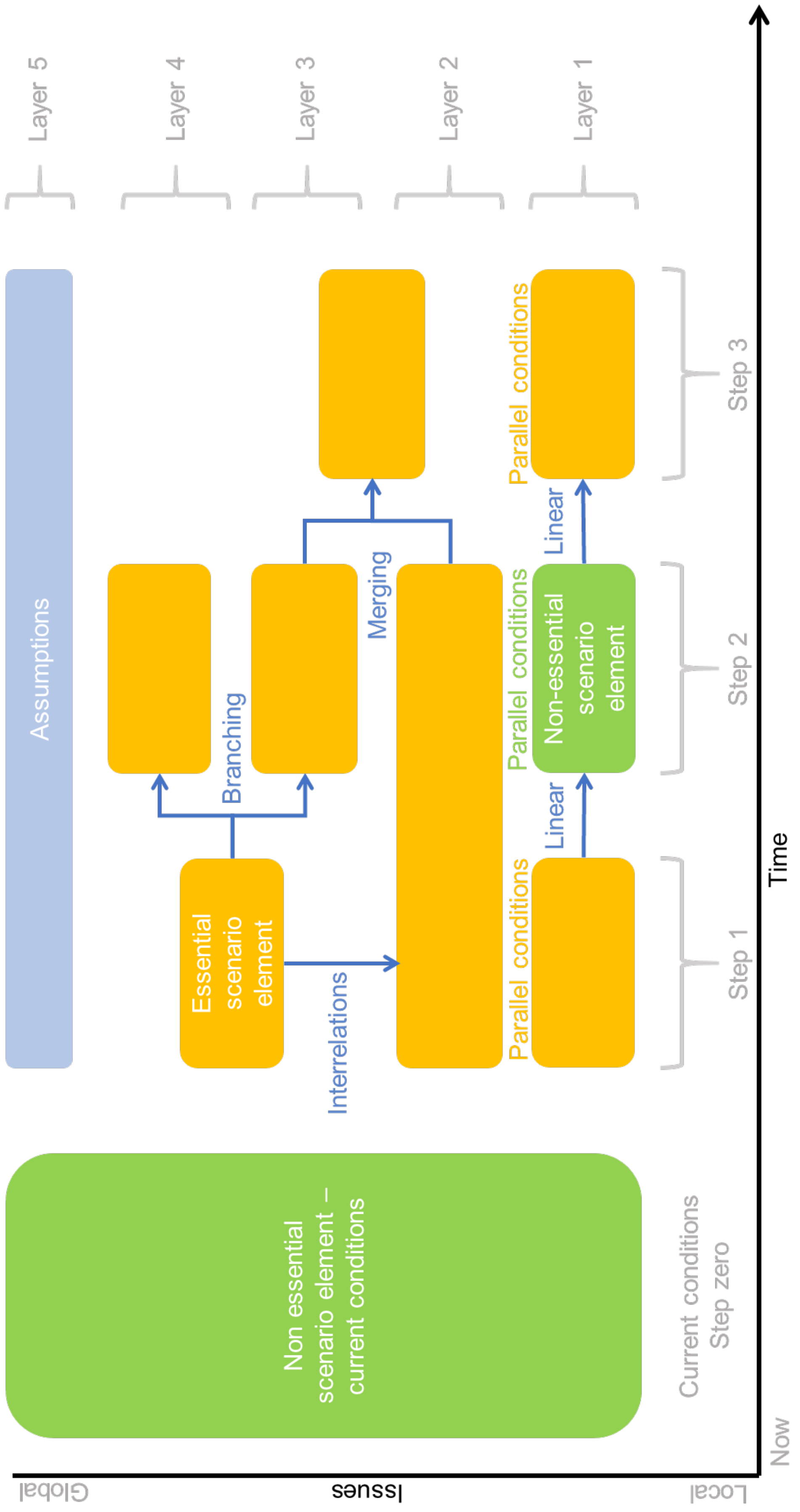

Figure 6-2: Schematic illustration of a scenario plot including descriptors used to describe scenario complexity.

With regards to the plotted form these scenarios took, the maximum number of steps in time in a scenario was 7 and the maximum number of layers (from more local to more global) was 14. Meanwhile, 15 scenarios were very simple consisting of one element only (i.e. 1 step and 1 layer) (Figure 6-3). The most common form of scenario had 3 steps and 2 layers accounting for 25 scenarios. Most scenarios had 5 or less steps and 8 or less layers. Given the number of things that could happen for example between now and 2100, and from local to international levels, it is clear from the limited number of steps and layers, these scenarios are very broad and sweeping descriptions of possible futures. However, this can be a good thing when it comes to plausibility, considering the conjunctive rule of probability theory (Section 4.2.4).

Interestingly, branching success and failure scenarios had an average of 3.1 steps and 3.4 layers, while success scenarios were very similar with an average of 2.9 steps and 3.7 layers. Using the number of steps and layers as a proxy for complexity, failure scenarios were generally simpler with an average of 2.9 steps and 2.4 layers while other scenarios were generally the simplest with an average of 2.6 steps and 2.0 layers.

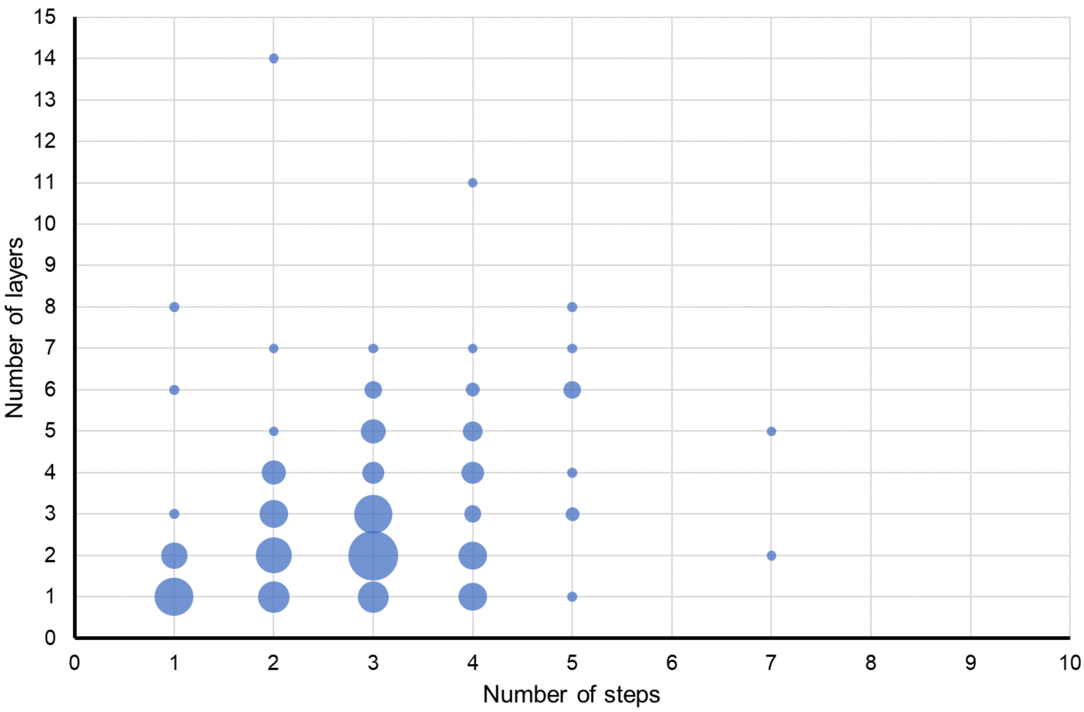

Figure 6-3: Number of steps and layers in the scenarios compiled from survey responses. Note: The larger the circle (by proportional area) the higher the number of scenarios with that combination of steps and layers.

6.2.2 Branching success and failure scenarios

Branching scenarios could either lead towards success or failure when it comes to fulfilling the UNFCCC objective. Seven of these branch scenarios were identified, each of which had a critical node i.e. responses and conditions that strongly influence the likelihood of achieving the UNFCCC objective (Section 4.2.4). These critical nodes highlight themes critical for effective or ineffective global responses to climate change.

Important themes identified included: cooperation versus defence, investing in research and development of long shot technologies versus close to market technologies, low versus high climate sensitivity, whether to raise or lower international climate change targets after a climate catastrophe, social change and transformation or overconsumption, timely investment in mitigation technologies and infrastructure, and timing of the global response (Appendix N).

6.2.3 Failure scenarios

Respondents, without exception, indicated that the current situation is not on path for achieving the UNFCCC objective, or indicated that the global response has already failed. For example, Respondent 23 stated “Well, first of all let's be clear that so far we have failed.”

To collect failure scenarios, respondents were asked to provide a scenario where the global response to climate change failed to achieve the UNFCCC objective. In addition to general follow up questions, for example on the actors involved, specific follow up questions included asking for a scenario where one or more parties withdraws from the UNFCCC and asking for a scenario where the UNFCCC objective is amended.

Failure scenarios identified from responses to the open-ended question are presented first, followed by withdrawal scenarios and amendment scenarios (Appendix N). Some of the main themes identified in general failure scenarios are: defence; failure of international cooperation on climate change; fragmentation of international cooperation generally; and, continued over-consumption.

Withdrawal scenarios included themes of populism and fragmentation of international cooperation as well as small vulnerable state frustration with the failure of international cooperation on climate change.

Scenarios involving the amendment of international climate agreements include a success scenario as well as failure scenarios. In the success scenario there is leadership from the youth and a social movement which infuses ambition into an amended UNFCCC objective. Failure scenario themes include climate change lock in, climate change impacts, withdrawal from the UNFCCC, and amendment of the Paris Agreement.

6.2.4 Success scenarios

Respondents were asked to provide a scenario where the UNFCCC objective is achieved. Some respondents struggled to respond with success scenarios or stated that they considered the success scenarios they provided unlikely. This is consistent with the UNEP Gap Report (UNEP 2017) (Section 2.2.4). Furthermore, some respondents challenged the notion of success. For example, in an overshoot-drawdown-stabilise scenario, Respondent 23 noted "most likely the removal will not be about roughly current levels but once that technology becomes possible, maybe we will begin to be adapting to… 500 PPM, and that becomes a new desirable level." Likewise, Respondent 17 noted, "then we return to 1.5, but it's the Earth without X." where "X" could be a set of ecosystems. Regardless, these success scenarios provide a sample of possible futures, making it possible to explore preconditions for more effective and less effective global responses to climate change, even if effective response scenarios are unlikely.

Some of the main themes identified in general success scenarios are enlightenment, social change, behaviour, business, technology, leadership, political will, policies, and international cooperation (Appendix N). Themes identified in GHG removal scenarios include technology, natural removals, energy, policy and international cooperation. Themes identified in stringent enforced agreement scenarios include international cooperation, geopolitical power, coalitions, budgets and security.

6.2.5 Other scenarios

In the semi-structured survey, respondents were asked what other things could happen that could either affect climate or the global response to climate change. Other scenarios were identified from responses to this question that show other, often extreme, sets of conditions or events that could affect the climate or the global response to climate change.

Some other scenarios do not have response themes (i.e. were not focused on responses to climate change), but rather featured issues and options related themes, for example an event, crisis, catastrophe or other issue other than climate change. Other scenarios also featured a diverse range of response themes including adaptation, conflict, defence, the international regime, international cooperation and failures of international cooperation on climate change, geoengineering, insurance and public service retreat, legal responses, technology, social change and even space colonisation (Appendix N).

6.3 Overarching themes identified in scenarios

While coding and analysing the scenarios, it became apparent that some themes were related and could be grouped. At the same time, it also became apparent that these overarching themes fitted into different parts of the CCNIIC Model and these overarching themes could also fit into a climate change impact-risk and response framework. As such Figure 6-4 includes the climate change, national interests and international cooperation categories from the CCNIIC Model, but also includes impacts and risks spanning the climate change category and part of the national interests category, as well as the responses which spans part of the national interests and the international cooperation categories.

Overarching impact risk themes in the climate change category consist of impacts and risks to physical systems and biological systems which together make up the environmental system. Impacts and risks that are in the national interest category consist of impacts and risks to human and managed systems. Responses in the national interest category consist of political will and policy, social change and behaviour, business and economic activity, technology and practices as well as other factors that influence decisions. Overarching response themes in the category of international cooperation consist of the international regime as well as international cooperation on climate change. The diagram does not address exogenous factors or other scenarios that might influence climate or the global response to climate change.

It should be noted here that while the overarching themes in Figure 6-4 attempt to be comprehensive, they are also a reflection of sample of possible futures collected. The extent to which the sample of possible futures presented in Chapters 7 to 11 are representative of the range of possible futures, or are biased, is difficult to judge (Section 5.2.3.2). Likewise, the extent to which the sample of possible futures biases overarching themes identified or the limits the extent to which these overarching themes are comprehensive, is also difficult to judge. However, these overarching themes seem consistent with the range of themes that could be drawn from comprehensive IPCC assessments.

Themes and scenarios related to these overarching themes are presented in Chapters 7 to 11. These overarching themes are analysed in Chapter 12.

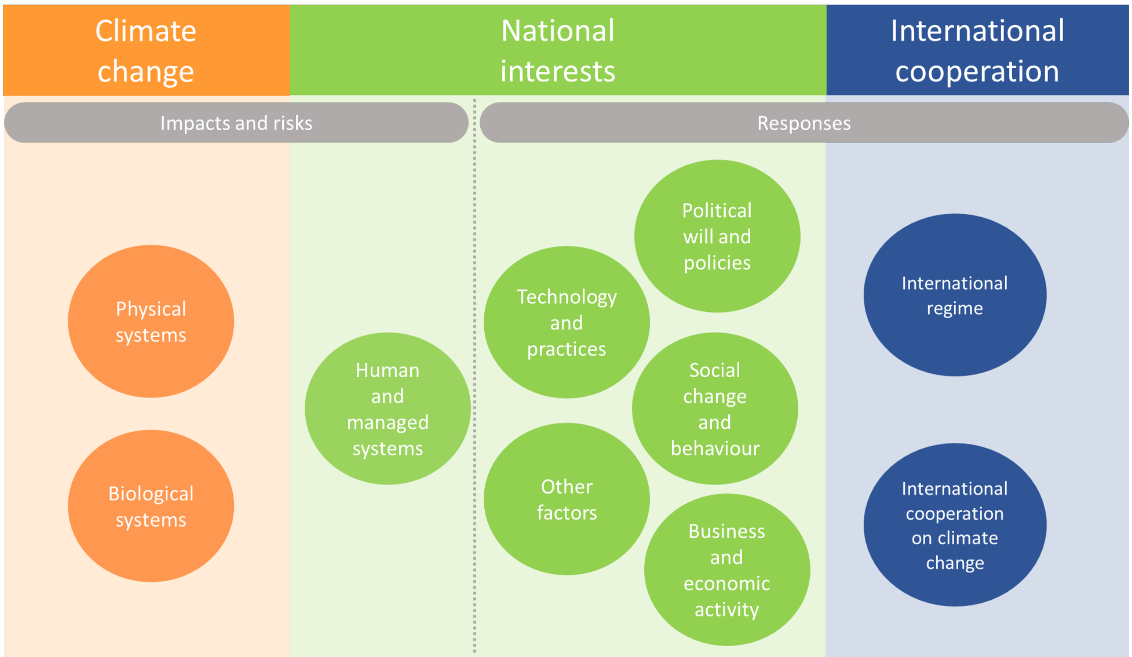

Figure 6-4: Overarching themes situated in relation to the climate change, national interests and international cooperation elements of the CCNIIC Model.

Chapter 7 Impacts, risks and responses

7.1 Introduction

This chapter presents scenarios and themes related to climate change impacts and risks to actors and their responses. To help address the question of what influence climate change might have on actors and the global response to climate change, from Section 1.6, two things are addressed in the thematic analysis, the first being the range of possible climate change scenarios (Section 7.2), the second being the responsiveness of actors to climate change (Section 7.3) including the implications different responses might have on the timing and scale of the global response. From the thematic analysis of scenarios, a set of response triggers and drivers are identified (Section 7.4) as well as response attitudes and inclinations (Section 7.5). Section 7.6 summarises themes from this chapter and indicates where these themes are analysed further in Chapter 12.

7.2 Climate change impact and risk scenarios

From the sample of possible futures, a diverse range of climate change hazards were identified (Table 7-1). As these climate change related risks and impacts neatly fit with the IPCC's categories of physical, biological and human systems (see light blue subheadings in Table 7-1), the IPCC categories were adopted for this study, along with definitions following the IPCC's Fifth Assessment Report (Table 7-2).

Table 7-1: Examples of climate change hazard related themes (in blue rows) and related notes from the scenarios.

Climate risk and impact related themes from the scenarios	
Climate change and related risks and impacts on physical systems	
Bigger hurricanes	Increased flooding
Changing coastlines	Ocean acidification
Even more rapid melting of Antarctic and Greenland ice sheets	Only lose a few islands (as opposed to many islands)
Fast feedbacks	Permafrost melt
Flooding	Positive feedbacks, where we have a massive rapid warming
Flooding of China Coastal Plain	Sea level rise
Flooding of Nile Delta	Tipping point
Greenland ice sheet (melt)	Weather variability
Climate change and related risks and impacts on biological systems	
Concerns on whether ecosystems can adapt	Mass die-off of species
Ecosystems not able to adapt	Widespread species loss
Loss of biodiversity	
Climate change and related risks and impacts on human systems	
Bangladesh ceases to be a viable country	Famine
Collapse in agricultural systems	Food crisis e.g. double bread-basket failure type event
Death from heat	Food security and insecurity
Disrupted food system	Losses in yields of food in crops.
Entire nations disappear if the sea rises	Perpetual retreat from the coasts
Failure of agricultural systems	Water security and insecurity
Unspecified climate change and related risks and impacts on human systems	
A crisis that is directly attributed to climate change	Crisis scenario
Catastrophe	Crisis years
Catastrophic events	Environmental catastrophe
Catastrophic impacts	Not sure it will be internationally catastrophic
Climate-driven catastrophes	Unforeseen crisis
Crisis	

According to the IPCC (IPCC 2018c), human systems are any system in which human organizations and institutions play a major role. The IPCC gives the examples of food production, livelihoods, health and economics (see Figure 2-3 in Section 2.2.2). The IPCC does not define physical or biological systems but does give examples. As such, the definitions for physical and biological systems were drafted by the author but include examples from the Fifth Assessment Report (see Table 7-2). The theme of risk is also from the IPCC but impacts are defined by the author.

Table 7-2: Climate change risks and impacts related themes. Source: Author, IPCC 2018c, IPCC 2014a.

Theme	Definition
Risk	The potential for adverse consequences where something of value is at stake and where the occurrence and degree of an outcome is uncertain.*
Impact	Effects on natural and human systems.^
Physical systems	Any system in which physical processes play a major role.^ This includes glaciers snow, ice, permafrost, rivers lakes, floods, drought, coastal erosion, and sea level effects.~
Biological systems	Any system in which organisms play a major role.^ This includes terrestrial ecosystems, wildfire and marine ecosystems.~
Human systems	Any system in which human organizations and institutions play a major role.* This includes food production, livelihoods, health and economics.~

* Definition from the IPCC 1.5 Degree Report Glossary (IPCC 2018c)
^ Definition by the author
~ Examples from the Fifth Assessment Report

7.2.1 Climate sensitivity

Climate sensitivity is very important as it regards the extent to which the accumulation of greenhouse gases in the atmosphere will result in climate changes. As such, climate sensitivity influences the scale of climate change and related hazards that people will need to deal with for a given concentration of greenhouse gases. In a scenario where climate sensitivity is lower than expected, Respondent 12 stated climate “changes will not be as fast as expected” hence “from a political point of view, that's good, because we… have a better chance of organizing.” Respondent 6 was less optimistic when it comes to climate sensitivity. After providing a couple of success scenarios, Respondent 6 stated “both [success scenarios] need to be qualified by the fact, they assume climate sensitivity is kind of what people think it is. Our bet would be climate sensitivity is far higher than people think it is… We think people are massively overestimating how much we understand about the climate system and the feedbacks”.

7.2.2 Climate change impacts and risks

From the sample of possible futures, there’s a broad range of climate change scenarios including scenarios with low climate sensitivity through to scenarios with “fast” climate feedbacks. There are scenarios that are benign and scenarios involving other disasters, crises or catastrophes that could influence climate or the global response to climate change.

Impacts and risks presented by respondents tended to be illustrative and less detailed than IPCC assessments of impacts and risks (see Figure 2-3 and Figure 2-6 in Chapter 2). Respondents tended to mention specific impacts and risks for the purposes of illustration. For example, Respondent 9 stated “One scenario would be that in the next few years we experience what we are already are experiencing, bigger hurricanes, sea level rise that effects people, et cetera..." The point is that something happens that could generate some sort of response.

The clearest exception was Respondent 9, who stated that the current level of global warming "has already set us on a track to many meters of sea level rise" Respondent 9 then focused on directly related risks, including for example "sea level rise happens at a rate that is slow enough for our political and social economic systems to adapt to" or "In the worst case scenario, the rise is going to happen too quickly to avoid large swathes of our population are losing their properties and their livelihoods."

In many scenarios the source of the impact or risk was unspecified, except to say climate change related impacts constitute a "disaster", "emergency" or "catastrophe". For example, Respondent 10 stated "... pressure and disasters influences [policy maker] decisions more than… anything." without giving further context on what such disasters might include. Respondent 13 gave scenarios where a "global emergency" related to climate change was a basis for an international response but the nature of the emergency was not specified. Respondent 14 stated "if there's some catastrophic, a series of certain catastrophic events" then there could be a response. Meanwhile, Respondent 8 mused "I wonder about if there is a major environmental catastrophe that somehow triggers people's consciousness to that we really need to change." Again, the nature of the catastrophe is not specified beyond being environmental. At a minimum, terms such as "disaster", "emergency", "crisis" or "catastrophe" indicate climate change is impacting human and managed systems, and hence the interests of actors.

From the sample of possible futures, some scenarios included "tipping points" and "fast feedback". For example, Respondent 20 noted "something could happen as a combination of positive feedbacks, where we have a massive rapid warming… fast feedbacks" and highlighted "one thing is a major concern is the release of a lot of CO_2 and methane from the melting permafrost in the Northern Hemisphere." Meanwhile, Respondent 2 noted with regards to climate change and related impacts "we don't understand whether these are straight line in effect [or] whether [there are] tipping points." In a failure scenario, Respondent 9 stated, "The questions are: will climate hit some tipping point so we can't recover from?" Our ecosystems aren't able to adapt." Specific examples including GHG release due to permafrost melting (Respondents 21, 20, 17), changing ocean currents (Respondent 15), ice sheets melting (Respondent 15) disruption to the monsoon (Respondent 6), methane hydrate release (Respondent 17). These concerns are consistent with issues raised by the IPCC in its Fifth Assessment Report which consisted of Atlantic MOC collapse, ice sheet collapse, permafrost carbon release, clathrate methane release, tropical forests dieback, boreal forests dieback, disappearance of summer Arctic sea ice, long-term droughts, Monsoonal circulation (see Table 2-2 in Section 2.2.3). The IPCC noted a great deal of uncertainty around these possibilities (Collins et al. 2013).

The extent to which future climate impacts might be a problem differed across scenarios. For example, Respondent 15 stated “Climate change is real. It's gonna be a significant problem by the end of the century according to the UN. We're probably talking about an impact that's equivalent to about 2 to 4% of GDP. So, it's the equivalent of each person, on average, on the planet being 2 to 4% less well-off by the end of the century.” The respondent also noted, “Overall and in the long run, global warming will be predominated by bad things which is why it's a problem. But, actually, right now, there's probably about equal good and bad stuff happening with global warming.” Interestingly, Respondent 15 also provided a scenario involving tipping points, acknowledging the possibility of changes that would presumably be outside the loss of economic activity estimates discussed.

Other respondents were less sanguine, for example Respondent 2 noted that a worst-case business as usual scenario “takes us into the world of four degrees plus against pre-industrial... Why is that our worst-case scenario? Because we don't actually know what will happen.”

Several scenarios highlighted impacts and risks to specific areas of the world. For example, Respondent 14 noted “There's certainly going to be places in the world where it won't be much fun to live and where food security is going to diminish significantly. The issue of food security and water security is going to flow on from these, the international issues around national borders and conflict between states over resources.” Likewise, Respondent 25 stated, “If you're in Northern-Eastern US or Central Canada or… New Zealand, you're probably fine. Africa is a disaster... it gets worse and worse, mass famine, immigration, refugees. Bangladesh ceases to be a viable country. The whole Nile river delta is under water… China coastal plain. There are hundreds and millions of refugees wandering around.” Respondent 24 noted “Look at the United States. We are facing some pretty hefty impacts of climate change increasingly attributable to climate change” suggesting the USA is also exposed and vulnerable to climate change.

It is important to note, the IPCC also mapped impacts and risks around the world in broad terms for its Fifth Assessment report (see Figure 2-3 and Figure 2-6 from Chapter 2) and have addressed reasons for concern from the Third Assessment Report through to the 1.5 Degree Special Report (see Figure 2-7 from Section 2.2.3). The impacts and risks highlighted by respondents are consistent with the IPCCs assessments although the language used by respondents to describe scenarios was a lot less formal, given the nature of a semi-structured interview.

7.2.3 Responses to impacts and risks to human and managed systems

From the sample of possible futures, only 25 scenarios indicated physical climate change drivers for a response. All 25 of these response scenarios involved impacts and risks to human and managed systems. This strongly suggests impacts and risks to natural systems (i.e. physical and biological systems) will have very little influence on the global response to climate change, while impacts and risks to human and managed systems will have a much stronger influence on the global response to climate change. Even the respondents that lamented the lack of a global response to date given evidence of climate change, only gave success scenarios where the global response is driven by impacts or risks to human and managed systems. This may be due to the study being focused on “what would happen” (i.e. scenarios) rather than “what should happen” (i.e. ethics).

7.2.4 Responses and the distribution of impacts, risks and power

The distribution of impacts was highlighted in several scenarios. For example, when it comes to climate change impacts, Respondent 8 suggested it could take “lots of local ones around the world to collectively trigger a change”, the premise being local impacts are more likely to influence people’s perceptions of climate change, and hence, it would take lots of local impacts around the world to create an effective global response.

In some scenarios, the distribution of impacts and risks were presented in the context of geopolitical power. For example, Respondent 14 stated that for impacts to influence that global response they would have to impact “nation states bigger than Tuvalu.” because “They've been pleading for action for a while, and have got very strong basis for the plea, but, you can, very easy to dismiss frankly, internationally.” The situation for powerful countries might be very different. For example, Respondent 7 put forward a stringent enforced climate agreement scenario, where “some as yet an unforeseen crisis” related to climate change affected a powerful state. This resulted in a situation where the agreement is “enforced by a group” described by the respondent as an “elite over a minority” and “that elite could be a China over diminishing Western World.” The Respondent also noted “power is the exhibition of authority, and authority allows you to maintain what you've got and increase [what you’ve got]” i.e. defend and pursue one’s interests. As such, the influence climate change and related impacts might have on the global response to climate change depends at least in part, on the power and influence of the actors being impacted.

In addition to the distribution of impacts across states, some respondents and scenarios included the distribution of impacts across wealthy and poor people. With regards to climate change impacts due to sea level rise, Respondent 20 stated “it will probably only have true political ramifications when it starts to impact wealthier parts of the community”. The respondent also noted “we already know that people that are wealthy and better educated, especially those people on the coast are very forceful in advocating for public money to be spent on coastal defences for example, like sea walls and installing pump stations and those sorts of things. Whereas people who are less educated and poorer are not very good advocates for themselves as far as that is concerned.”

7.3 Responsiveness and preconditions for effective responses

From the thematic analysis, the timeliness and scale of the global response were highlighted by respondents as being important for an effective global response to climate change. Together, these characteristics constitute responsiveness, i.e. the extent to which human actions, or inactions, are timely and of sufficient scale to fulfil the UNFCCC objective.

7.3.1 Timeliness

Timeliness refers to the extent to which the global response to climate change is happening quickly enough to achieve the UNFCCC objective without calamity or the need for extreme interventions. In this regards, Respondent 2 noted “The challenge is not to agree to do something, it's to do it and the pace at which you do it.” In total, 17 scenarios from the sample of possible futures directly addressed the timeliness of the global response to climate change. This included 3 branching success or failure scenarios, 9 success scenarios, and 4 failure scenarios.

The need to respond at scale between now and 2030, or even 2025, was highlighted in scenarios as being critical (Respondents 26, 13 and 9) when it came to global responses that appeared to rely on mitigation of greenhouse gas emissions. Respondent 6 noted “2025 it's critical because, you know, the trajectories you set in 2025 towards 2035 and 2040 pretty much determine if you're gonna get… anywhere near two and a half [degrees] [or] at 1.5 or well below two [degrees]”. Meanwhile, 2023 was identified by Respondent 13 as being important for the voluntary submission of revised NDCs. Respondent 9 suggested the same thing but by 2025. These scenarios follow a path similar to the IPCCs (2018a) “stabilises at or below 1.5°C”, although the level of warming could be higher. The period between 2020 and 2030 was also identified as being very important in the IPCC 1.5 Degree Report (IPCC 2018a).

Respondent 18 put forward a scenario where greenhouse gas emissions are mitigated in the second half of the century and greenhouse gas removals are used around the end of the century to lower atmospheric concentrations of greenhouse gases (see Figure 5-5 in Section 5.3.1). Respondent 18’s scenario involved overshoot and drawdown, a much more extreme version of the IPCC’s “temporarily exceeding 1.5 °C and returning path”. Overshoot and drawdown scenarios come with the risk that climate changes might not be reversable if feedbacks or tipping points are breached.

7.3.2 Scale

Scale refers to the size of the response with respect to the size of the problem and what needs to be done. Respondent 27 noted “the scale of the problem seems to be substantial”. Along the same lines, Respondent 18 noted, “We're starting, we're already experiencing impacts of climate change associated with roughly 1°C warming, and those impacts are growing in scale and in frequency and across sectors like agriculture, coastal areas, health.” The scale of impacts might trigger or drive responses, for example Respondent 14 suggested “Particularly the ocean current [impact] which, because it's a very clear cause and effect there, that would galvanize action in Europe on a very large scale” referring to the possibility that the Atlantic Meridional Overturning Circulation (MOC) current could slow or stop altogether, leading to rapid cooling in Europe (see Table 2-2 in Section 2.2.3).

The scale of GHG emissions mitigation and GHG removals are related. For example, Respondent 24 noted “50, 60 gigatons which is where we're heading now of carbon [removals] per annum is impossible. So, we will have to do the number one priority which we need to do anyway which is reduction of emissions, yes, to zero. Initially, to net zero and hopefully eventually to zero.” As such, mitigation (i.e. reduction of emissions) is related to the scale and viability of GHG removals. This is consistent with the IPCCs findings (Section 2.3).

Given the scale of the problem including quantities of GHGs in the atmosphere, Respondent 27 noted “large scale carbon dioxide removal… is gonna have to be part of the mix” of actions in response to climate change. Respondent 14 noted “It's a few years since I stopped following greenhouse gas removal technology, but the ones that I was familiar with, all seemed to use an awful lot of energy. And I… know nothing to make me optimistic that this could be done on a grand scale.” Respondent 23 noted “I have been following this, maybe more than most co-participants. I think it is delusional, to think that it can be done at the scale that is needed. I mean, it's technologically possible, of course, but the amount of energy that needs to go into this, the amount of, where do you stuff the carbon once you've sucked it from the atmosphere and so on?”

Highlighting the relationship between timing and scale, Respondent 24 noted “the longer we wait with deployment of CDR, the more challenges that might arise. Because they will take a long time…to bring these technologies to scale would require years and decades. So, let's get going as soon as possible”. Respondent 18 suggested, that it may be “more towards the end of the century [that we] would really have the scale of investments in carbon removal that we need.”

Respondent 18 also noted “one scenario, and the most plausible in my mind is that happens after 2100, because I think, in reality it'll probably take that long before we've gotten serious enough about the policy action and had all the investment and the technologies in manufacturing at scale so that it's more easily economic, and more easily, can direct the capital needed. But dramatic impacts up until that point, until we get stabilization” As such, Respondent 18 identified preconditions for stabilisation of atmospheric concentrations of GHGs as being “dramatic impacts”, “investment”, “technologies” and “manufacturing at scale”, and GHG removal technologies being “economic”.

With regards to afforestation and GHG removals by trees, Respondent 3 noted “It’s around tenure and it’s around shifting in incentives. You know, let’s do that in a scaled-up way.” Taking into account land use for removals, Respondent 6 noted “So, you can only see [greenhouse gas removals] really working [at the] global scale under very high cooperation scenario because there's likely to be a need for quite significant transfers especially if you expect the value of farmland to go up.”

Respondent 9 highlighted the need for scale when it comes to adaptation and mitigation, and stated “We could all but see the, you know, large companies, philanthropists, people who have access to real finance, view, or have climate change become more of their priority and they start financing climate adaptation, mitigation projects on a large scale.” Respondent 9 also addressed the scale of resilience and adaptation when it comes to food production, and stated, “food production wise, I think we have a lot of experience in terms of large scale food production in certain places that can be applied to others and we have drought resistant crops et cetera that are more able to cope with our changing climate that [if] shared more widely could mean food security for more people around the world and again in a best case scenario nations would work together to utilize these technologies to everyone's benefit.”

Respondent 9 also addressed the scale of behavioural change, noting “We could see large scale change on the household level where people are eating less meat and having more carbon neutral lifestyle, fuels like prosperity of kind of a green economy that trickle down to the household level. [It] could be a bright new world [laugh]”. Along the same lines, Respondent 6 highlighted the possibility of “EVs taking off [on] a massive scale” or “the technology around fake meat taking off at very significant [scale]”.

7.4 Response triggers and drivers

The theme “triggers and drivers” was identified during the analysis of scenarios. Triggers and drivers refers to things that create or sustain reactions (Section 7.4.2), or non-reactions (Section 7.4.1), to climate change and its impacts. With the issues of timing and scale from Section 7.3 mind, an important question is when might actors respond to climate change and related impacts? Triggers and drivers can help address this question.

7.4.1 No trigger response – driven by other interests

Cynical and non-responses are no trigger responses, where climate change impacts and risks are not considered in decisions. In such scenarios, other actors need to do more to limit climate change and its impacts, compensating for deliberate and incidental negative contributions to the global response from cynical actors and non-response actors respectively. Presumably if climate change and related impacts get sufficiently severe, then the triggers and drivers for cynical and non-response actors might change, for example discovering some ambition and taking action due to impacts or an emergency.

Table 7-3: No trigger responses and related definitions.

Theme	Definition
Cynical response	Action based on self-interest, disregarding evidence on climate change and related issues, making negative contributions to the global response to climate change.
Non-response with negative incidental contributions	Human actions, and inaction, that affect the climate, where decisions to act are made for reasons other than climate change or related impacts. In this case, incidental contributions to the global response to climate change are unhelpful, for example reducing climate resilience or increasing atmospheric concentrations of greenhouse gases.
Non-response with positive incidental contributions	Human actions, and inaction, that affect the climate, where decisions to act are made for reasons other than climate change or related impacts. In this case, incidental contributions to the global response to climate change happen to be helpful, for example increasing climate resilience or limiting atmospheric concentrations of greenhouse gases.
Apathetic or hopeless response	A lack of interest, ambition or concern[14] for climate change and related issues or despair regarding the possibility of addressing climate change.
Hypocritical response	Human actions or inaction that affect the climate or the global response, by an actor that has expressed concern about the very same actions or inaction.

[14] Adapted from the Oxford Dictionary definition for “apathy” which is “Lack of interest, enthusiasm, or concern.” In the context of the global response to climate change, the word ambition substitutes for enthusiasm.

No trigger responses identified from the sample of possible futures (Table 7-3), consist of cynical responses (Section 7.4.1.1), non-responses with negative incidental contributions to the global response to climate change (Section 7.4.1.2), non-responses with positive incidental contributions (Section 7.4.1.3) apathetic or hopeless responses (Section 7.4.1.4), and hypocritical responses (Section 7.4.1.5).

7.4.1.1 Cynical response

Epitomising the cynical response, Respondent 6 provided a scenario where “there's gonna be a fundamental push… promoting fossil fuels using coal, and the kind of you know incumbents climate denial type scenario.” Furthermore, incumbents could “use that as a kind of organ of state craft.” Such an attitude has no trigger for a response to climate change, but instead there are deliberate negative contributions to the global response to climate change.

7.4.1.2 Non-response with negative incidental contributions

The non-response theme was identified when Respondent 1 stated “it will be exogenous factors… that drive that” referring to the global response to climate change. As such, climate change is not a consideration in this scenario, yet these exogenous factors are driving the global response to climate change. Like cynical responses, this is a no-trigger response, but it is possible there could be incidental positive contributions to the global response to climate change, although given the current situation with regards to technologies and practices, it would seem more likely that there will be negative contributions to the global response to climate change overall.

The lack of a global response to climate change was highlighted in many responses as being the reason climate change is a problem and as such, non-response with negative contributions was identified as being an underlying theme. As noted by Respondent 5, “We had the science, there and then, to say that [is] the level of problem and… we need to take action. If not to take action, those are the consequences we'll be facing”.

7.4.1.3 Non-response with positive incidental contributions

In the scenario provided by Respondent 1, non-response makes a positive contribution to the global response to climate change because “climate change now is just so embedded in the green economy, everyday policies and practices” and “actors don't necessarily care about climate change. I mean, it's just... This is what businesses do. This is... how we make money these days. This is the latest things that we all want to do if we want to get funded.” As such, actors are making a positive contribution to the global response to climate change but for reasons other than climate change.

7.4.1.4 Apathetic and hopeless response

Apathy and hopelessness are variants of non-responses, highlighting underlying attitudes. Apathy refers to a lack of interest, ambition or concern[14] for climate change and related issues, meanwhile hopelessness refers to despair regarding the possibility of addressing climate change. Respondent 9 stated, “further catastrophe would have probably the effect of fuelling more and inaction because then you reach a point, if you do reach a tipping point then it's even more difficult to fix the problem. So, you might even get more apathy to act where nations have said it's too late and the problems are too great.” Hence there is non-response due to an attitude of apathy. Meanwhile, Respondent 14 noted that some very large release of greenhouse gases from the environment “sort of introduces a hopelessness at an individual or societal level which is not particularly helpful.” Respondent 14 also noted that a tipping point might also end up with a non-response and attitude of “hopelessness”.

7.4.1.5 Hypocritical response

The hypocritical response was not explicitly stated, but rather was derived from something Respondent 23 said while being interviewed at the climate negotiations in Katowice, specifically, “the key actors is us who produce fossil… fuel emissions. You have a car, I have a car, I have a heating system, I travel, I fly we all do that. And, of course, we don't make those decisions totally irrespective of society. …if everybody goes to the Bahamas for holidays then why should I not go. Right?” Given the context of the response, it highlighted the conflict between expectations, consumptive behaviours and climate concerns. Another important reason for including hypocritical response as a category, was because cynical response was already in the list and it seemed hypocritical to omit hypocritical responses, given that most of the author’s contributions to the global response are hypocritical.

7.4.2 Trigger responses – driven by climate change and other factors

Trigger responses involve decisions and actions based at least in part on climate change or related impacts. The scale and timeliness of responses depends in part on triggers that initiate a response, and drivers that sustain a response, including the urgency and ambition that come with particular responses.

Trigger responses identified from the sample of possible futures (Table 7-4) consist of impact responses (Section 7.4.2.1), risk responses (Section 7.4.2.2), emergency responses (Section 7.4.2.3), enlightened responses (Section 7.4.2.4) and cooperation response (Section 7.4.2.5).

Table 7-4: Trigger responses and related definitions.

Theme	Definition
Impact response	Actions, or inaction, where climate change and related effects on physical, biological or human systems are a factor in the decision to act or not.
Risk response	Actions, or inaction, where the potential for climate change and related effects on physical, biological or human systems are a factor in the decision to act or not.
Emergency response	Emergency response is an urgent reaction to climate change and related impacts or risks.
Enlightened response	Enlightened responses come about from awareness that creates change. Enlightened responses can be driven by awareness of climate change and related impacts and risks as well as awareness of other things not directly related to climate change, for example the value of international cooperation.
Cooperation response	International cooperation on other issues leads to a realisation that international cooperation could help limit climate change and its impacts.

7.4.2.1 Impact responses

20 impact response scenarios were identified from the sample of possible futures. Impact responses are actions, or inaction, where climate change and related effects on physical, biological or human systems are a factor in the decision to act or not. For example, Respondent 8 wondered if a major environmental catastrophe could trigger people's consciousness about the need for change (Section 7.2.2). Meanwhile Respondent 3 stated "I guess what drives progressive action is social acceptability of climate action and what drives that, series of very high impact events". With regards to creating a global response, Respondent 21 stated, "I think it would probably end up having to be some extreme event happening to businesses." For example, "Some shock to the stock exchange that was clearly due to climate change. So, something happened and it wipes a bunch of, you know, companies profit zone."

Given the limited time available for effective mitigation responses without GHG removals, some fairly significant impacts would need to be experienced very soon if there is to be a timely mitigation response. Interestingly, Respondent 6 highlighted "A double bread-basket failure type event." and stated "We kinda expect to see one of those before 2025..." However, one of the problems of impact responses is that the hazards generating the impacts being experienced are likely to be locked in and further changes in the distribution of hazards experienced are also very likely to be locked in as well due to inertia (Steffen 2012). Adaptation will be required and GHG removals may also be required.

7.4.2.2 Risk responses

Risk responses are actions, or inaction, where the potential for climate change and related effects on physical, biological or human systems are a factor in the decision to act or not. For example, Respondent 9 put forward a hyperbolic success scenario where there is a global response because "the scientific community says we really can't afford not to act. We are very sure that we'll reach a tipping point in 20 years and you have to… decrease emissions or we are all going die." Other risk response scenarios were less extreme, including for example a scenario that Respondent 6 referred to as a "risk-rules based scenario" where actors respond to risks.

Risk responses are based on expectations about the future including for example fears. In this regards, Respondent 14 noted "people in the society have to be scared. There has to be some fear to drive change. They've got to be scared of losing property, losing food. Not necessarily an immediate … it's got to move the level of understanding, concern has to notch up quite a bit". There is a question as to whether risk response scenarios relying on "fear" can drive attitudes that are cooperative rather than defensive (Section 7.5.1.1).

Respondent 5 put forward a scenario where there is a "massive campaign on informing people… on the climate issues to be sensitive because each individual… person has to act." The respondent gave an analogous example of advertising the risks of cigarettes, and noted that despite the wealth of the industry, people have been informed of the risks of smoking cigarettes and "many people have stopped smoking.” Such a campaign would have to be initiated very soon if it was to lead to a timely risk response.

Risk responses react to potential impacts before they happen and as such risk responses, at face value, appear more timely than impact responses. However, this statement does not take into account costs or the effectiveness of responses, or the possibility of new technologies being developed that could help with the global response later. Another tricky issue raised by Respondent 15 is that “you can always, for any policy, make up very low probability scenarios and say, ‘Give me all your money’” but at the same time, “we have no idea of how much our policies will… change that probability”.

7.4.2.3 Emergency response

An emergency response is an urgent reaction to climate change and related impacts or risks. Respondent 13 provided a scenario where climate change and related impacts constitute a “global emergency” and noted the possibility of “emergency powers” or “emergency planning” being used to address climate change. Respondent 25 noted the possibility of responsibilities for climate change being “handed… to the emergency services”. The differentiating characteristics of an emergency response are urgency and ambition. Emergency responses could be risk responses or perhaps more likely, impact responses.

Respondent 6 noted “there's no way it’s a cost-benefit analysis issue that they [will] do anything. The numbers are not big enough in a cost benefit world where everything is fungible. The only way you deal with it is if things go fundamental[ly] economic, or national security, and your ability to maintain stability internally or on your borders.” As such, Respondent 6 made a clear distinction between the effectiveness of responses based on a cost benefit criteria, compared to responses where climate change is treated as either a fundamental economic or national security issue. In short, an impact or risk response relying on cost benefit analyses are unlikely to sufficient, but an emergency response might be able to generate responses of sufficient scale to limit climate change and its impacts.

7.4.2.4 Enlightened response

Respondent 26 stated, “basically you would need a flash of genius, awareness, enlightenment across all societies.” and then “there's radical transformation and then, everybody just goes, ‘Yeah, that's, we're all going to pull in the same direction.’”

Respondent 23 offered three enlightenment scenarios. For example, Respondent 23 noted, “It sounds like science fiction, but I really think that there needs to be reckoning. I think we need to get sufficiently close to the edge of our humanity” before we “recognize that we need to work together to help each other.” In the second scenario, Respondent 23 stated that if the global response succeeds in fulfilling the UNFCCC objective, “it's likely that we get there not because of our own climate people doing, but because of a broader cultural change in planetary forces.” The respondent also noted that “if we don't care about the planet, we're unlikely to care about people.” And in a third scenarios, Respondent 23 quoted Saleemul Huq who said "Slavery did not end because it became uneconomical or because, you know, certain new technology. It was also very centrally an embrace of a moral imperative." Respondent 23 went on to say "until we recognize that there needs to be a sense of justice, a sense of humanity as a driving force, if we continue to aspire to have economics or policy or regulations as the thing that takes care of our global atmosphere, I think we're going to continue to be too slow." It should be noted that it is debated whether slavery was ended due to a moral imperative, for economic or other reasons, or a combination of reasons (Engerman 1986). However, a moral imperative was at a minimum an influence.

Respondent 8 focused on enlightened leadership, and suggested, "maybe we have a huge change in global leadership somehow and people's mentalities change, and their priorities." Related to the theme of enlightened response is the cooperation response.

7.4.2.5 Cooperation response (e.g. due to a pandemic)

Cooperation driven responses refers to responses to climate change driven by a realisation that international cooperation is useful and can be used to limit climate change and its impacts. In the case of cooperation driven responses, the decision to respond to climate change comes about because of some crisis, catastrophe or disaster, such as a global pandemic that gets people thinking about climate change as well. For example, Respondent 22 gave a scenario where the global response to a pandemic could "demonstrate the value of global cooperation" and this "may enhance global cooperation to deal with it." referring to climate change.

7.5 Response attitudes and inclinations

Response attitudes and inclinations refers to ways of thinking about climate change and related issues, including predispositions influencing options considered and actions taken. Response attitudes and inclinations identified from the sample of possible futures consisted of cooperative responses, competitive responses, technological responses and defensive responses.

7.5.1.1 Defensive versus cooperative

Defensive responses are reactions to climate change where actors attempt to preserve what they have and limit loss and damage. Meanwhile, cooperative responses are reactions where actors work together to address climate change and related impacts.

In two different scenarios, defensive and cooperative responses are shown as branching options. For example, Respondent 6 put forward a scenario where there is "a big fuck off event, climate-driven event" and noted "There's a real question though whether that would drive defensive... or actually more cooperation". Likewise, in a scenario involving a spike in GHGs releases from permafrost, Respondent 21 noted this could lead to people having the attitude of "let's start doing something about it together" or the attitude of "look after ourselves". Respondent 26 suggested there could be "emergency level global cooperation where everybody is on the same page" but then noted "It's not gonna happen. [laughter]".

With regards cooperative attitudes and inclinations, Respondent 21 stated “I think cooperation is always going to… be much more beneficial”. However, Respondent 1 noted that there has been a “top down” approach which focused too much on cooperation. Respondent 1 noted that governments have indicated “Just wait for us, we're going to cut the grand political scheme that we're all going to agree on and once we've got that grand political scheme, we'll be able to tell you what you need to do in terms of emissions reduction.” The Respondent noted “that's hugely inhibiting. I think it prevents innovation, encourages a kind of a slow gradual emissions decrease rather than thinking more creatively.” The time required to organise and agree to cooperate is an issue when it comes to timeliness. Issues of ambition, non-participation (e.g. withdrawal) and non-compliance (i.e. cheating) also mean cooperative attitude alone, may have trouble creating a global response of sufficient scale to address climate change.

With regards to defensive attitudes and inclinations, Respondent 6 noted that a crisis or catastrophe can drive people into security mode, and “The general thing that happens when people go into a security mode is they get short-termist, distrusting and [make] defensive investment[s] and so it's never good for anything long term or cooperative.”

Respondent 6 noted concerns around security can drive a defensive attitude and that a defensive response can lead to a situation that is “distrustful, populist, very much about we wanna keep our cake, we don't wanna share our cake with anybody else. Lots of walls. Lots of fences. Generally, quite unpleasant.” In a scenario involving the fragmentation of international cooperation, Respondent 21 noted “The response to that is to become much more defensive and trying to sort things out by yourself and your own region.”

Respondent 11 noted, “people with power, people who are in the defence industry, they want to present this as a security problem, not as a climate change problem.” The reason being, they “can build more aeroplanes and build bigger walls” and as such, “they make money out of that.” Respondent 11 also noted that when things get bad, that’s when people with the means might take a defensive attitude, for example, “when food is not available, or when temperatures become unbearable or when wealthy people are perceived to be protecting themselves behind high walls”. This might also happen at the national level according to Respondent 3 who put forward a scenario where “countries that are doing better… are seeking to retain that by building more insular sort of, you know… you get islands of wealth and… expanding areas of governments falling apart”. Defensive attitudes, at the cost of cooperation, could generate adaptive responses and building of resilience, but only for those individuals, groups or states that have resources to support this. A defensive attitude seems very unlikely to be able to generate an effective global response of any sort, but rather appears likely to generate a fragmented response, one that is unlikely to be timely or at sufficient scale.

7.5.1.2 Competitive

Competitive response attitudes or inclinations are visible where actors have expectations of some reward, which drives activities and engagement in technologies or practices that make a positive contribution to the global response.

Several scenarios included competitive attitudes, while several others highlighted how markets might be incentivised, driving a competitive response to climate change with positive contributions to the global response (i.e. as a co-benefit).

In a scenario featuring competition, Respondent 27 highlighted that a competitive attitude could include "[the] perception of first mover advantage", "natural one upmanship or one up personship" and "looking at what your competitors doing". Importantly, "competition is stimulated" by seeing "who can invest the most in a bunch of projects, because they're gonna make the most money in the future". Hence competition could influence and generate a coherent global response to climate change. Importantly, competitions creates "a race to the bottom of emissions ". In such a scenario, where a "winning team" is formed around a technology, including business and government, it is possible that "there's a magic moment… or there's just a tipping point, you know, in terms of the proliferation of clean tech and the other things."

Respondent 6 contrasted competition with cooperation noting "There is an alternative scenario… it gets us quite close to [the UNFCCC objective], which is perhaps less cooperative so more a slightly competitive" scenario with a "much stronger role for cities and companies".

From the scenarios, competitive attitudes hold potential to scale action that can make positive contributions to the global response, including for example technologies, but this depends on incentives structures. Conversely, a competitive attitude might even drive a cynical response and the scaling of GHG emitting or climate vulnerable technologies, business models or interventions.

7.5.1.3 Technological

From the sample of possible futures, a technological response attitude or inclination is where actors expect there are physical, chemical, or biological properties, related objects, knowledge and processes that can be used at will to solve the problem.

Respondent 24 noted "there are some people who believe that tomorrow there will be a technological miracle that will solve our problems". Similarly, Respondent 17 noted some people think "There must be a technical fix for everything, right?" As such, some actors seek technology based solutions to climate change.

With regards to timeliness, Respondent 15 noted the need to "dramatically increase… investment in research and development.", specifically in "the long shot things that'll actually work out over the next couple of decades." so that there are geoengineering and other options to address any unexpected climate changes such and feedbacks or tipping points.

With regards to feasibility of technological options, Respondent 21 noted “it seems to me that it would be simpler to try to scale negative emissions technologies, than it would be to rely on us all changing who we are, 'cause we know that it's very difficult for people to change.” However, while Respondent 21 claimed “I'm with the sort of technology optimists” the Respondent also noted “I think it can achieve a lot, but it's not gonna achieve the fundamental underlying changes that are required for us to stop worrying about you know, ecosystems and that sort of thing.”

7.6 Summary

The results presented in this chapter help address the question of what influence climate change might have on actors and the global response to climate change (Section 1.6). From Section 7.2 there are a range of possible impact and risk scenarios, and responses too. Section 7.3 highlighted the extent to which responses might be timely or at scale, essential characteristics of responsiveness. Meanwhile, Sections 7.4 and 7.5 showed there are a range of possible response triggers and drivers as well as response attitudes and inclinations, each of which influence the type of response and its likely effectiveness. As such, the influence climate change impacts and risks might have on the global response to climate change includes many possible combinations of scenarios requiring further analysis.

The themes from this chapter form a basis for the analysis in Chapter 12 and the development of a climate change signal response model in Section 12.2. Furthermore, the themes from this chapter also form a basis for the discussion in Chapter 13 regarding climate change signals (Section 13.5), as well as the influence of climate change on responses (Section 13.6).

Chapter 8 Actors and their interests

8.1 Introduction

From the searchable sample of possible futures, scenarios involving national interests and domestic responses to climate change were analysed, including broad categories of actors and the types of actions they might take. From Section 2.5.4, much of the global response to climate change happens at the domestic level by actors in States and the global response to climate change is assessed as the sum of responses by these actors. Actors featured in the sample of possible futures, including social, political and business actors each contributing to the global response through their behaviours, policies and economic activities respectively.

This chapter presents themes and scenarios related to social change and behaviour (Section 8.2), political will and policy (Section 8.3) as well as business and economic activity (Section 8.4). Section 8.5 summarises themes from this chapter and indicates where these themes are analysed further in Chapter 12.

8.2 Social change and behaviour

The overarching theme "social change and behaviour" addresses the interests of people, as individuals, households and communities, and the actions, or inactions, these people might individually or collectively take (Table 8-1). Illustrating the concept of social change, Respondent 23 suggested "there needs to be a sense of justice, a sense of humanity as a driving force" in society for there to be an effective global response to climate change. Respondent 6 noted the need for a "social contract". With regards to behaviour, Respondent 9 noted the impact of behaviours are small on an "individual scale, but large scale [if] everyone does them ".

From the sample of possible futures, social change and behaviour can help put the global response to climate change on path towards fulfilling the UNFCCC objective, for example in the case of enlightenment. Alternatively, social change and behaviour can keep the global response to climate change on path towards failure in the case of overconsumption or social unrest.

Table 8-1: Social change and behaviour themes with descriptions.

Theme	Definition
Social change	Social change refers to a shift in common values, norms and expectations that influence behaviours of individuals, households, groups and communities, businesses and governments within a society. In short, it's a shift in the way individuals and groups live together.
Behaviour	Actions, and inaction, by individuals and households. This includes purchasing choices as a consumer. This can also be thought of as the options taken or not taken by individuals and households.

Social change and behaviour related themes consist of: triggers and drivers (Section 8.2.1); leadership and policy driven social change (Section 8.2.2); enlightenment (Section 8.2.3); youth led social movements (Section 8.2.4); behavioural responses (Section 8.2.5); overconsumption (Section 8.2.6); social disruption (Section 8.2.7); inequity, exposure and vulnerability (Section 8.2.8); and, social contracts (Section 8.2.9).

8.2.1 Triggers and drivers of social change and behaviour

Based on the sample of possible futures, it is possible that social change and behaviour can be triggered or driven by impacts, risks, or enlightenment including cooperation responses. For example, Respondent 14 stated that if people are scared of climate risks, this will “get people to take individual action” and “get people to …drive full political action.” Respondent 5 provided a risk response driven social change and behaviour scenario involving a massive campaign informing people on climate change (Section 7.4.2.2). Respondent 9 noted, “I think there's more pain mainly for the lower classes before the upper classes, the power holders, are forced to change.” Similarly, Respondent 20 noted “it [i.e. climate change] will probably only have true political ramifications when it starts to impact wealthier parts of the community”, and “in a western essentially liberal society… it could still lead to political turmoil”.

At the same time, some things could undermine a response, for example, Respondent 3 noted that “there are all sorts of, you know, scandals that could emerge that could severely undermine the trust that everyone has within the system and the trust of science, the trust of whether actors are doing what they say they would do. A big scandal with, you know, an emission trading scheme”. Respondent 12 noted that “certain groups are claiming that it's gonna lose our islands” and “If you really look at the literature about SLR[15], there's still a lot of uncertainty about islands disappearing and we need to be careful around that so what if even if we're so-called runaway climate change, more than two degrees, you'll only lose a few islands”. In such a scenario, “that's not gonna be good with respect to the credibility of the groups who are using that narrative to drum up support for climate policy and action.”

8.2.2 Leadership and policy driven social change

Only 1 of the success scenarios involving social change and behaviour was not triggered or driven by climate change impacts or risks. Rather, it was a response to leadership, political will and policy. Respondent 21 noted it is possible that “someone comes in as a Democratic candidate that has more extreme views on a Green Deal” and once the policy is implement and people see “the benefits of when this gets put into place” then, “there's sort of a groundswell of the population which are actually on board that no longer see this as sort of a costly burden on the US economy but see the benefits that sort of green revolution can have.”

8.2.3 Enlightenment

In the previous chapter, Section 7.4.2.4 addressed enlightened responses to climate change. While an enlightened response may be part of a wider global shift, each state and set of domestic actors forming a society would have a slightly different enlightened response. For example, Respondent 26 noted that there could be a recognition that “there needs to be a change in how we live in society in terms of travel, how we eat”, “All businesses shareholders recognize that you know, you can't get your pension or your investment returns from things that are contributing to climate change.", and “There is a recognition that

[15] SLR = Sea Level Rise

there needs to be some redistribution of wealth". As a result, "there's radical transformation" because "everybody just goes, 'Yeah, we're all going to pull in the same direction.'"

8.2.4 Youth led movement (social change)

The possibility of youth led social change was featured, for example in the branching success or failure scenario from Respondent 23. In this scenario "The generation of our children is going to not give a damn what is expected of them" and they will "take what they want by taking it." This could result in overconsumption due to a competitive attitude of "I want to succeed and have, you know, the most expensive vehicle". Alternatively, this could lead to "socially-oriented youth, becoming a force of nature" and a "radical collective transformation for the wellbeing of people and planet."

Likewise, Respondent 18 put forward a scenario where "there's really widespread public mobilization throughout all countries to act in a much more urgent and ambitious way than is happening now". And Respondent 25 suggested that it is possible "Enough people in the United States, perhaps UK, and Brazil, South Africa, India, young people, hopefully, of my kids' generation… just say, 'You guys have made a big fucking mess, get out of the way we're taking over and this is what we're gonna do.'"

8.2.5 Behavioural responses

A range of possible behavioural responses were highlighted that could make a positive contribution to the global response to climate change. For example, Respondent 18 noted behaviours individuals and groups could take including, "personal responsibility for the actions that we take", "demand accountability from their leaders, both political leaders and business leaders" and "responsibility to speak through voting." Likewise, Respondent 8 had a scenario where there is "a shift from a lot of consumption to reducing general consumption and being more conscious about what people purchase..." From Section 8.2, Respondent 9 noted that large scale changes can happen if everyone changes their behaviour. Respondent 9 also suggested behavioural changes "like eating less meat and [heat] saving or having more energy efficient products in our lives, having better, and using more sustainable transit options, or divesting their finance." And from Section 7.3.2, Respondent 9 noted the possibility that philanthropists and large companies could start financing adaptation and mitigation at scale.

Respondent 8 noted for there to be changes in consumption there needs to be "a confidence [in]… technologies to replace fossil fuels and things like that". Respondent 8 also highlighted that "we need… consumption signalling… a change." to businesses. Respondent 18 included a range of roles for individuals and households, civil society, business in a successful global response scenario (Table 8-2).

Table 8-2: Behavioural responses including actors, roles and actions. Source: Author and Respondent 18.

Actors	Responses (roles and actions)
Individuals and households	“personal responsibility for the actions that we take.”
	“a critical role for educating people, for people to motivate and inspire each other”
	“speak through voting.”
	“demand accountability from their leaders, both political leaders and business leaders.”
Civil society	“educate themselves.”
	“hold their politicians accountable”
	“hold the business community accountable through their investments, through liability and through their purchase decisions.”
Business and economy	“a huge shift towards purchasing based on carbon impacts and carbon leadership associated with products and services.”
Source: Author	*Source: Respondent 18*

Respondent 15 doubted it is possible to have a global response to climate change at scale coming from social change and behaviour. Respondent 15 noted “Look, there's a lot of small things that can have a tiny impact.” including virtuous things such as switching “off the light” or having “short showers”. The respondent noted “there is a tendency for people to also believe that "Oh, now I've done something virtuous. Now, I'm also allowed to do something wicked.” which undoes the benefit of the virtuous act. The respondent also noted if money is saved by these virtuous behaviours “I'm gonna use that for something else which is also going to emit CO_2.” Hence, the “rebound” effect discussed in economic literature. The respondent stated, “the fundamental point is that even if you manage to get people really concerned or really focused on this, the amount of impact from a personal choice is going to be fairly small... So, fundamentally this is not about changing behaviour… society shouldn't… have to worry about all kinds of things.”

However, Respondents 6 and 26 provided a list of behaviour and related scenarios that might contribute to effective global responses to climate change (Table 8-3).

Table 8-3: Possible behaviour related scenarios. Source: Author, Respondent 6 and Respondent 26.

Themes	Quotes
Behaviour, technology	“EVs taking off [on] a massive scale”*
Social change, behaviour	“big shifts in consumer preferences”*
Behaviour, technology	“the technology around fake meat taking off at very significant [scale]”*
Social change, behaviour	“so, a large youth based social movements around diet.”*
Leadership, political will and policy	“I'll say, kind of, cities really taking a lead, for multiple reasons, to drive development and deployment of new technology”*
Social change, political will and policy	“Trump doesn't get elected and then [laughs]” and “America re-joins”^
Social change, political will and policy	“they listen to the young.”^
Legal precedent	“There's been two or three litigation cases with children or young people holding to account their governments and businesses”^
Social change, political will and policy	“there's been a recognition that the climate justice movement is right”^
Social change, political will and policy	“there's been a recognition that… the rights of Mother Nature needs to be respected as well”^
Enlightenment	“we become much more aware of our interconnection with global ecosystems”^
Source: Author	*Sources: * Respondent 6, ^ Respondent 26*

8.2.6 Overconsumption

Not all social changes or behaviours in the sample of possible futures were positive. For example, a couple of respondents (5 and 21) expressed concern on issues of consumption. Respondent 5 noted "...there's no discussion on over-consumption..." or "overproduction" and highlighted that “overconsumption has not been addressed or discussed over the UNFCCC” and has “not been given any prominent role in the SDGs”. The respondent noted that overconsumption is considered a "good thing for society" as it drives economic activity, while the only "bad thing is poverty". Respondent 5 also expressed concern around China's "over-consumption" following the patterns of Western countries before them. Respondent 21 expressed concern about consumption in "Asian countries" noting that a successful scenario would include these countries “skipping or jumping ahead..." and consumption trends taking "...a slightly different direction “ from the West.

In Section 8.2.5, Respondent 8 noted the possibility of a behavioural response where consumption is reduced but also noted that society needs to be confident that substitute technologies will provide the same utility. Meanwhile, Respondent 11 noted “it's hard to resolve the amount of consumption, and the consumption, kind of, is related to our economic utilization of resources, which is related to climate change. Can we change our thinking about that without a more profound sort of spiritual change?”

8.2.7 Social disruption

In a situation where there is food insecurity and wealthy individuals and households are defending themselves and their property, Respondent 11 stated “then you see that turning into social disruption.”, and “I think that that could happen in our cities. That could happen in different places”. Likewise, Respondent 24 put forward a scenario where “the economic costs and therefore the hardship on people is substantial and as these extreme events will increase… at some point… worst case scenario, I think governments will break down.” Respondent 11 also noted “the people who are feeling the pain are not the ones that have the power.” Hence “there's more pain mainly for the lower classes before the upper classes, the power holders, are forced to change.”

8.2.8 Inequity, exposure and vulnerability

In a sea level rise scenario where there is insurance and public service withdrawal from coastal areas, Respondent 20 noted “more wealthy people can just avoid the problem by moving out”, meanwhile, “people who are owner-occupiers of their coastal properties, maybe left behind and in fact, precisely because house prices, the value of coastal properties will decrease. People who don't have much money may actually go to these areas… because they are now affordable to them.” Furthermore, it is possible that “perversely we actually might increase the hazards on the coast because of the stratification” “because of market forces and people are going to where there is affordable housing even if the housing is in potentially a hazardous area”. Likewise, Respondent 10 noted, there could be a scenario where, “Maybe some places they're better adapted than others.”

8.2.9 Social contracts

Respondent 24 noted that "there are pathways that are feasible, but it requires a kind of social contract of the global level that we just simply don't have." This social contract needs to acknowledge that "... We do need economic development… we do need to figure out our problems, we do need to have jobs for people all of that is a reality. Now, I know that [at] the theoretical level it is totally possible to do that."

Linking social change and behaviour with political will and policy as well as business and economic activity, Respondent 6 stated, "it's critical to have a clear social contract on the transition, which is… a clear sense of agreement between the population and government and affected groups both affected by climate change and affected by the transition - that there is a fair deal between those elements." However, Respondent 6 also noted that currently "we don't have the social permissions to get to well below two" degrees Celsius of global warming. In short, without a social contract, the global response to climate change will lack scale and timeliness.

Respondent 17 noted "the Trump voters, are more in the distrust camp… they don't want to help too much because they feel like somebody's going to be a freeloader." Meanwhile the respondent noted "I'm like, 'Yeah. There's going to be freeloaders. Who cares? That's life, right?'" As such, the question of freeloading is something a social contract will need to address.

8.3 Political will and policy

Political will and policy refers to the ambition level of government leaders, and others in government when it comes to positions on climate change, and the interventions they make (Table 8-4). Respondents expressed disappointment regarding political will and policy responses to climate change and frustration that political leaders had not done more to address climate change given the threat of climate change. Respondent 25 stated "we have the technology to solve the problem… while you can argue 20 years ago that it was a technological issue, it's not anymore. It's purely a political issue". The Respondent went on to state "I think the main thing that we're missing at the moment is leadership, political leadership." Likewise, Respondent 2 stated, "The impact of a changing climate is likely to pose one of the greatest strategic threats or challenges, perhaps is a better word, to nations. The question is are nations, and in particular leaders, up to, and capable of, making the necessary decisions, some of which will be painful, and have impact on our lifestyle?" Respondent 24 was very succinct regarding political will and policy, "I think the leaders have failed to do that. It's as simple and as complicated as that."

Table 8-4: Political will and policy themes with descriptions.

Theme	Definition
Political will	The ambition level of government leaders, and others in government, to act on climate change and related options.
Policy	Positions and interventions.

The overarching theme "political will and policy" includes an analysis of political will and policy as a response to stress signals highlighted in IPCC assessments (Section 8.3.1). Other political will and policy themes identified from the sample of possible futures consist of: emergency responses (Section 8.3.2); social and business influences on political will and policy (Section 8.3.3); institutions and development (Section 8.3.4); policy directions (Section 8.3.5); technology driven political will (Section 8.3.6); policies on technology and practices (Section 8.3.7); energy policy (Section 8.3.8); infrastructure policy (Section 8.3.9); public service withdrawal (Section 8.3.10); localisation (Section 8.3.11); agriculture, forestry and land use (Section 8.3.12); planning (Section 8.3.13); failure of political will and policy (Section 8.3.14); and, defence (Section 8.3.15).

Note: Political will and policy scenarios included central government and local government. Scenarios addressing international cooperation between states, or between local government bodies from different states, are addressed among other things in Chapter 10.

8.3.1 Political will and policy as a response climate stress signals

From the sample of possible futures, scenarios involving political will and policy included emergency responses to impacts on human and managed systems (Section 8.3.2) as well as responses to social and business interests (Section 8.3.3). With regards to impacts on human and managed systems, Respondent 24 also noted "the attribution science is getting better and the probability assigned to a particular event because of climate change is actually increasing. So, I guess the point I'm making is that what we are seeing today in many parts of the world is increasingly linked to climate change directly." This is consistent with Table B-1 from Appendix B which summarised the changing state of knowledge and information on climate science, risks and impacts as published in successive IPCC assessment reports. Given the sample of possible futures has no scenarios where there is a response to impacts or risks to physical systems, information on climate science, in and of itself, is unlikely to generate substantial political will or policy response[16].

8.3.2 Emergency response

Respondent 2 indicated the possible preconditions for political will to emerge include impacts on human systems when a warning light "starts flashing amber or red [for] the politicians around the world". The Respondent also highlighted social change where "a government might find itself... under huge pressure from its citizens because it's done nothing to ensure quality of health... to the point at which they know they won't be re-elected or something like that." As such the link to impacts on human systems is made along with social change and behaviour in the form of voting. Respondent 2 noted that political will for policy comes starts at "The point at which the risks associated with doing nothing are greater than those of doing something" and "a recognition that... there is an issue in whatever form it takes, that unless you… take action to do something, the

[16] It is important to note here that while climate science by itself does not appear to be a compelling signal to political actors, climate science is often an important input to impact attribution studies and studies of climate change related risks to people, their property, and livelihoods.

impact on your well-being and prosperity will be so great that it'll outweigh any potential constraint imposed on you by acting."

8.3.3 Social and business influences on political will and policy

Respondent 27 noted politicians respond "to the appetite that their constituents, in the form of businesses, investors, as well as citizens" and the things constituents have "mandated them to do" and as such politicians respond to social change. Respondent 27 also noted that "In terms of sort of de-carbonizing very quickly… there are signs of political will to drive this. Political will that's based on, not just politicians out there for a legacy, but politicians responding to the appetite that their constituents, in the form of businesses, investors, as well as citizens, and have kind of mandated them to… from very small towns to cities to even… national governments as well."

Contrasting behaviour with political will and business interests, Respondent 21 suggested "individual behaviour, like that doesn't really have much to do with it. That is about choosing what your policy response is". The respondent then stated "it comes down to probably government regulation and a handful of companies deciding that this is the approach that should be taken". As such, the respondent indicated that a precondition for an effective global response is having powerful and influential political and business actors driving the response rather than social change or behaviour as a precondition.

Respondent 5 noted "the policy maker would only act under public pressure, if you have a strong public opinion," hence social change can create political will and the voting behaviours in democracies could also create political will. However, Respondent 5 also noted "public opinion can come only if they're informed, if they're aware." Respondent 18 noted that political will created through social change would make it possible to "put in place the policy regime and really the mandatory commitments needed, and we're holding the businesses accountable and businesses you know, are fully kind of invested in this solution".

Respondent 9 provided a scenario where impacts on human systems and a humanitarian outcry "pushes people to elect officials that think addressing climate change is a top priority in nations across the world", i.e. "Voting for people who think climate change is the priority." Respondent 9 went on to say "and then we see countries not only fulfil their commitments under Paris Agreement but after a review of those commitments when science tells us that we still have more to do, they put forward in 2025 a commitment that will bring us in line with the temperature reductions we need. Then they work to meet those."

Respondent 11 stated that if "the situation becomes desperate enough that… the public demands change of their leaders" then "leaders can enforce change even when certain companies… are gonna suffer from that." The respondent provided the analogy of "the breakup of AT& T, the breakup of Standard Oil, you know, it's not that the government can't address, large economic interests, they can. They have the power. But it has to be quite a clear issue and a lot of political support."

Respondent 21 noted that when there has been social change, society could state “what's acceptable and what's not acceptable to do and what needs to be done and put pressure on governments”. Respondent 21 also suggested that if some sort of Green Deal is successfully implemented in the United States it could lead to a groundswell of support for a green revolution (Section 8.2.2). In this global response scenario there is a proactive US and European response with “support from industries and individuals”, and with enough support, change could be “quite fast”.

8.3.4 Institutions and development

In one scenario, development levels and domestic institutions were highlighted as possible preconditions to an effective domestic response. Specifically, Respondent 21 noted that for some countries responding to climate change is “going to be very difficult cause they're not quite at the same level of development that, or even have the same political systems that would allow that to happen.” and “because they're still going through the levels of development and require high levels of growth, in India, that sort of thing. Then… how does that growth happen? …that probably comes down to a number of things with finance being a huge thing, people being willing to invest and also some levels of regulation”

In a scenario where impacts on human and managed systems has resulted in internal displacement and migration, Respondent 6 stated “elected officials have to respond” including supporting “adaptation to the extent they can” and this could include “solar radiation management”. In this scenario, ultimately there is further “hardship on people” and in a “worst-case scenario” there would be social unrest and institutional failure as “governments will break down.”

8.3.5 Policy directions

Many scenarios included policy options or actions, but few described the characteristics of what constitutes policy. However, back in the first paragraph of this Section 8.3, Respondent 2 noted that policy addressing strategic issues such as climate change is usually decided by political leaders and can have impacts on every part of life, including individual lifestyles. Meanwhile, Respondent 25 mentioned “direction from governments” in the context of markets, highlighting an important aspect of policy, which is direction. Policies identified in different scenarios included a “carbon price”, a “carbon tax”, “subsidies”, “NDCs”, the funding of “research and development”, as well as positions related to international cooperation.

8.3.6 Technology driven political will

From Section 7.5.1.2, Respondent 27 provided a scenario where technology drives competition and “a race to the bottom of emissions”. Respondent 27 also noted there could be “competition between nation states” as well as competition between economies, businesses and investors.

8.3.7 Policies on technology and practices

Respondent 11 stated “I think that there is a place for government to create the right incentives and investment and promote investment in those kinds of technologies but leave space for the private sector to actually accelerate that and to produce that.” Respondent 11 also noted “the free market could play a very positive role… but I don't think that the free market will unilaterally create the technologies or invest in those technologies, to bring about that level of change with… negative [emissions technologies]”.

In Section 7.5.1.3, Respondent 15 noted there need for governments to invest heavily in research and development of “long shot things” rather than “close to market technology”. Respondent 15 noted “If we do that, we have a much greater chance” of achieving the UNFCCC objective.

Respondent 11 put forward a scenario where “some of those countries that have a history of innovation… get them to be thinking about this, the way that universities and departments of engineering are incentivized by government grants.” The respondent stated, “it should be investing and giving the signals to the private sector in those countries or globally that this is the direction we're going and we are going to be investing, we are going to be procuring.” Maybe, “change will happen much faster than we think away from a carbon-based economy”. And as a result, there is a “tipping point” for example with “renewable energies” or “food production systems and the reaction against, sort of, what I call industrialized food”.

8.3.8 Energy policy

Respondent 6 stated with regards to achieving the UNFCCC objective, “the only way you get into the position [is] to take on and retire existing assets.” Furthermore, it is possible that incremental energy demand “is met by renewables and efficiency.”, but “What is necessary is we get rid of coal power stations, which are 15 years old.” As such, some technologies may need to be excluded from use.

In another scenario, where a defensive policy position is adopted, according to Respondent 6, governments “don't do the aggressive” climate change related policies required, for example they don’t unravel “existing fossil actors because of their role as national champions”. Then with time “the price on the economy” makes action “much harder”, hence “you might be deploying clean tech[nology] a lot but you are probably not getting rid of dirty [technology].” Respondent 1 highlighted that actors may “Retreat to what you can provide internally or with people you trust…. renewable energy technology is not produced everywhere… for many countries around the world, fossil fuels remain most easily accessible national resource of energy… people would maintain their own economic self-interest more.” Then, “All of those would speak to a decline rapid decline in any ability to achieve emissions targets.”

In Section 7.4.1.1 Respondent 6 put forward a scenario where states promote fossil fuels despite climate change. Respondent 6 noted this scenario could include “US, Australia, Russia, Saudi (after the Saudi leadership change)… India on a bad day, Japan". As such, it is possible states could privilege special interests in the energy sector ahead of addressing climate change.

8.3.9 Infrastructure policy

Respondent 27 noted that sub-national governments could be important investors in low greenhouse gas emissions infrastructure, along with business and financiers. The timing of investment was noted as being very important. Specifically, the respondent noted, "If that's not done in the next decade… we're locked into higher emissions …for another 30, 50 years" and noted "some might argue that it's game over in some ways…". However, this assumes that the infrastructure is actually used for its design life and does not become "stranded".

8.3.10 Public service withdrawal

In a scenario where there is insurance withdrawal in advance of climate change impacts, Respondent 20 noted cascading effects might include, "city authorities themselves may start to withdraw maintenance of their water and sanitation and certain other services and road maintenance and things like this". Such public service withdrawal could be abrupt especially as climate change related impacts start manifesting themselves unambiguously. In situations where sea level rises, and other impacts, are anticipated and predictable, public service withdrawal may be scheduled years in advance.

8.3.11 Localisation

Localisation is where non-state actors were empowered to develop and respond to climate change and other issues at the local level. For example, Respondent 17 noted "if you just ask… how people would want to design their communities if they could… what you find is that even though they might be focusing on something like safety in the case of cycling, or just a clean environment, which doesn't necessarily have to be, pro-climate… the outcome of a lot of this will be in fact, very sustainable. And so, the cumulative effect of allowing local people to decide is that suddenly you end up with a system where nobody wants to have anything dumped on them, right? And so suddenly, we have to rethink our industrialized world, right? People will want to have healthy communities, they want to have good jobs."

Respondent 17 also noted that "if you really focus on this local decision-making, you would have greater satisfaction overall, and you would have a discussion about the values across these rifts that we have today." The Respondent also stated "From what I understand, from democracy theory or whatever, there's a bit of a consensus that democracy works best in spoonfuls. At small levels. And the more you go to these gigantic state things like the European Union and whatever, the more cumbersome it becomes. It's more distant" to people.

With these things in mind, the Respondent suggested that when it comes to "International trade laws… the last word should be at the local level." However, the Respondent also acknowledged that there are certain things such as "standards for industry" that may be best addressed globally. The respondent noted that “there's a role for corporations.” For example, “community solar projects or wind farms or whatever are installing turbines from big corporations.”, and as a practical matter, “local citizenry… might come up with a solar roof for the school, but they're not going to come up with an electric vehicle.” As a result of localisation, Respondent 17 thought local businesses “would thrive pretty well.” The scenario put forward by Respondent 17 focused very much on social and community empowerment.

From Section 7.5.1.2, Respondent 6 provided a success scenario involving a level of localisation and competition. According to Respondent 6, in this scenario, businesses and local government “would need to be given the ability to raise money and spend money and make choices, to exercise their so-called purchasing power.” and there would be “distribution of power away from centralized decision-making allowing people to adopt technologies much faster.” Furthermore, “at the moment, it's seen as a complement for government but it needs to get a lot more radical to be a big replacement for central state power.” Then, “large corporates and cities using that purchasing power [on] both infrastructure and energy and food to drive change into the markets as they are the major drivers of economic growth and wealth.” This could lead to “deploy, digitize resilient joined up infrastructure” and coupled with a “bottom-up disruption and for that has to [be a] much stronger pushed from consumers to EVs and resilience in agriculture.”, then it “doesn't perhaps get you all the way to well below two, but it gets you kind of near it nearing between the two and the two point five.”

With regards to motivations, the respondent stated, “For cities it's about being liveable and attractive [for] talent and investment. For companies, it's about having supply chains for investors it is about judging their portfolios.” Respondent 6 also noted “we can't do a lot about geopolitics, but [we] can do quite a lot about decisions made at local level and company level as non-government activists and social movements so it's a complement of plan A at the moment. But…if it was really deployed as a plan B, it could make a significant difference.” The respondent did note that “if we're in a really bad geopolitical situation [with] the rise of autocracy… it's very hard to see that one working.”

In contrast with Respondent 17’s social and community empowerment, Respondent 6’s scenario is much more focused on empowering existing local government and business actors to address issues locally. In either case, sovereign states would need to empower these actors, and decentralise decision making – hence the theme “localisation”.

8.3.12 Agriculture forestry and land use

With regards to land use related responses and actors, Respondent 8 noted that “ultimately it's the national governments… if you are gonna do massive tree planting… you've got all these issues around land tenure and compensation… I think it's quite complicated”. Only by addressing these things is it possible to have “A lot of tree planting, I guess a lot of soil management techniques.” are required for an effective global response to climate change.

8.3.13 Planning

After highlighting the likelihood of failing to adapt to climate change, Respondent 6 went on to say, “Coherent resilience plans that stress tests to three [or] four degrees and look to build in national and international resilience in those things” are required, and “of course, that has the other benefit of making the impacts of carbon policy failure much clearer at the national level.” because risks of policy failure are identified, for example in reports related to stress tests. Respondent 6 stated, “success would look like for us is a kind of coherent [resilience plans], like we have, coherent low carbon plans in countries.”

8.3.14 Failure of political will and policy

Failure scenarios included a lack of social change and political will. For example, Respondent 21 noted there could be a lack of social change because people are “not feeling the pressure on them to make the changes” and voters have “other priorities”. As such, there is a lack of political will and policy “not anywhere near as sufficient or fast to achieve stabilization of CO_2.” In such a scenario we could “see a path where we would end up looking at a sort of three and a half degree [Celsius] world by the end of the century.”

Respondent 20 highlighted the issue of sea level rise, rising groundwater and flooding in the short term as well as changing coastlines which “our decedents will have to deal with” Respondent 20 noted that in “the best-case scenario… sea level rise happens at a rate that is slow enough for our political and social economic systems to adapt to.” However, “the worst case would be political stagnation and trying to deal with this at a policy level” indicating political will may be lacking and policy may not be effective addressing rapid sea level rise.

8.3.15 Defence

With regards to defensive attitudes and policies, Respondent 25 noted “democratically or whatever elected governments… have a few years to sort this out because if we don't, we assume the whole issue gets handed, first to the emergency services” and “then ultimately, to the military… I mean, it becomes one where militaries from the rich countries are employed for a crowd control.” resulting in “fortress Europe, fortress North America, fortress Japan, fortress North China”. In such a scenario “Business is fucked... The only thing that will matter is that they, how they can cozy up to whoever is in power for their own national markets. I mean, the global marketplace under which most modern businesses seeks to thrive or whatever, ceases to exist in any real way.” Meanwhile, with regards to civil society, “They mostly get lined up and shot; if they speak out of turn.” As such, Respondent 25 cautions that an emergency response could be defensive, fragmented and very difficult for many actors, including the loss of current institutions and freedoms.

8.4 Business and economic activity

Business and economic activity refers to actions, or inaction, by individuals or groups undertaking productive activities, in many cases driven by a profit motive (Table 8-5). In this regards it was noted by Respondent 6 that “the business community is a bit tricky because the business is to make profit. And it is not easy… to have any business sector going… against [its] interests.”, suggesting that responding to climate change might be against some business interests.

Table 8-5: Business and economic activity themes and descriptions.

Theme	Definition
Business	Actions, or inaction, by individuals or groups undertaking productive activities, in many cases driven by a profit motive. This includes finance and investment and decisions by business leaders and shareholders.
Economic activity	Production and consumption of goods and services by individuals and groups.

Business and economic activity issues and themes analysed from the sample of possible futures consist of: triggers and drivers of a business response (Section 8.4.1); market driven responses (Section 8.4.2); research and development (Section 8.4.3); technology (Section 8.4.4); re-industrial revolution and green economy (Section 8.4.5); infrastructure investment (Section 8.4.6); localisation (Section 8.4.7); agriculture and food production (Section 8.4.8); insurance withdrawal (Section 8.4.9); and, defence (Section 8.4.10).

8.4.1 Triggers and drivers of a business response

In a scenario involving social change and behaviour, Respondent 8 noted that it is possible that these changes could feed “into the company's ethos.” involving “a change in, I guess, mentality among everybody and shareholders and about what's important and what's valued.” However, the respondent also noted that there needs to be confidence in “technologies to replace fossil fuels” and “confidence that actually the whole economy won't fall down if they try and phase out or replace fossil fuels.”

Respondent 18 thought that “There'll be more conflict over resources and more scarcity of key resources that they need as part of their manufacturing processes. There'll be reduced economic output, so which reduces demand for their services”. As such, “most businesses will see that they're getting hurt economically.” and “there'll be an impact on free trade agreements and greater security issues that'll make it harder to do business.” Then the “majority of businesses will clamour for more political leadership, more aggressive government action”. According to Respondent 21, this could include “all these big companies come together and say we want to set a global carbon price.” as well as “Trying to influence, trying to get some more rules WTO related to import tariffs. Carbon related import tariffs, something like that.” Respondent 18 noted that “there still will be a few recalcitrant industries, but I think that'll become much smaller.” indicating cynical responses will have less influence on the response to climate change over time.

From Section 7.4.2.1, Respondent 21 noted the possibility of an extreme event attributable to climate change impacting businesses and stock exchanges.

According to Respondent 8, it is possible that business could be part of an enlightened response to climate change. However, the scenarios provided by Respondents 21 and 18, it is impacts on profitability that are assumed to be a driver for business responses.

8.4.2 Market driven response

Respondent 22 stated "I think industry is actually, the major leader, because, they have a pure motive to the meet market demand." Furthermore, "there's new technologies being developed and have been developed and industry now sees a lot of, potential in green technologies, green products because the people want it, you know." The Respondent noted the need for demand from developed countries to drive this while at the same time making life easier for people i.e. "get an economic break".

Respondent 1 noted "if we think about the green economy and we think about climate change finance, and we think about all the things that businesses are doing, that's where the action is happening… it's not necessarily all being done in the name of climate change. It's not all necessarily directly linked to climate change. It will be done for all kinds of other reasons but climate change in many cases." Respondent 25 stated, "I think most of what we need, or at least the preconditions for most of what we need is now in the process of being delivered by the marketplace. But without direction from governments it will not happen quickly enough." hence, "Climate change is one of the great market failures of all time."

Respondent 18 put forward a scenario where low carbon energy technologies get "near zero costs energy." then there could be "completely market-driven solutions we'll never even get to mandatory requirements mandatory emission or actions." In a related scenario, Respondent 18 noted "what would be most effective is that markets are driving the transition… renewables have become so cheap that we're producing not only all electricity and all heat but all chemicals and manufacturing processes are driven by renewable energy and it may not only be renewable, we may have some progress in nuclear fusion and other zero-carbon sources. And ultimately, we won't actually need policies because it's that's the economic preferred low cost and alternative." Respondent 18 also cautioned, "in the land use sector, I think we still will need some continued regulations to better manage carbon, even though there [a]re lots of co-benefits" because land use is "such a distributed sector." In this scenario, energy prices change so much that prices alone drive actions. As such, a non-response based on energy prices includes positive contributions to the global response to climate change but land use remains an issue.

Respondent 25 noted that in a defensive policy environment "the global marketplace under which most modern businesses seeks to thrive… ceases to exist in any real way." As such, "The only thing that will matter" for businesses is "how they can cosy up to whoever is in power for their own national markets."

8.4.3 Research and development

Respondent 15 noted that political leaders need to greatly increase investment in research and development (Section 7.5.1.3) to have a greater chance of fulfilling the UNFCCC objective (Section 8.3.7). However, Respondent 15 cautioned "Businesses, obviously, want you to invest in stuff that's close to market but if it was close to market, they would already be investing in it" Furthermore "If we spend lots of the research and development money on companies, we're gonna get close to market technology perfected which is not really what this challenge asks for." Instead, scenarios with research and development in long shot things is are more likely to help fulfil the UNFCCC objective (Section 8.3.7).

With regards to technologies for greenhouse gas removals, Respondent 20 put forward a scenario where "government" is "mandating it, and subsidizing" these technologies. In this scenario, there's "a mix of government, government-supported research and also research and development invested by the private sector." making it possible that there could be "a new technological revolution around, direct removal."

8.4.4 Technology

From Section 7.5.1.2, Respondent 27 provided a scenario where competition between actors around a new technology helps limit climate change and its impacts. Using renewable energy as an example, Respondent 27 stated that "Once there's enough, you know, the 'Elon Musks', those investors, that have divested from fossil fuels and try to get into renewables in some shape or form."[17] becoming a "winning team" including the "big investment houses and big political actors" and "consequently finance, will drain away from these losing, old school." technologies.

8.4.5 Re-industrial revolution and green economy

Respondent 18 noted in an enlightenment scenario described in Section 8.2.3 that it is possible there could be a realisation by shareholders and others about the need for divestment from businesses that make negative contributions to the global response. Respondent 9 noted it is possible that "large companies, philanthropists, people who have access to real finance, view, or have climate change become more of their priority and they start financing climate adaptation, mitigation projects on a large scale." Then "we could have a re-industrial revolution [laughs] of clean technologies and fuels renewable energies, and clean transport and greater efficiency et cetera." In this scenario, "We could see the economic benefits that renewable energy technologies and other low emissions technologies are already reaping kind of hit the market in the United States and other large developing and developed economies and the real benefits of those could kind of fuel [a] re-industrial revolution." Furthermore, it possible that there could be "prosperity… a green economy that trickle down to the household level."

8.4.6 Infrastructure investment

Respondent 22 noted that businesses "could be putting money into infrastructure investments that help us address and reduce emissions or not." and highlighted the importance of timing, specifically "If that's not done in the next decade now, that window's half-closing. Then we're locked into higher emissions" for a long time to come and its essentially "game over" (Section 8.3.9) with regards to the "viability to cut emissions" assuming infrastructure is used for its design life. However, it is possible that fossil fuel reliant infrastructure investments could become stranded, in which case

[17] Elon Musk being a prominent entrepreneur behind the company Tesla famous for its electric vehicle, solar PV and electricity storage technologies.

investments may be abandoned before the end of design life, hence limiting greenhouse gas emissions from the investment. As such, fossil fuel reliant infrastructure investments might not lock in as much greenhouse gas emissions as anticipated.

8.4.7 Localisation

A very different scenario involves localisation where "the last word should be at the local level." for example when it comes to international trade laws (Respondent 20). Respondent 20 went on to say, "I mean, local businesses would, I would expect they would thrive pretty well.", while at the same time "there's a role for corporations" for example manufacturing technologies like electric vehicles or related to renewable energy. As such, businesses would operate under a new global trade and domestic governance regime.

8.4.8 Agriculture and food production

With regards to behavioural change and food, Respondent 8 noted there "may be a shift from… animal products". Furthermore, the respondent highlighted that "because we, humans depend on it", then "I'm relatively positive… that we will ensure that and continue producing enough food" at the "global aggregate level". However, the respondent noted that "there are examples of food production failing at the moment". From Section 7.3.2, Respondent 9 noted that there are many large scale food production technologies that could be shared and applied around the world increasing food security. Respondent 7 noted that "Getting cheap bulk foods to masses might be straight forward but getting niche products might become much more difficult." As such "getting middle-class products to middle-class people is going to become a lot more difficult." Respondent 26 stated "if we can't adapt quickly enough to ensuring supply of and distribution of food" then "large areas of the world will go into extreme hunger".

8.4.9 Insurance withdrawal

Respondent 20 stated it is possible that "insurance industry may withdraw insurance to coastal communities well before the actual physical environment starts to be a problem", and then there could be "cascading and flow-on effects for people being able to afford to live in those places". Insurance withdrawal, like government service withdrawal includes issues of equity.

8.4.10 Defence

From Section 7.5.1.1, Respondent 11 indicated that people with power in the defence industry have an incentive to present climate change as security problem because they have a role, can sell equipment and make money.

8.5 Summary

From the thematic analysis of survey responses and the sample of possible futures, three overarching sets of actors, interests and responses were identified consisting of social change and behaviour, political will and policy as well as business and economic activity. There are many possible response scenarios and themes involving social, political and business actors.

Furthermore, there are many combinations of these scenarios, and pathways, that could contribute towards fulfilling the UNFCCC objective (i.e. success). These scenario combinations are mapped out and analysed in Section 12.3 including socially driven responses (Section 12.3.1), politically driven responses (Section 12.3.2) and business driven responses (Section 12.3.3). Importantly, effective responses involve multiple actors and interests. Combinations of actors and interests are analysed further in Section 12.3.4. Meanwhile, Section 12.3.5 analyses actor interests and incentives to mitigate and adapt to climate change. The discussion in Chapter 13 also addresses actors and interests (Section 13.7) along with the need for coalitions (Section 13.8) supporting effective global responses to climate change.

Chapter 9 Response options

9.1 Introduction

The previous chapter addressed broad categories of actors, interests and actions. This chapter addresses specific options and actions actors can take that influence, and contribute to, the global response to climate change. Options available and the actions taken, depend on technologies and practices (Section 9.2) including greenhouse gas removals from the atmosphere (Section 9.3). Importantly, there are a range of other factors (Section 9.4) that can influence incentives for actors and the actions they take. Section 9.5 summarises themes from this chapter and indicates where these themes are analysed further in Chapter 12. Note: International cooperation options for state and non-state actors are addressed in Chapter 10.

9.2 Technology and practices

In an effective global response scenario from the sample of possible futures, Respondent 21 noted "Technology can achieve a good deal of this" (Section 9.2.4). In the context of over-production and people's perceptions, Respondent 5 noted "It looked like technology will solve the problem". As such technology is an important theme in the context of options and possible actions.

With regards to practices, Respondent 1 queried "why not just focus on actions? Why not just focus on practices? Why not just focus on making environmental practices more appealing, more positive more incentivized, whatever we want to?" Meanwhile, Respondent 18 noted the possibility of "knowledge sharing and policy, good practices". As such, practices are an important theme in the context of options and possible actions.

With regards to definitions, technology and practices are methods, including objects, activities and rules, used when attempting to achieve something. Technology and practices (Table 9-1) include greenhouse gas removals, solar radiation management, energy, transport, infrastructure and buildings, natural resource management and afforestation for example. Each of these things were mentioned in scenario responses. However, given that the analysis in subsequent chapters focuses on response strategies rather than specific technologies and practices, these technologies and practices are not defined below, with the exception of greenhouse gas removals and solar radiation management which link to wider strategic response issues (Table 9-2).

Table 9-1: Technology and practices definitions.

Theme	Definition
Technology	Methods used (i.e. techniques) when attempting to achieve something, that rely on physical, chemical, or biological properties. This includes objects used for a particular purpose, the processes used, and information related to these things.
Practices	Methods used when attempting to achieve something, that rely on properties of human, ecological or environmental systems.

Technology and practice themes identified include: technology breaks the box (Section 9.2.1) and fundamentally shifts systems; technology can create coalitions and movements (Section 9.2.2); utility and substitution (Section 9.2.3); overproduction and economic growth (Section 9.2.4); and, technology and climate risk (Section 9.2.5).

Table 9-2: Greenhouse gas removals and solar radiation management definitions.

Theme	Definition
Greenhouse gas removals	The extraction of chemicals that drive global warming and climate change, from the atmosphere.
Solar radiation management	Solar radiation management refers to the intentional modification of the Earth's shortwave radiative budget with the aim of reducing warming. Artificial injection of stratospheric aerosols, marine cloud brightening and land surface albedo modification are examples of proposed SRM methods.*

** IPCC 2018c*

9.2.1 Technology breaks the box

Respondent 24 noted "You know sometimes [it is] technology that break[s] the box." indicating that technology can fundamentally change systems. Respondent 25 put forward a technology scenario where "Wind and solar are the cheapest way to add new power generation to the grid. Electric vehicles reduce primary energy consumption in the transport sector by two thirds, while… solving pollution problems. You know, smart grids happening everywhere. The evolution of technology in eating, in all sorts of other areas. The ability to actually monitor the planet in terms of what's happening in ways which would allow us to control deforestation, illegal deforestation if anybody wanted to. Lots of exciting new techniques in agriculture which dramatically reduce, the requirement for nitrogen input and hence nitrogen oxide emissions, et cetera, et cetera. I mean, it's technology. We have the technology. That's, and I think that's been, has been created through a combination of government incentives and innovation within business to provide more efficient, better products." As such, Respondent 25 indicated technology can have multiple functions, can generate new response options, and as such, can fundamentally shift systems.

9.2.2 Coalitions and movements

After addressing political will and policy, Respondent 27 put forward a scenario where a coalition of actors, i.e. a "winning team", forms around an amazing new technology that helps the global response to climate change rapidly scale up (Section 7.5.1.2 and Section 8.4.4). Respondent 24 noted "you need a coalition of the key forces that govern society to do this better and of course the private sector, and the governments, and to some extent the various civil society movements." And observed, "So, what we've seen in the solar energy revolution, I think it's remarkable. That's some of the more positive developments, you know. There is not only negative, right. I think that's a good example where technology can actually create movements." As such, technology can influence options available and the things people rally around. This includes influencing social change and political will.

9.2.3 Utility and substitution

Respondent 16 noted it is possible that there could be “new technologies that can easily be used, particularly if they are appropriate for the developing world” and these would be quickly adopted. Then, “that would make things completely obsolete, you know, the oil economy quite obsolete for instance.” Such technology could even “take the world by storm”.

Respondent 14 stated “There needs to be a bit more of technological breakthrough” resulting in the use of “electricity cars… using electricity generated by the non-fossil fuel sources” and this becomes the “norm everywhere.” The respondent noted that for the required global response and related behavioural and political changes to happen, technology “needs to be available… it needs to be in prospect as well.” At some level there needs to be faith in the technology and its ability to meet people’s expectations and aspirations.

9.2.4 Overproduction and economic growth

With regards to overconsumption and technology, Respondent 5 noted “we produce and we consume far more I think that we need for the wellbeing of the people.”, but because people think technology will solve climate change and other problems (first paragraph of Section 9.2) this creates the impression that “we can forever continue and increasing our consumption production patterns.” Likewise, Respondent 21 noted that even though technology can do a lot “if you have increasing demand for goods and services, I don't see how that's compatible with the real best-case scenario.” Respondent 21 also noted that other fundamental changes are needed to improve the outlook for ecosystems for example (Section 7.5.1.3). Respondent 17 noted concerns regarding carbon capture and storage, in particular “the storage part because of that kind of creates this waste product that now we also have to monitor it and whatever, if there's a leak and stuff like that.” Importantly, technology can have unintended consequences including the creation of wastes and generation of demand for further inputs for the production and operation of technologies.

9.2.5 Technology and climate risk

Respondent 2 noted “If two degrees is what the scientists judge as the point at which we can manage the risks 2.1 degrees is the least worst if you follow me. Now there's going to be a margin of error in that, clearly. And a lot of it is driven by what we believe technology can offer us by way of mitigation or adaptation.” As such, faith in technology influences the perceived risks that come with climate change.

Respondent 20 noted the possibility of using “solar radiation management” in the context of addressing fast feedbacks. Likewise, Respondent 24 provided a scenario where “the only option is to use solar radiation modification to relatively quickly bring the temperature down”. As such, solar radiation management is a possible option. Note: See Section 11.5 for more on solar radiation management.

9.3 Greenhouse gas removals from the atmosphere

Greenhouse gas removal scenarios address the extraction of greenhouse gases from the air by any means including the use of technology or by natural means (e.g. resource management practices encouraging the growth of trees, biological activity in soils or the sea). Some respondents noted, without prompting, that greenhouse gas removals are required to limit global warming. For example, Respondent 1 noted that a scenario where the UNFCCC objective is achieved "puts you in negative emissions... territory." which is consistent with the literature (Section 2.2.4). Other respondents were asked a specific follow up question, asking for a scenario where greenhouse gas removals are used to achieve the UNFCCC objective.

9.3.1 GHG removals as a supplement to mitigation

Respondent 21 noted "there's two options", consisting of, "either you reduce demand" of things generating greenhouse gas emissions "or, you use negative emissions technologies." The respondent also included a third option, "I guess the other option… is that neither of those are required." essentially suggesting that if climate sensitivity is lower than expected, then mitigation or greenhouse gases may not be required.

Respondent 24 noted "I don't see carbon dioxide removal as… the factor to stabilize the emissions. It's a supplementary activity that we, unfortunately, now have to do because we have gone so far." due to the volumes of greenhouse gas emissions (Section 7.3.2). Hence the need to reduce emissions to zero. Respondent 24 went on to state "And until that time comes we have to make use of carbon removal first to offset, to balance, and then to remove whatever level of carbon we think needs to be removed." with the aim of stabilising atmospheric greenhouse gases at safe levels. As such this is an overshoot and remove scenario, consistent with research summarised in IPCC assessments.

Respondent 24 also noted, "the longer we wait with the reduction of emissions the more CDR we have to use… And it gets pretty big… the longer we wait. The second is that… the longer we wait with deployment of CDR, the more challenges that might arise. Because they will take a long time…to bring these technologies to scale would require years and decades. So, let's get going as soon as possible, because anyway, the carbon needs to be removed so, it doesn't matter if you remove it too early. But it matters if you remove it too late." Therefore, working on GHG removal technology and practices is also a risk management strategy, one that helps ensure technologies, practices and capacities to implement these things are ready in case of need.

9.3.2 GHG removals as a contingency option

Respondent 6 suggested greenhouse gas removals be kept as a backup option in case climate sensitivity is higher than expected. The respondent stated "we have BECCS in our scenarios [as a] way of dealing with the high climate sensitivity rather than a way of dealing with the fact we didn't insulate houses quick[ly] enough." As such, the respondent noted "I would like to leave negative emissions as a way of dealing with surprises on climate science rather than failures of climate abatement. Because I worry a lot more about surprises in the climate system, and if we use up all the BECCS to deal with our climate policy, then we got no… other leavers to pull that'll keep us on the safe side.” In short, GHG removals could be kept as a contingency option.

9.3.3 GHG removal practices

A couple of respondents put forward greenhouse gas removal scenarios that involved biological greenhouse gas removals without technological greenhouse gas removals. For example, Respondent 14 noted “Well, a best removal system is photosynthesis and green growth”. Likewise, Respondent 21 stated “we’ve had a technology that we’ve known about, and we have known it’s the cheapest technology. …forests… we should have more of them… we should get more carbon into them.”

However, Respondent 24 noted “Even with the some of the technologies that are referred to as nature based you actually have to do some pretty hard work to get them done. Afforestation we know is challenging. It doesn't happen by itself. And maintaining high levels of carbon in the soil doesn't happen by itself.” By contrast, Respondent 3 noted “we know how to shift the incentives for communities around forests. We have done it in many countries now.” Respondent 3 went on to state “We know how to shift the incentives for farmers around managing their soils and woodlands and their forests better.” From Section 7.3.2, this should include land tenure if scale is to be achieved, and as such, Respondent 3 even suggested the “UNFCCC should have some statements around tenure.” Respondent 14 suggested “you've probably got some potential for co-opting the public into… helping… [It] might be digging up your path and planting it for instance, so I think you might generate some more… carbon dioxide absorbing greenery around the place, and that potentially could be done in a large scale, subject of course to what the climates doing by way of delivering rainfall.”

9.3.4 Practical limitations

Respondent 6 noted “I know there's a scenario where you have a small amount of mechanical removal but a large amount of natural replenishment particularly around soils. And restoring the degraded... forest plan, which gives us a bit more wiggle room but I think it's a small proportion of the game.” By way of contrast, in Section 7.3.2 Respondent 14 expressed pessimism regarding the scale at which GHGs might be removed due to challenges such as the energy required and where to put removed GHGs. Likewise, Respondent 26 noted that GHG removals “needs big time investment in large scale physical technologies” and “There are lots of questions about carbon capture and storage in terms of its effectiveness, in terms of the physical investment, the energy requirements to even build the number of plants that you would need. So, getting to the point of stabilization, it's you know, it's a big question whether that's possible”. Respondent 23 noted that they think it is “delusional” to think GHG removals can be done at the scale required to limit climate change even if it is technologically possible. (Section 7.3.2). However, the Respondent also noted “If we find a way to create energy very affordably, like some truly genuine revolution in photovoltaics or in going deep into the guts of the earth or something, maybe energy becomes so cheap that [GHG removals] can be done.” With regards to the cost of energy, in Section 8.4.2 Respondent 18 suggested that it is possible renewable energy becomes so cheap that it addresses all types of energy needs, including energy needed for heat, chemical processes and manufacturing. However, Respondent 23 noted that with cheap energy “it would also be easier to adapt to the consequences because you can desalinate water and you can do all sorts of things with energy.” Furthermore, “I think that the amount of land and energy needed for removing enough carbon from the atmosphere is, if that is profitable or affordable, then many other things involving adaptation also will be.”

9.3.5 Trade-offs and unintended consequences

Respondent 27 noted, “there will be trade-offs.” that need to be addressed if these greenhouse gas removal methods are to be applied. Other respondents specified what some of these trade-offs might include. For example, Respondent 26 noted with regards to “carbon capture and storage” that “it's a very industrial strategy that will take away from more localized smaller scale [actions]. It would… either write off completely or undermine efficiency strategies.” Respondent 26 noted a possible scenario is that “people have been pushed off the land, for example, [for] bioenergy, carbon capture and storage strategies.” Respondent 3 stated, “when we have looked to carbon capture and storage in real ways, there are very few sites have been identified where it's a realistic prospect. Where it is a realistic prospect in terms of the geology often it is not in terms of water intensity. So, if you add six years to a coal station basically it consumes more water. In a lot of water scarce locations you know, like Saudi Arabia which has the best geology for CCS, what are you gonna do? You know. This is not a win-win by any means, it’s a trade-off.” With regards to “bio-energy carbon capture and storage”, Respondent 26 noted this could result in “appropriation of land and land use in certain ways that will definitely displace people, either physically or culturally from their activities”. It was noted that greenhouse gas removals is “one of those big solutions that will you know, from a sort of a climate justice perspective, I think will be really quite problematic, for the poorer and more vulnerable.” From Section 9.3.4, Respondent 23 highlighted the possibility that the land and cheap energy required for GHG removals might be used for other purposes including adaptation highlighting that decisions are made based on options available and that options change as technologies, practices and prices change.

9.3.6 Political will and policy

Respondent 20 noted “CO_2 scrubbing from the atmosphere, that's expensive technology”, and as such, removals scenarios require “government mandating it, and subsidizing”, as well as “a mix of government, government-supported research and also research and development invested by the private sector.” perhaps leading to “a new technological revolution around, direct removal.” From Section 8.3.7, Respondent 11 noted there is a role for government to create incentives for the private sector and markets to develop technologies that help address climate change. The

Respondent also noted the private sector won't develop negative emissions technologies of their own accord. Hence government support for research and development is required.

With regards to the conditions required for actors to actually conduct atmospheric GHG removals, in Section 7.3.2 Respondent 6 noted GHG removals requires high levels of cooperation including large financial transfers to compensate actors for opportunity costs including land uses in the case of BECCS. However, from Section 7.5.1.3 Respondent 21 noted that is simpler to scale negative emissions technologies than change peoples' behaviours. This is essentially a path of least resistance approach.

Respondent 1 asked "unless we have bioenergy carbon capture and storage, where are the negative emissions coming from to deliver those climate policy targets?" The Respondent also noted "All the targets you see today are about reducing emissions. The national targets [INDCs]. They're not about going to negative territory."

9.3.7 Timing of GHG removals

With regards to timing, Respondent 18 put forward a scenario where "sometime after 2050, maybe right after 2050, we'll really start to see dramatic declines in emissions and then more towards the end of the century would really have the scale of investments in carbon removal that we need. I'd hope that it would be quicker than that, but I [am] trying to be realistic." According to the scenario, "geoengineering and carbon removal from the atmosphere" is one of a mix of actions, that also included "widespread adoption of renewable energy and energy efficiency", "low carbon agriculture and forestry", and "methane captured from landfills and industry" for example.

Respondent 18 stated, "one scenario, and the most plausible in my mind is [greenhouse gas removals] happens after 2100, because I think, in reality it'll probably take that long before we've gotten serious enough about the policy action and had all the investment and the technologies in manufacturing at scale so that it's more easily economic, and… can direct the capital needed. But dramatic impacts up until that point, until we get stabilization..." This last scenario assumes no tipping point is passed or crisis is caused by climate change and climate change is reversible.

Respondent 17 provided a scenario that started with "let's assume that this negative emission stuff, whatever it is, is going to work." then "we might get back down to 1.5 after touching 1.8 or whatever". However, the respondent also noted "So, in 2100, we're good, but we're good in a potentially different world" that might be missing "coral reefs" lost due to "ocean acidification" or something else (Section 6.2.4).

9.4 Other factors influencing actions

Other factors are other things that can influence the global response to climate change. From the sample of possible futures, other factors include things such as: leadership (Section 9.4.1); prices and the costs of technology (Section 9.4.2); carbon prices (Section 9.4.2); finance and investment (Section 9.4.4); law, contracts and legal precedent (Section 9.4.5); migration (Section 9.4.6); and, conflict (Section 9.4.7).

9.4.1 Leadership

From the thematic analysis and for the purposes of this study, leadership is the ability of individuals from any walk of life to make things happen and have others follow. Importantly this includes people from government, business, civil society and communities for example. From the sample of possible futures, leadership themes and issues related to the global response to climate change included: the need for leadership (Section 9.4.1.1); urgency and ambition (Section 9.4.1.2); cultural and historical connection (Section 9.4.1.3); and, the idea that "leadership breaks the box" and can shift systems (Section 9.4.1.4). It should be noted that leadership also featured at the international level, but this is addressed in the next chapter in Section 10.3.2.

9.4.1.1 The need for leadership

Respondent 24 said "I think that we need to have the opposite of what's happening today in the world. In terms of what's happening in the geopolitical sphere… But it is this incredible shift of focusing on yourself. When we, none of us exist in isolation." Therefore, "one needs to do almost the opposite. But for that, you need leadership who can sell this to the public… There are different ways societies are set up. China is very different than the United States or Switzerland or Sweden. They all have their particularities but in each, there are different ways that ultimately the public has to be engaged."

Respondent 14 noted that for the UNFCCC objective to be fulfilled, "There needs to be a bit more of technological breakthrough… there has to be leadership from countries… people in society need to be scared".

9.4.1.2 Urgency and ambition

From Section 7.3.1, Respondent 2 highlighted the need for a timely response and in the same scenario noted climate change is a strategic threat that needs to be addressed by political leaders, including making tough decisions and convincing the populace (Section 8.3).

Respondent 23 had a scenario with "some very charismatic and informed and good-willing and motivating person or group of persons, whether it's a president or a new head of COP, or youth movements storming in demanding a change that actually is desired". With regards to social change, this could "infuse a level of energy that is more analogous to religious movements, or Gandhi, or civil rights and anti-slavery." meanwhile the global response to climate change could "get closer to the 1.5" while at the same time getting "closer to the stated aspirations of common but differentiated responsibilities and so on, and development and everything".

In Section 8.4.2, Respondent 25 noted, that to fulfill the UNFCCC objective most of what is needed for a global response is being delivered through the marketplace, but this response is too slow. Hence, Respondent 25 went on to state the market is "Sending, sort of, signals in the right direction… but… it "needs a Jacinda equivalent in most countries to just say, 'Fuck you guys, get on with it. I don't wanna hear it, your excuses and your bullshit.'" In short, urgent government direction is needed for a timely global response. Jacinda in this context refers to the New Zealand Prime Minister at the time of the interview.

9.4.1.3 Cultural and historical connection

Respondent 14 stated "there has to be some leadership from countries that people look up to and that leadership has got to be dramatic, visible and seen to be transferable". The respondent also suggested that "ideally you'd have regional leaders, because the different countries, different cultures, different religions look to different leaders for guidance." The respondent suggested leadership could come from China, an African country but it is difficult to know which country, a European country perhaps Italy or Greece rather than a Nordic country, and the Democratic Party in the United States but only "if they can get their shit together and decide that they are truly a supporter of democracy and can unhook themselves from their traditional connections with big business and big lobbyists" The respondent noted that leadership would need to include governance "that accelerates the technology development from concept to delivery."

9.4.1.4 Leadership breaks the box

Respondent 24 also noted that an effective global response to climate change "requires an understanding by the global community that we're in deep shit and only the radical action can take us on a path which is both from a carbon point of view, matching the UNFCCC objectives and does not destroy sustainable development". Furthermore, "this needs to be sold to societies." For this to happen you need "political leadership… you need people who are charismatic, strong, who are able to get out there and basically… sell the idea that we have a problem. And we will fix it. We can fix it. It is not the end of the world but we need to do this together… I don't just mean government leaders mind you. We need leaders in NGOs, in private sector, in religion, all those different groups because it is the leaders who break the box in which we are located." With regards to breaking the box, this seems similar to the concept of "growing the pie" or "expanding the pie" in negotiations where more and more issues and are linked and addressed together, so trade-offs can be made and decisions agreed by all parties (Wetlaufer 1996, Basadur et al. 2000). Kingdon (1995) also noted that leaders can link and reframe issues, redefine problems and agendas so that some solution can be adopted (Kingdon 1995). As such, leadership can fundamentally shift systems and the options considered by society, government or business.

9.4.2 Prices and costs of technology

Respondent 15 stated, "fundamentally, the only way I can imagine that we're gonna achieve some sort of stabilization on a fairly low temperature is if we manage to get technologies that are cheap and produce about the same benefits as fossil fuels do now." As such, "The fundamental point here is much more about getting green energy to be so cheap that it's close to taking over." and "we need technology in order to solve this if you're gonna, if it's both gonna be politically realistic and if it's gonna be realistic economically to stabilize at a low level." "But if we can make technology that's gonna be cheaper… that are green then we can get this takeover. If we don't, it won't happen." These are essentially conditions for a non-response with positive incidental contributions to the global response to climate change.

Respondent 18 put forward a scenario where “we get quickly to the zero carbon near zero costs energy.”, then, “most of the problem can be dissolved.” but “We still have land use and few other issues to deal with.” Alternatively, “If it's the case that it's not really zero cost energy, but it's, you know, a cost that developed countries can afford, developing countries can't or the infrastructure and technical skills needed are significant”, then that would “be good news for the global climate, bad news in terms of regional disparity.” In either scenario, the respondent thought “it'll move us towards completely market-driven solutions we'll never even get to mandatory requirements mandatory emission or actions.” The respondent also stated that “I don't think we have the political will for it to be policy-driven. I think it'll be technology-driven supported a little bit with policy.” This indicates that cost is not the only factor influence the options considered and actions taken, but other issues such as the capacity to act may also have an influence.

9.4.3 Carbon price

Respondent 17 noted “There is a carbon price out there, different regions have it, it's very low, it doesn't cover enough space.”, so “let's have a carbon price that requires actually a global government, that's always like the step that they leave out is you need for the carbon price to work.” Then, “we would actually draw a line and say, ‘Here's the budget for this year and next year and all that.’” and, “say, ‘What would it require for us to get this carbon price?’ It would require actually 190 or whatever how many countries we have sitting down and saying, ‘Yeah, that's right.’” Then, “if we move from carbon price to global government, and then we say, ‘Okay, we acknowledge that there's gonna be winners and losers.’”, and “Then you have to start saying, ‘Okay, now we can talk about’ We've sort of described the problem, what would be the remedies for that situation so we can actually work this out.” Lastly, “you would have to probably come up with something like transfer payments or border taxes or… something along those lines”.

Respondent 17 noted “Because under a carbon price, there're gonna be winners and losers… we would need to talk about, "Okay, what kind of compensation mechanisms, transfer payments?" You know, the whole thing becomes super complex. But saying, ‘Let's have a carbon price,’ is a simplification.”

9.4.4 Finance and investment

Finance is the source of money and this could be for any activity or investment. Finance was mentioned, along with terms such as investment, usually with the source (i.e. actors) indicated for example business or government. Finance can be an important part of change, for example in Section 8.4.4, Respondent 27 noted that it is possible finance could rapidly move away from fossil fuel technologies into “amazing” new technologies such as those used for renewable energy generation. Finance, in this scenario, is important for sustaining and scaling up technologies and business models. Finance and investment might also support research and development, infrastructure or energy, meanwhile finance might also support international cooperation, or other things such as transfer payments, all of which were mentioned in the sample of possible futures.

9.4.5 Law, contracts and legal precedent

Respondent 26 noted that for effective contributions to the global response from the law “you have to have a good legal system that can respond as well” and, “you need a scattering of cases in different jurisdictions” in particular when it comes to “private sector law around, investment and, say foreign direct investment”. With these preconditions it is possible that legal systems may help with “ensuring that all investments, don't contribute to climate change”; “flagging up this fiduciary responsibility of shareholders and investors”; “they can start to influence the standards and requirements, within private sector law.”; rule on “domestic private legal systems, in relationship to, investment, company responsibility et cetera.”

Respondent 26 also noted “I think there's some really big issues at the international level and at the national level about ensuring that all investments don't contribute to climate change so, I mean, we're seeing this in the sort of flagging up this fiduciary responsibility of shareholders and investors, so sort of, to de-carbonize their investments, both for, for the real fact that they'll, the investment won't be realized if, if you don't de-carbonize, because there won't be a future.” The respondent noted “that that's big area, which is very different from this litigation, which is much more trying to hold to account, government.” Respondent 26 also noted that legal “systems learn from other systems”.

In addition to private sector law, Respondent 26 addressed “public interest litigation to call to account that the government is failing to do enough in terms of either mitigation or adaptation for climate change.” This could be “a means in to using the legal institutional structures to try and change the policy framework in a country.”

9.4.6 Migration

Respondent 24 noted “when the immediate changes in climate which have impact on agricultural production, things like that, will produce mass migration.” Then there will be “initially, internally displaced, some of which will then result in externally displaced. And that is where things are really going to hit the fan, so to speak.” Respondent 21 made the link between climate impacts, domestic institutions and migration, noting “if there isn't enough of a, sort of credible institutions within their own country, these people may leave their own country... People are going to start going elsewhere and then you're going to see sort of responses to migration and immigration that are potentially going to become more and more strained”.

9.4.7 Conflict

Two failure scenarios featured the theme of conflict. For example, Respondent 26 noted there could be “more tension and conflict in urban spaces” and “there's gonna be real fights over natural resources.” Respondent 26 also noted social change that could result from conflict, stating “conflict brings violence and… extreme politics, and sort of complete social breakdown.”

According to Respondent 14, possible preconditions leading to conflict include “The issue of food security and water security”, “international issues around national borders” and “conflict between states over resources.” Respondent 26 also noted conflict could result from conditions such as “if we can't adapt quickly enough to ensuring supply of and distribution of food” or due to demand for “Primary natural resources even to create a green eco, you know, to create a low carbon world.” Furthermore, it is possible “people have been pushed off the land, for example, [for] bioenergy, carbon capture and storage strategies.” hence, “there's gonna be this movement of people into urban centres.” creating conflict.

9.5 Summary

When it comes to response options and related scenarios, technology is an important theme as are practices. The availability of technologies and practices is an important influence on the options that might be taken by actors. Given that the GHG budget is likely to be breached, the availability of GHG removal technologies and practices can either be part of efforts to off-set, stabilise or reduce atmospheric concentrations of GHGs or serve as contingency options. Other factors can also influence the uptake of technologies and practices and the effectiveness of responses to climate change such as leadership, prices or finance. Other influences also include legal and contractual considerations, migration, and the possibility of conflict. Each of these factors can have a bearing on actor interests and their incentives to act on climate change.

With regards to further analysis of the scenarios and themes in this chapter, the influence of technology, prices, and the commercial viability of options is analysed in Section 12.3.5. The scenarios and conditions under which actors might undertake GHG removals are mapped out in Section 12.4 and discussed in Section 13.9.

Chapter 10 International cooperation

10.1 Introduction

The IPCC defines climate change as a collective action problem at the global scale (IPCC 2014a) and dedicated a chapter to international cooperation in its Fifth Assessment Report (Stavins et al. 2014). Many scenarios from the sample of possible futures featured international cooperation and are presented in this chapter, helping address the question of: What are the preconditions for effective international cooperation on climate change? From the sample of possible futures, a set of themes and scenarios were identified regarding the overarching international regime complex (Section 10.2) as well as international cooperation (Section 10.3) for example regarding triggers and drivers, interests and actions.

Given the importance of stringency and compliance from Section 3.3.3, the semi-structured survey included a follow up question asking respondents to give a scenario where there is a stringent enforced international agreement on climate change. These scenarios and themes are presented in Section 10.3.4.

Section 10.4 summarises themes from this chapter and indicates where these themes are analysed further in Chapter 12.

10.2 International regime

As noted in Section 2.5.4, climate change and related responses are part of an international regime complex. The response to climate change is among many issues on the international agenda, and agreements on trade and other issues can influence the global response to climate change (Stavins et al. 2014). Given that there are a range of international issues that could affect the global response to climate change, it is important to analyse the international regime and the influence the international regime might have on the global response to climate change. From the analysis, themes and scenarios identified include: globalism versus nationalism (Section 10.2.1); climate change emerging as a premier issue (Section 10.2.2); a climate focused international regime and what this might look like (Section 10.2.3); the UNFCCC as a coordination body (Section 10.2.4); and the possibility of a business dominated international regime (Section 10.2.5). It is also possible that there could be fragmentation or collapse of the international regime, however these scenarios are presented in Appendix O as they are failure scenarios and provide limited insight on preconditions for effective global responses.

10.2.1 Globalism versus nationalism

Respondent 13 noted "you've got to, gotta step back from climate and sustainability issues for the moment and see what's happening in the world politically and you've got massive movements going on. One is more of an intellectual realization that we have to cohere together as a species and however we structure ourselves politically for decision making. So, I just call that the globalist approach. And then you've got the nationalist-populist backlash against the migratory flows especially, and so you have it in the United States and in Venezuela and quite possibly Brazil, …you do have spots of populist backlash and for that matter inside Europe and the UK. So, it begs the question as to how those competing, and they are conflicting forces, play out to make decision making on anything whether it's military but also on sustainability and climate". Wider movements, and tensions, between globalism and nationalism will influence international cooperation on climate change.

10.2.2 Climate change as the premier global issue

Respondent 14 noted that in a scenario where there is "Food insecurity, locally and increasing nationalization, leading to increasing conflict.", then the UNFCCC "may need to become the premiere… leading United Nations organization." In this scenario, "the UN might start to be centralized around that body because, if the negative scenarios play out, [and] climate change starts to dominate everything." As such, the scale of climate change impacts and risks could make climate change a central focus for international cooperation generally.

10.2.3 A climate focused international regime

Respondent 13 stated "in a global emergency, you'd have to say, 'Right, the UN is taking a lead, and it's the Security Council, and it's working with the WTO and the World Bank.' And UNFCCC is simply negotiating machinery feeding into it." Because it is an emergency, "You can trigger chapter seven enforcement powers in the Security Council". For institutions to work together, there would "have to be an agreement, it would have to be economic sanctions through coordinated between UNFCCC, WTO, and Security Council. With leadership from the Security Council, with a strong Secretary-General, and a sobered collective resolve inside the Security Council." The respondent noted that "if the [Security] Council won't do it, then the secretary general could set up subsidiary bodies… and report into the Security Council… put proposals to the Security Council..." Importantly, in this scenario the international regime addressed aviation and shipping while also allowing for other institutions to be part of the regime. See Figure 5-6 in Section 5.3.1.

10.2.4 UNFCCC as a coordination body rather than a decision body

Respondent 6 put forward a scenario where "The UNFCCC …is not the body that decides, but organizes how we address it.", furthermore, "it organizes other organizations to address climate change in their work and… the response to climate change, but it's not… the thing that does everything..." The respondent suggested a scenario where the UNFCCC is "evolving into a much stronger global risk management organization. Much stronger focus on monitoring the earth system impacts, global system impacts with… it as an advisor in parallel to Security Council and the GA [and the UNSG's office]". The UNFCCC "looks at impacts overall and how the global system is responding..." The respondent went on to state "it needs to turn into a more of a[n] IAEA nuclear weapons convention style body not a WTO type body."

Respondent 6 noted "the core piece that the regime adds to build agreement is an independent measure of what countries are doing, so what we don't want is to be arguing over the CIA's version of Chinese emissions verses the Chinese version of Chinese emissions. We've seen that in nuclear proliferation, [that] it really helps to have a kind of IAEA style [institution, where] we all agree what everybody is doing.” Respondent 18 didn’t mention the IAEA, but did state “I don't think there'll be oversight of national policies… there will be sort of voluntary teams who go and check what countries are doing, but I don't think they'll be real enforceable policy reviews.”

With regards to international institutions other than the UNFCCC, UNGA or UNSC, Respondent 6 suggested a scenario where there is growth “in the climate orientation of all the other bits of regime” including the IMF, multilateral development banks and FAO for example, with “integration of climate into their everyday business”. In this scenario, the UNFCCC is “the delivery arm” rather than the driver of these things. Hence “there's a kind of… global climate agency model”.

10.2.5 Business dominated regime

Respondent 7 provided a scenario where corporations dominate affairs including the global response to climate change. The respondent stated, “So we no longer have a Football World Cup [of] Nations, but a Football World Cup of Corporates.”, and “that could happen… if society becomes so individualistic that governments… are hollowed out and lose their controlling power” and power shifts “almost entirely to the corporates.” In such a scenario, corporations and financial institutions say “Look, UNFCCC you have not moved fast enough Governments you have not moved it. We're in ‘schtook’. We are running out of places to move our businesses to.” Then with the involvement of the G7 and BRICS, the global response could be “through financial instruments. Financial mechanisms. So, whether its green taxing or shifting to a carbon, a genuinely carbon economy in other words carbon becomes the currency, not dollars.” The respondent also noted that “the leverage for dissent has disappeared.” meaning the opportunities for social change would be limited.

10.3 International cooperation on climate change

From the CCNIIC Model from Section 3.3.2, international cooperation on climate change is an important part of the global response. International cooperation on climate change refers to actors from different states acting in a coordinated way to address climate change and related issues. From the sample of possible futures, important themes and issues related to international cooperation on climate change include: triggers and drivers for such cooperation (Section 10.3.1); global political leadership (Section 10.3.2); global political power and influence (Section 10.3.3); possible stringent enforced international agreements (Section 10.3.4); and international cooperation options (Section 10.3.5).

10.3.1 Triggers and drivers

An important part of understanding preconditions for an effective global response to climate change is understanding triggers and drivers for international cooperation on climate change. From the sample of possible futures, triggers and drivers might include: maintaining a rules-based regime (Section 10.3.1.1); national interests (Section 10.3.1.2); an emergency global response (Section 10.3.1.3); business interests (Section 10.3.1.4); and, enlightenment (Section 10.3.1.5).

10.3.1.1 Maintaining a rules-based regime

Respondent 6 provided a scenario where "international cooperation is essentially driven by major powers doing state-to-state diplomacy and realizing that they both have an interest in keeping temperatures somewhere around two degrees." Furthermore, "they believe that maintaining the climate regime is a critical part of maintaining the overall rules-based regime… I mean the linkages, with trade and investments and other pieces. So that's the kind of top-down state to state geopolitical scenario." In this scenario, there is "a rebirth of multipolar cooperation" with "lots of lovely leadership, people get together, they coordinate, they keep markets open, central decisions in China and India."

In another scenario, involving a stringent enforced climate agreement, Respondent 6 put forward two preconditions consisting of "they want it because of the climate risk." And "...they believe in international rules, so that they will not renege on it because they want to show that international rules work and that's not just for climate but for other things."

10.3.1.2 National interests

With regards to underlying assumptions, Respondent 6 stated "we think there is a core realists national interest scenario where none of them can maintain the security and prosperity of current levels in a kind of two and a half degree and above world." Furthermore, "it's in a broad concept of security both hard and economic". As such, "it's a risk and rules based scenario... And both of those motivations are what drives action, it's not just climate risk driven, it is driven by geopolitical drivers". The Respondent also stated, "it's kind of what people, you know, hope happens and that would give us a decent chance with a kind of tailwinds around the global economy of shifting investment, so that's the kind of international cooperation scenario." The Respondent also noted that "We think climate change is a fundamental geopolitical issue now and that wouldn't have been true five years ago.", and as such climate change "is part of those things major powers need to cooperate on to maintain a kind of a bundle of cooperation which, again those are never done as single issues. They are done in bundles".

In the "risk-rules based scenario" Respondent 6 identified risks affecting national interests of geopolitically powerful states, "for Europe its migration and the stability of North Africa primarily, for China and Japan its primar[ily] food stability and internal stability for China. For Brazil there isn't really one because they're too complacent. For the US, they are one of the most exposed developed countries for internal damage, but let's see if… they kind of believe it again. India, most vulnerable country, monsoon rainfed agriculture, enormous disruption." (Table 10-1). Despite these risks, these states have not yet responded and time is running out for timely mitigation based risk responses.

Table 10-1: National interests that could drive risk responses for geopolitically powerful states or regions in the case of Europe. Source: Respondent 6.

Region or State*	National interests driving risk response
Europe	Migration
China	Internal stability and food security
Japan	Food security
Brazil	None i.e. "too complacent"
US	Exposure to climate change loss and damage
India	Vulnerability including monsoon rainfed agriculture

** States or region in the case of Europe, that are big enough to upset a treaty if both sides don't get what they want. Russia and Australia were noted as being minor players by comparison.*

10.3.1.3 Emergency global response

Respondent 13 noted "I would anticipate that at some stage and there's going to be emergency powers kicking in at international level and on the question is do they kick in somehow the global level Security Council whatever. Because of, humanity will suddenly start baying and saying, "Enough [is] enough we got to change some things very fast." The Respondent also noted, "Does that occur before 2030 or after 2030? By definition if it is after 2030 it is too late"

Respondent 7 stated, "I think it can only come out of some as yet an unforeseen crisis. I can't see us working towards it incrementally. Incrementalism seems to have failed. So, it looks like the stepwise change would probably have to come through someone's yet unforeseen" crisis. Respondent 14 noted a stringent enforced agreement could happen, "When… more nation-states start to plead for [a stringent international agreement that is enforced], plead for action."

Respondent 9 noted that the trigger or driver for a stringent enforced international agreement could be "the scientific community says we really can't afford not to act. We are very sure that we'll reach a tipping point in 20 years and you have to increase emissions or we're all gonna die. Decrease emissions or we are all going die. Or we have some kind of like catastrophe that can spur a similar response."

Respondent 27 stated, "I think it will be driven more by other reasons… if things start going really hectic and really disruptive and it might be driven by fear and by strong security imperatives and climate changes coming up more and more." Then "Politicians just follow what their constituents and what their… ethnical grouping tell them so if that stuff shifts then the global agreement will suddenly become super strong and everyone will be super committed because that's doable and it's advantageous for other reason".

10.3.1.4 Business interests

Respondent 21 suggested business interests could drive a stringent enforced international agreement. From Section 7.4.2.1 Respondent 21 noted that an extreme event could affect businesses and stock exchanges. In the same scenario, Respondent 21 went on to state that "the response the next day is… all these big companies come together and say we want to set a global carbon price." The Respondent noted, "people can respond and make changes very quickly if they are threatened."

10.3.1.5 Enlightenment

Respondent 20 noted that an enlightenment scenario could lead to “an atmosphere of intense global cooperation and goodwill”. In this atmosphere, “the key players globally, that have the highest carbon intensity emissions, are agreeing on a global technology transfer and cooperation and mitigation, and also, facilitating the transfer of those technologies, and also agricultural practices, to what we mostly call the developing world, other developing countries.” Furthermore, “externalization of fossil fuel impacts, combustion, is brought into the fold through carbon taxes, and… subsidizing green technologies. So, basically, reining in and, neutering the independence of these major international corporations that are behind many of these emissions”.

10.3.2 Global political leadership

In a scenario focused on international cooperation and climate negotiations, Respondent 25 suggested it would help if there was “a Jacinda equivalent in most countries”, and these leaders would “give their instructions to their negotiators to fix it. And they're not going to take no for an answer and they're not going to take excuses and they're not going to take blaming it on somebody else.” Respondent 25 noted it is possible that “the Chinese say, ’Okay, well, all right, we're gonna do this. We're gonna lead this. …this is how we're gonna define the new rise of China.’ And they could, easily. They have the money, they have the technology, they have the influence.”

Respondent 25 also noted political leadership “will depend upon the outcome of the 2020 election.” and “We're due for a renewal in generational terms in political leadership in an awful lot of places. Donald Trump is an old man. Shinzo Abe is old. Bolsonaro is old… I think that's what's required, and I think that's the only thing that's going to make a difference.”

From Section 9.4.1.3, Respondent 14 provided a scenario where there is multipolar leadership driving the global response to climate change, including regional leadership and leadership from countries with cultural connections and influence. Similarly, Respondent 10 suggested “The other scenario is… big developing countries like China and India, are taking the lead.” In another scenario, Respondent 12 suggested “[China] have to change how they consume materials and how they build their cities.”, then they push similar policies through “Their network that Belt and Road… seaways initiative.” In this scenario, China say to ASEAN “you have to make sure that those laws will be sustainable.”

10.3.3 Geopolitical power and influence

Several respondents highlighted the role of geopolitically influential actors in their success scenario. With regards to China, India, Brazil, South Africa, Respondent 9 noted “most important factor is not only to their economic size and the rate they produce emissions [but] also their geopolitical power and influence.” Furthermore, “where they lead the world follows. Especially with regional powers like Brazil, South Africa, China, et cetera. They set the tone of Africa's response, South America's response, et cetera.” This is a multipolar leadership scenario.

In Section 7.2.4 Respondent 14 noted that a stringent enforced agreement would require pleas from states bigger than Tuvalu. The Respondent went on to state “the pleas have to come from countries that are potentially dramatically affected and whose culture or population, people, are of value by other nations states, otherwise they'll say, ‘Sorry, we're gonna look after our own self.’ So, who might that be? I don't know, I'll think about it.”

Respondent 7 also noted “Well, so where's, who's got the power? Who's got the authority? And what would cause the G7 to screw it up enough to give it away? What would cause say the BRICS to get enough clout, what would be their counter move to side-track with G7? I think it's difficult to see a consensus… the power dynamics would change… it's going to have to be quite a different move.” As highlighted in Section 7.2.4, “power is the exhibition of authority” allowing those with power to “maintain” and “increase” what they have.

With regards to the sample of possible futures, two different types coalitions were identified, consisting of a coalition of powerful states (Section 10.3.3.1) and coalitions of less powerful states (Section 10.3.3.2).

10.3.3.1 Coalition of powerful states

Respondent 21 noted “globally at the moment, it's really a handful of large players that are causing the majority of emissions and really”, and “you need them around the table agreeing on a way forward to solve that”. As such, “it's getting China and the US and the EU and India and Brazil or not, maybe a handful of others to agree on a way forward for this.” In short, its about getting an agreement “That's as beneficial across the, you know, across them on this as possible.” Then, “everyone else has to fall in line anyway because they want to trade with the big trading partners”.

Respondent 6 noted that for a stringent enforced agreement to work it would need “a club of 6 to 10 countries who are the core of the agreement and don't renege”. With regards to other Parties, “anybody else just comes along for the ride. And if you do get a rogue nation, like Australia, they get slapped down with trade sanctions again, but, again that's minor stuff… that's not a major part maintaining stability.” The Respondent noted, “It's strategic stability done by people sitting in rooms talking to each other.”

Respondent 7 stated, that a stringent enforced agreement could be “enforced by a group.” The Respondent suggested that this would involve “an elite over a minority” (Section 7.2.4) and with regards to a stringent enforced climate agreement, “it's going to be very uncomfortable” particularly for less powerful states and actors.

Respondent 16 put forward a scenario where “the big emitting countries want to be part of it, but… they feel the others are not contributing enough… because it shouldn't be only on them. So, they can actually say, ‘No, we'll only do it if these countries also come on board.’" thus forcing smaller less powerful states to participate.

10.3.3.2 Coalitions of less powerful states

Respondent 16 put forward another scenario where “big countries that are emitting don't want to be part of” a stringent enforced climate agreement, then “75% of the countries can go there and say, ‘You know, no this is how it will happen.’ Although in terms of warding off greenhouse gas emissions, they might be 30%, 40%.” As such, a large coalition of small emitters could conceivably be formed leading to a stringent enforced climate agreement.

Respondent 12 noted “If ASEAN is able to… have more power over its natural resources that's good leverage against consumers like China and the US. Or for the bigger countries. Maybe in our terms, ‘Okay, you want our minerals? You want our fish? You want our gold? Want some of our forests, and the rubber? And the palm oil for the chips? You have to agree to these.’” Then at the regional level there can be “more stringent application or formulation of the climate agreement.”

10.3.4 Stringent enforced international agreement

The semi-structured interview included a follow up question asking for scenarios that would result in a stringent enforced agreement. In a few cases, respondents volunteered stringent enforced agreement scenarios without being asked the question. Important themes and scenarios identified regarded: national interests (Section 10.3.4.1); business interests (Section 10.3.4.2); voluntary stringency (Section 10.3.4.3); climate change being elevated to the United Nations Security Council (Section 10.3.4.4); transparency, reporting and verification (Section 10.3.4.5); enforcement and compliance (Section 10.3.4.6); and, non-compliance with agreements (Section 10.3.4.7).

10.3.4.1 National interests

Respondent 6 noted, “A stringent international agreement rests on the foundation of national interest, so if the major powers want it to be stringent it'll be stringent.” The Respondent stated “I don't believe trade sanctions, or so-called international law is what keeps order, agreements together. I think people stay in agreements because they are in their interest at international level, what the agreement does is make it easier to stay together and to kind of fossilize the politics, and ratchets, in, and make defections costly in terms of broader international politics which is important, is not, everything else.” Furthermore, “trade sanctions and enforced environmental agreements only work if small countries defect.” as opposed to large countries defecting.

10.3.4.2 Business interest driven scenario

From Section 8.4.1, Respondent 21 suggested a coalition of business interests could drive a stringent enforced international agreement for example including a carbon tax or climate change related trade tariffs.

10.3.4.3 Voluntary stringency

Respondent 26 provided a scenario where there is voluntary stringency. Preconditions included, “nationally determined contributions are well-planned”, “the political will is there, then it could be, it could be achieved.”, and “the Paris Agreement implementation framework is effective, with the report back, the stock-taking, the transparency framework”. The Respondent noted “all of those things are very difficult. [laughs]”. According to the Respondent, this would mean eliminating the ambition gap by 2019 so “these national determined contributions get us to the target by 2050….”

10.3.4.4 Climate change elevated to the United Nations Security Council

Respondent 13 put forward a stringent enforced international agreement without prompting. The scenario starts with a situation where “the US comes to the party and even though the[y] are only, what is it 15% global emissions or something. Politically, it makes a huge difference if they are cooperative” and this “returns normalcy to the UNFCCC entire machinery”. Then there also has to be “a new resolve based on the 1.5 report and other reports” and “we all agree that we have to stay on a 2.6 [RCP]” followed by “an extraordinary array of revised INDCs voluntarily submitted prior to 2023.” At this point there is “another counting”, the scientists note that there have been progress but not enough, and States increase their ambition, coupled with “a realization by Europe and North America and Japan, and North Korea and Australasia, that we do have a historical obligation.” Respondent 13 then noted “The second step is do you succeed each of those… revised INDCs in that same year is getting close to 2.6 RCP and therefore, on track to two degrees. Then you have to make sure that somehow that's enforced.” From Section 10.2.3, Respondent 13 noted sanctions would involve the coordination between the UNFCCC, WTO and Security Council. The Respondent also noted that in case of a climate change driven global emergency, leadership would need to be taken by the Security Council with support from the World Bank, WTO and the UNFCCC serving as a negotiating forum.

Respondent 25 also put forward a scenario where the United Nations Security Council is “revamped” and its members “put climate as a central issue there, which maybe doesn't get determined from the Security Council. But it's directed or led, shall we say.” Then “In terms of a particular punitive mechanism… if you get the Russians the Americans and the Chinese and the Indians, the Brazilians and a few others… a representative from Africa… [they] Wouldn't have to. They all said, do it. A list of consequences from trade embargoes to, you know. They would be able to make them a series of offers, which they would not be in a position to refuse.”

10.3.4.5 Transparency, reporting and verification

Respondent 6 also stated, “the other key bit of the regime which is incredibly important is transparency... So, we [are] arguing about real, as opposed to arguing about the facts, which is the best way to show distrust and to fracture the agreement…. The core end of the regime is providing that transparency... The other bit is it gives a platform for the most vulnerable countries to put pressure on the big countries which was quite important in the first stages of the regime. It moves the needle a bit. Make defection more costly for China and India if loads of poor countries in Africa are saying, "You are fucking us over.” As noted in Section 10.3.4.5 in such a regime it is essential to have independent and credible verification of emissions from countries, including the possibility of “IAEA style” country inspections.

Respondent 14 stated, “The best way to do [it] is from international scrutiny of performance and that requires, signatories to collect and publish accurate information on what they are doing and you will know well as I do that's a pretty patchy sort of system…if my crisis scenario is right, then the incentives for good behaviour on the countries or regions that are being most severely affected are fairly high for good behaviour. But I'm not quite sure how you would enforce it."

10.3.4.6 Enforcement and compliance

Respondent 23 stated "I think that any form of enforcement is unlikely to be motivatived by the document of the text, and by the doc, by the climate global aspirations. I think it's more likely to be about geopolitics and, you know, keeping someone in check with the excuse of a symbolic platform of the climate." Furthermore, the Respondent stated, "I think that as long as nation states, want to retain the concept of national sovereignty above global well-being, chances are that there will be at least one entity that will say, "Screw the collective. I want to be better." And if that entails, you know, violating the written text of the agreement, they're gonna try to get away with doing it."

Respondent 17 stated "At this point, I think because it's kind of five minutes past midnight", for a stringent enforced agreement "you probably would have to have some policy where you just started taking things away from people."

The Respondent 14 noted "I'm not sure about enforcement. I've never been really confident that any of the UN agreements have been particularly well enforced." With regards to "What might it look like? It might involve sharing technologies, so quick transfer of technologies, where technology is part of the fix. It might involve relaxation on international barriers to trade, to migration, to financial systems, aid."

Respondent 9 highlighted possible mechanisms, for example for Parties to be "able to utilize the perks of the agreement such as market or you can also tie it to finance so if a nation didn't meet its obligations they would not be able to receive finance for climate change adaptation et cetera." Furthermore, "you could go broader and link the Paris Agreement to other multilateral agreements and so if nations weren't compliant with them to reduce emissions, they could be subject to trade sanctions or economic penalties… or the loss of rights under other conventions like biodiversity etcetera, the loss of status on world heritage and stuff."

Respondent 18 suggested: "one enforcement mechanism could be trade. The access to markets could be contingent on proper action to reduce emissions and to support others in reducing emissions."; "other enforcement mechanisms could have to do with requirements in terms of payments to compensate others."; "Although, still a little bit of a challenge but dues responsible for international institutions could be higher for those that aren't taking, aren't meeting their mandatory commitments."; and "if you're a developing country, you're less able to receive aid, that could go in either direction based on your progress."

Respondent 3 noted "If you're holding governments to account to achieving Paris, first of all, there needs to be a way of portioning targets to those governments and that politically proved impossible as we saw in Copenhagen. So, we went with the bottom up, you know, everyone say what you can do."

Respondent 10 suggested, “Montreal protocol which has been implemented and the strong commitment with which it was implemented, you know? If I see a successful case, successful experience and similar thing can deal with greenhouse gas emissions.”

Respondent 10 noted that for a “stringent agreement you put also the tools for its implementation. It's laws, regulations and, different enforcement mechanism. I think there is, they can use experience from… Kyoto protocol because there are compliance and enforcement mechanism, yes, to make sure that this is implemented. So, I think there is enough experience if the world is committed they don't lack, mechanism. There is laws, there are everything. What is needed is the commitment to implement enforce, the political commitment.”

10.3.4.7 Non-compliance with agreements

Respondent 6 addressed incentives and national interests, stating “The incentives on countries that defect from a stringent environmental agreement are, if they have lots of cheap fossil [fuel] and they want to export lots of stuff. Now that solar is cheaper than fossil in most of those countries, it is really unclear whether we['re] gonna see that kind of small energy dense Saudi, Australia, Russia defection because actually quite a lot of them have lots of desert and lots of sun and so they can find low carbon alternatives which are as lucrative for their energy intensive industries.” However, this assumes that energy is substituting energy. In energy exporting states, it is export revenue that needs to be substituted rather than domestic energy consumption which is what renewable energy addresses in many cases. It may be possible that some countries can substitute fossil fuel related export revenue with revenues from the export of minerals required to support an energy transformation (IRENA 2019).

10.3.5 International cooperation options

There are many possible international cooperation options. Respondent 18 alone provided a set of 13 possible international cooperation options related to climate change, addressing themes such as information, sanctions, penalties and compensation, finance, oversight and regulation, subnational government participation and private sector participation. These themes and others are discussed below, including the possibility of: focusing on research and development (Section 10.3.5.1); focusing on what works (Section 10.3.5.2); carbon budgets and prices (Section 10.3.5.3); international support for localisation (Section 10.3.5.4); subnational participation in the Paris Agreement (Section 10.3.5.5); climate finance (Section 10.3.5.6); and, implementation of conditional and unconditional NDC’s (Section 10.3.5.7).

10.3.5.1 Focus on research and development

From Section 7.5.1.3, Respondent 15 indicated that dramatically increasing spending on research and development is important for an effective global response. As such, Respondent 15 suggested the “UNFCCC should focus a lot more on getting nations to spend money on research and development. It's much cheaper, it's much easier, it's also much easier to validate 'cause you can do it. You know, you can, say, just at the end of this year, you can actually see in the budget for the next year how much money you're gonna spend."

10.3.5.2 Focus on what works

With regards to focusing on what works, Respondent 3 noted the need for an international regime that consists "less of policing and more a celebration of progress that's real, sort of real economy shifts, rather than words." A key assumption is that "if our attention is around positive deviance and what are the most effective interventions within a sector or within an economy, or how to incentivize significant and real behavioural change or change in decision rules… we begin to create a race to the top, rather than policing at the bottom." In practical terms the Respondent suggested that "we need the UNFCCC process, and instruments like the Talanoa Dialogue, the Global Stock Take and the compliance mechanism's to be doing is highlighting success, rather than policing failure." With regards to information and signals that might help, "the doing business rating is a good analogy for this. Ease of doing business rating highlights the countries that are doing best." It could be possible to "set benchmark, efficiency, carbon intensity of segments of the economy."

10.3.5.3 Carbon budget and price

From Section 9.4.3, Respondent 17 noted that an effective carbon price would require global governance to set a carbon budget each year. The Respondent highlighted that this would require agreement between 190 states. Given that there would be winners and lossers, a carbon tax would likely involve transfer payments, border taxes and other mechanism all of which becomes very complex given the number of states and diverse interests involved.

10.3.5.4 Localisation

Respondent 6 noted that to initiate the localisation, "this requires horizontal diplomacy… this sort of city and business and investor grouping." and it is essential to have "a load stone in the international agreement, an idea of we're going somewhere, we can see everybody moving, and a clear sense of transparency." Respondent 6 also noted "you still need enough state to state glue to keep that going, then I think you can build out those coalitions quite strongly" and as such localisation is a matter of political will and policy regarding centralisation and decentralisation of power between state actors and non-state actors.

10.3.5.5 Subnational participation in the Paris Agreement

The sample of possible futures included the possibility of non-state actors participating in the Paris Agreement. For example, Respondent 26 noted it is possible that even with the United States withdrawing from the Paris Agreement, "you've just got states coming forward and saying, "Well, we're gonna stick with these targets and these goals then we're gonna find ways to working and feeding in what we're doing, our actions." Then and obviously cities". As such it is possible that there could be the establishment of "a framework within which that they can contribute and play a big part of..." Respondent 26 also noted "And that's why I think Paris is very interesting. It's like the architecture could exist without states. You have to have some stock taking and transparency with that reporting and engagement across different actors who are the people that are contributing to the reduction in emissions and the ones that are contributing to the adaptation".

With regards to adaptation, Respondent 18 stated "I think you'll bring in the subnational governments, I think probably outside the UNFCCC, but there'll be processes for industry and for commitments and collaboratives."

10.3.5.6 Climate finance

Respondent 16 noted that developed countries needed to provide funds because "A lot of private actors, state actors changing their ways of doing business… catalyzed by the GCF or any other, scenario in both the business they do in the developing world or in their individual countries." The respondent also noted that developing countries could have a policy of "screening the right type of businesses to come to their country" for example including businesses with "resource efficient technology" or business "investment in the renewable sector".

Respondent 9 highlighted the need for large developed countries as well as large developing countries with high emissions, to engage in mitigation. Furthermore, the respondent noted the need for "developed countries to own up to their responsibilities reducing emissions". International cooperation could come in the form of "funding, climate adaptation and mitigation projects in developing states to share technology, share environmental technologies to build capacity of other nations so that more people can live in a safer world." The Respondent also stated, "I think for finance historically developed countries, so the West, the US, Canada, the EU, Japan, Russia, historically the West but it's developed."

10.3.5.7 Conditional and unconditional NDCs

Respondent 3 noted, "because there was so much hot air, or you know, the country NDCs were actually quite low ambition, we're going to see a number of countries go further than what they said they'd do."

Respondent 10 noted conditional NDCs would require "developed countries provide… what they committed in terms of finance, in terms of the basic evolving technology". Furthermore, developed countries would see "developing countries also committing, at the highest level to contribute through the domestic tasks, using domestic resources and also efficiently use resources from, developed countries to implement, yes, measures that can contribute to green growth". Importantly, in an impact response scenario, there could be "a common goal.", i.e. common national interests.

10.4 Summary

International cooperation scenarios included concerns regarding international regimes and the tension between globalism and nationalism. Meanwhile it is possible that climate change becomes the premier global issue and a focus of international cooperation. Other possible scenarios regarded the UNFCCC becoming a secondary body coordinating climate action with the United Nations Security Council leading the global response. It is even possible that business interests could dominate international cooperation and the global response. In addition to these scenarios, possible triggers and drivers were presented along with scenarios related to leadership, geopolitical power, stringency and international cooperation options. These scenarios and themes are mapped out in Section 12.5 showing combinations that could contribute towards fulfilling the UNFCCC objective. Meanwhile, coalitions and effective international cooperation are discussed further in Section 13.8.

Chapter 11 Other scenarios

11.1 Introduction

Respondent 23 noted “we, climate people, put climate problems too much at the centre of the future.” and while the outlook is “very bad” there are “many other things that can go much worse including nuclear.” Hence the need to consider other scenarios and how they could affect climate or the global response to climate change. These other scenarios are important given the long periods of time being considered when responding to climate change, and the many other things that could happen over these periods.

From the sample of possible futures, others scenarios included: cyborgization including socioeconomic implications (Section 11.2); enlightenment (Section 11.3); volcanic eruptions (Section 11.4); solar radiation management (Section 11.5); population decline (Section 11.6); conflict (Section 11.7); catastrophic cooling events (Section 11.8); response to other events or crises (Section 11.9); and environmental feedbacks (Section 11.10). Section 11.11 summarises themes from this chapter and indicates where these themes are discussed in Chapter 13.

11.2 Cyborgization makes homo deus

After noting they had spent some time in San Diego, Respondent 11 said, “the capacity of biotechnology to change the way people look, live, their abilities to integrate technology into the human body to do genetic modification”, then “we start to see sort of the elite become more separate from the rest of humanity. That's, I think, a possibility.” Meanwhile, “the rest of humanity sort of suffers along with a more and more degraded environment.” Respondent 23 put forward essentially the same scenario, and stated, “I think the developments in biotech, genetics cyborgization” make it “inevitable that within a generation, within 50 years, the possibilities of augmenting individual powers, like the premise of the book, the Homo Deus, man god” Then there is a situation where there is, “the bifurcation of a human species between the haves and the have-nots”. The Respondent also noted that the split between the haves and the have-nots is already happening.

11.3 Enlightenment

Respondent 23 stated “I really think that there needs to be reckoning. I think we need to get sufficiently close to the edge of our humanity… [to] …recognize that we need to work together to help each other.” The respondent suggested that “Breakthroughs in artificial intelligence” could “make people recognize that we have to become a more, solidarious species.” Respondent 8 stated that “a war, a massive world war or something” is “probably going to take away the focus from the environment, and other things.” but might ultimately result in “a huge change in global leadership somehow and people's mentalities change, and their priorities.”

Respondent 22 noted that it is possible that there could be some other crisis such as global pandemic or bug causing population decline, which “would [affect] markets, it would affect politics”. Furthermore, it could “demonstrate the value of global cooperation”, and “it may enhance global cooperation” and “it might bolster the strength of the UN”.

Respondent 25, when asked about other scenarios, noted “Well, my favorite, of course, is contact with another sentient species.”, “Which… focuses the mind.”

11.4 Volcanic eruptions

Respondent 14 said “Massive volcanic eruptions… could really skew the concentrations big time.” increasing atmospheric concentrations of GHGs through a natural process. The respondent went on to say, “The volcanic eruption is a worst-case scenario for me, because that introduces a feeling of hopelessness, you know, you've got no control."

Respondent 18 noted there could be “a period of lots of volcanic eruptions.”, then “Dust and aerosols in the atmosphere… slow down the warming” for a period of time, but “then we'll have a big jump up in the warming.” Respondent 23 also put forward a volcanic eruption scenario and made the link with solar radiation management related responses (Section 11.5).

Respondent 23 noted it is possible that there could be another “Tambora-like volcanic eruption”. This “blocks so much sunlight that the planet goes through a phase of severe cooling where the science would say irrefutably that it's like a couple of years and then we go back to normal, so the climate change problem, the global warming problem will not go away.” The respondent also noted, “it may buy us a little bit of time.” Based on the experience of this event, “it may be, ‘Holy smokes’ blocking sun that like can go so wrong that, you know, we enact a law that says it cannot be done.” Alternatively, “It may end up… naturalizing geo-engineering”.

11.5 Solar radiation management and geoengineering

Respondent 15 noted that to avert catastrophic risks such as Gulf Stream switching off or the Western Antarctic ice sheet “tipping into the ocean” then “...the only way that we can actually do anything about this would be through geo-engineering. That's the only way that we can do something in, you know, say a couple of years or maybe even a couple of days… compared to any climate policy that would really take 20, 30, 40, 50 years to manifest itself in the climate system.” The Respondent also suggested, “if you're worried about these black swan events you should really be focusing a lot more on at least tracking our ability to do geo-engineering.”

Respondent 20 put forward a branching scenario where there is “even more rapid melting of Antarctic and Greenland ice sheets and those sorts of things.” or fast feedbacks (Section 11.10.3). In response to this, there is “solar radiation management”, specifically it is possible that “an individual country or even an individual wealthy person, a billionaire, could just start doing it”. Respondent 20 explored possible geopolitical responses to such unilateral solar radiation management.

Respondent 20 noted that “If it was a smaller state, I think it would become an issue at the United Nations level and possibly at the Security Council.” This could result in one of three possible situations: where the unilateral action could “force the issue, around reducing greenhouse gas emissions”; there could be a “fracturing of the United Nations body, of those countries that support them and those that don't.”; and, it is possible that to “stop them” there is “military action”, and as such unilateral solar radiation management “could lead to war.”

Alternatively, Respondent 20 noted that “if it was the United States or a China, I think people would act vociferously, or vocally, but there would be nothing left they could do about it.” Respondent 20 also noted that unilateral solar radiation management could lead “others to start doing the same”.

11.6 Population decline

Respondent 11 noted it is possible that there could be “a radical collapse in the numbers of humans on the planet” for example due to “a health issue rather than say a nuclear war or rather than a slow progression of climate change leading to social disruption leading to you know collapse of the global economic order or food production systems”. The respondent noted that something like this could be “the earth’s solution”.

11.7 Conflict

Respondent 23 noted that possibility of war for example due to macho politics, and that this could include: “scrimmages”; “some really stupid decisions will lead to war at the regional level”; and, “some really stupid decisions will lead to… devastation”. Respondent 23 noted that dealing “with global climate change, requires global institutions.” But cooperation would be undermined if other states and their leaders don’t play by the rules i.e. “if someone is going to kick the board.” The respondent also noted that conflict “will have the result of dissolving the trust in multilateral systems that keep us safe from each other.”

Respondent 6 also highlighted the possibility of “an outbreak of hot war in various places”. The respondent noted that “the distraction caused by hot war has already been a real problem for climate politics.” as “bandwidth of prime ministers and security operators… It’s completely been taken by hot wars.” Such a scenario would “lower the willingness to take on [climate] fights.”

11.8 Catastrophic cooling events

Respondent 25 noted there are multiple possible scenarios that could result in a catastrophic cooling event. These include: “A series of volcanic eruptions”; “a limited nuclear war, which would hopefully sober people up a bit.”; and, “massive disruption or a meteor strike or something like that.” These events could “precipitate rapid global cooling, knocking global economy back, or population back, through loss of agricultural production for a decade or so.” This could also “take the population of the planet back from the eight or nine to three or four billion” constituting “an existential threat in the short term”.

Respondent 25 noted that after the event, it is possible that there will be “some semblance of human societies” and perhaps “a chance to start over in a way.”, because the event has happened “without destruction of the whole fabric of civilization as we know at present. Some of the institutions would survive, maybe the UN survives, maybe, you know, the telephone networks survives, the internet survives, or loses chunks of it for a while”.

Respondent 25 also noted an alternative scenario, where the event would “blow our civilization down to the level of, sort of, medieval warlords and shit like that.” It is even possible that “human civilization is wiped out all but for a few leftover pockets of humanity going back to, neolithic hunter gatherer kind of things. If that happens, well, I mean, you would've fulfilled Article Two, but nobody would know what the fuck that was.”

11.9 Response to other events or crises

Respondent 22 provided a scenario where there is some other global event and asked if it is climate change related. If so, it may help generate a global response to climate change, but if not, it may distract from the global response to climate change.

11.10 Environmental feedbacks

From the sample of possible futures, several environment feedback themes and issues were identified, including: methane related feedbacks (Section 11.10.1); ocean heat release (Section 11.10.2); and feedback related ecosystem adaptation (Section 11.10.3).

11.10.1 Methane feedback

Respondent 17 expressed concern around permafrost melt related GHG emissions and methane hydrate stability, noting it is possible that “you just end up with this you know, 10-year very dramatic spike because it doesn't have such a long atmospheric life”. The respondent suggested that such an even “would be very hard to detect in a way because we're not emitting it. And the frozen tundras not a lot of people there.” The respondent also asked, “And how would you stop it?”

Respondent 21 expressed similar concerns around permafrost related GHG emissions and noted that “it could be responded to in one of two ways.” including “look after ourselves.” or “let's start doing something about it together”. Panicking is also a possibility. The Respondent noted “if you're in rich country … or as an individual will be fine and hence that's why you don't do it”. From Section 7.5.1.1 the Respondent indicated cooperation is much more beneficial.

11.10.2 Ocean heat release

Respondent 18 noted “oceans have been making things better right now.”, absorbing heat and taking it to the depths, but when this heated water comes to the surface again, atmospheric “warming is going to accelerate.” The Respondent noted “Impacts will be even more severe [and] hopefully that means our actions and response will be quicker.” It should be noted that there is a question as to how long such heat release would take to manifest.

11.10.3 Feedbacks and ecosystem adaptation

Respondent 20 noted, “something could happen as a combination of positive feedbacks, where we have a massive rapid warming… fast feedbacks” for example due to “the release of a lot of CO_2 and methane from the melting permafrost in the Northern Hemisphere.” Then this, “begs the question whether ecosystems have the ability to adapt to changes and a fast feedback for greenhouse gas emissions rapidly increasing atmospheric concentrations it would be analogous to a super volcanic eruption or a meteorite impact for example, that we've seen in the geological past “and “we could see a collapse in agricultural systems and a mass die off of species.”

Respondent 20 also noted, “We know that the planet, is extremely sensitive to even minor environment changes in temperature, especially increases in temperature so we know the climate, it takes several thousand years for the planet to cool into an ice age, but over a few centuries, the temperature can rise significantly”. Furthermore, in previous warming events over short geological period of time, “ecosystems have adapted because… plant and animal communities” were “still able to migrate.” However, “with changes that are happening now potentially so quickly that they won't have time to” adapt, and, “humans have altered the planet so much we've got cities and roads and farm areas… which present barriers to migration and natural eco-systems, so it's a double whammy.”

11.11 Summary

Given the long periods of time being considered when addressing climate change, it is important to be aware of other possible scenarios that might influence climate or the global response to climate change. From the sample of possible futures, a mix of wild and human events or processes were identified that could influence climate or the global response to climate change. Possible wild events and processes include volcanic eruptions, environmental feedbacks and catastrophic cooling events. Possible human events and processes include cyborgization of humanity exacerbating inequities, enlightenment, population decline, geoengineering as a backup option to feedbacks, conflict including nuclear war, as well as the possibility of solar radiation management technologies being deployed. These other scenarios could influence climate or the global response and are discussed further in Section 13.10.

Part IV: Analysis, discussion and conclusions

Part IV: Analysis, discussion and conclusions consists of three chapters:

Chapter 12 analyses themes and scenarios from the searchable sample of possible futures, mapping possible climate change signals, responses and pathways.

Chapter 13 discusses the key questions from the introduction with a focus on preconditions for effective global responses to climate change.

Chapter 14 summarises the findings of the study and highlights the contributions of the study to knowledge while also recommending further research on some issues.

Chapter 12 Analysis of themes and scenarios

12.1 Introduction

This chapter analyses the themes and scenarios presented in Chapters 6 to 11 and provides a basis for the discussion in Chapter 13. Section 12.2 analyses themes from Chapter 7 and Chapter 9 related to the question of how climate change impacts and risks might influence the global response to climate change, and develops a climate change signal response model. Section 12.3 analyses the actors, interests and actions involved in global responses based on the themes from Chapter 8. This includes mapping possible preconditions and responses related to social change and behaviour, political will and policy as well as business and economic activity. Section 12.4 analyses preconditions for actors to remove GHGs from the atmosphere at a scale required to limit climate change to safe levels based on themes and scenarios from Chapter 9. Meanwhile, Section 12.5 analyses preconditions for effective international cooperation on climate change, based on themes and scenarios from Chapter 10.

12.2 The global response system

The CCNIIC Model of the global response system was developed in Section 3.3.2 addressing interactions between climate change, national interests and international cooperation, but did not address the question of how actors might respond to climate change impacts and risks. Table 12-1 follows the CCNIIC Model, provides definitions for overarching themes from Figure 6-4 (Section 6.3), and makes a distinction “impacts and risks” and “responses”.

Table 12-1: Summary of overarching themes and definitions organised in relation to the CCNIIC Model.

	Overarching theme	Definition
Impacts and risks	Climate change	
	Physical systems	Any system in which physical processes play a major role. This includes glaciers snow, ice, permafrost, rivers lakes, floods, drought, coastal erosion, and sea level effects.
	Biological systems	Any system in which organisms play a major role. This includes terrestrial ecosystems, wildfire and marine ecosystems.
	National interests	
	Human and managed systems*	Any system in which human organizations and institutions play a major role.* This includes food production, livelihoods, health and economics.
	Responsiveness	The extent to which human actions, or inactions, are timely and sufficiently scaled to fulfil the UNFCCC objective.
Responses	Social change and behaviour	The interests of people, as individuals, households and communities, and the actions, or inactions, these people might individually or collectively take.
	Political will and policy	The ambition level of government leaders, and others in government when it comes to positions on climate change, and the interventions they make that influence fulfilment of the UNFCCC objective.
	Business and economic activity	Actions, or inaction, by individuals or groups undertaking productive activities, in many cases driven by a profit motive.
	Technology and practices	Methods including objects, activities, rules and knowledge used when attempting to achieve something.
	Other factors	Other things that can influence the global response to climate change.
	International cooperation	
	International regime	The rules and norms that guide interactions between actors from different states. This includes state actors and non-state actors.
	International cooperation on climate change	Actors from different states acting together to address climate change. This includes state actors and non-state actors.

* *IPCC 2018c*

The distinction between climate change “impacts and risks” and “responses” by actors is important as it provides a basis for understanding how actors might respond to climate change. Based on this distinction, and the results of the thematic analysis in Chapter 7 and concepts from Chapter 2 and Chapter 3, a “signal response model” for the global response system is developed, with Sections 12.2.1 analysing the climate change signal including signal strength and Section 12.2.2 analysing possible responses.

12.2.1 Climate change signals

A signal is information about a situation, system conditions or phenomena that influences decisions. While signals generally regard current situations or system conditions, they can be used to monitor phenomenon and assess future risks. From Section 3.2.4, the TCFD identified two broad types of risk related to climate change, consisting of physical risk and transition risk (TCFD 2017). From the sample of possible futures, both physical and transition risks are identified along with impacts. With these things in mind, Section 12.2.1.1 analyses physical signals (i.e. impacts and risks), Section 12.2.1.2 analyses physical signal strength, and Section 12.2.1.3 analyses transition risks and the influence these risks might have on actors and their ambition levels.

12.2.1.1 Physical signals

Physical signals regard climate and related physical hazards from the CCNIIC Model in Section 3.3.2 and the interactions these hazards have with domestic state and non-state actors. Conceptually, physical signals could include an actor’s own experiences, news reports, research or risk analyses. From the literature and sample of possible futures, there are a range of physical signals identified, including: climate science (Section 2.2.2); impacts on human and managed systems (Section 7.4.2.1); risks to human and managed systems (Section 7.4.2.2); impacts and risks to natural systems (Section 7.2.3); and, the IPCC’s five reasons for concern (Section 2.2.3).

Importantly, from the sample of possible futures, impacts and risks to human and managed systems are the only identified drivers of effective global response scenarios (Section 7.2.3). Following the IPCC’s conceptual model for understanding climate change related risks (see Figure 3-1 in Section 3.2.1) impacts and risks to human and managed systems consist of climate change and related hazards (i.e. climate stress) coupled with the exposure and vulnerability of actors and their interests (Figure 12-1).

It is important to note here that the concept of “climate stress” builds on work by Warner and van der Geest who identified and defined “climate change stressors” as the “Manifestations of climate variability and climate change in specific ecosystems (for example, rainfall variability, droughts, floods, cyclones and tropical storms, glacial melt, sea-level rise, etc.). This could involve extreme weather-related events and more gradual changes.” (Warner and van der Geest 2013, p. 369). Given that “people are integral parts of ecosystems” (Millennium Ecosystem Assessment 2005, p. V), human and managed systems can be stressed by these manifestations of climate change.

Even though climate change signals generated by “climate science” or “impacts and risks to natural systems” don’t appear sufficient to generate effective global responses to climate change based on the sample of possible futures (Section 7.2.3), that doesn’t mean they don’t create a signal. Climate change signals from “climate science” or “impacts or risks to natural systems” are related to actor interests by “concern” rather than “exposure” or “vulnerability” of actors, their property or livelihoods. Hence the dashed lines linking “climate science” to “actor interests” and “climate change and related hazards to natural systems” to “actor interests” in Figure 12-1.

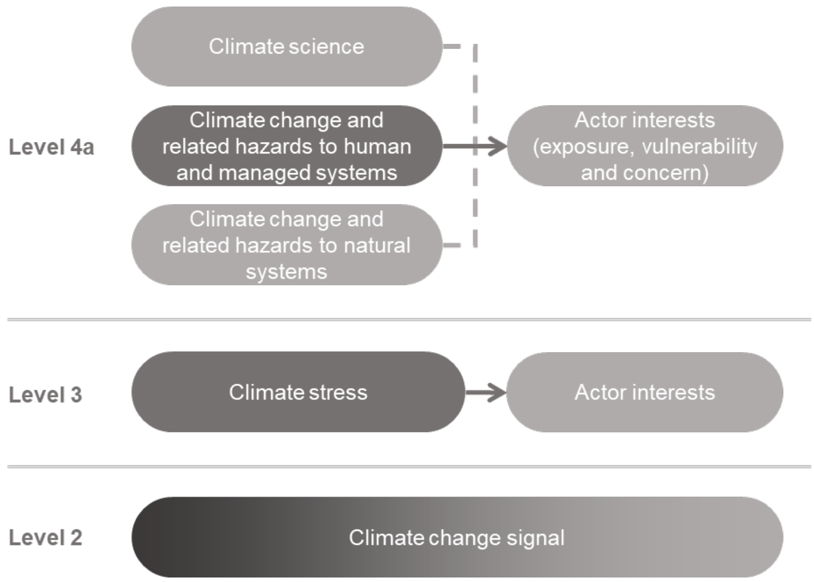

Figure 12-1: Climate change signal as a function of climate stress primarily in the form of hazards to human and managed systems, and actor interests including exposure, vulnerability and other concerns.

The IPCC’s “reasons for concern” include the risk of impacts to a mix of natural, managed and human systems (Section 2.2.2) and represents forms of climate stress. With regards to generating a climate change signal, the “distribution of impacts” (i.e. RFC 3) is particularly important as it is the distribution of impacts that dictates which actors and interests are affected and the extent to which they are affected by various “reasons for concern” (Figure 12-2).

Note: Levels in Figure 12-1, Figure 12-2 and subsequent figures refer to levels of disaggregation, with concepts broken down further into constituent parts with each additional level.

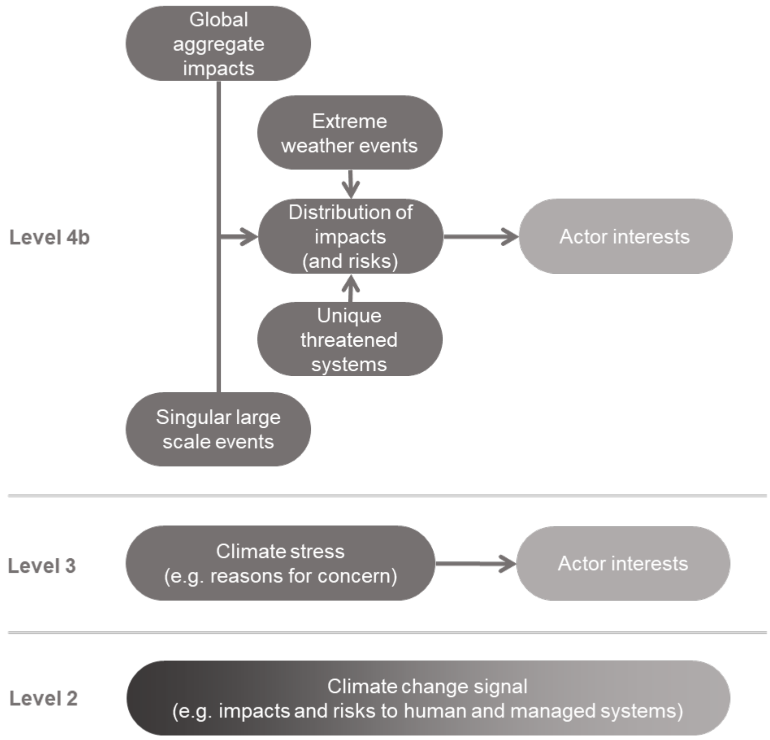

Figure 12-2: Alternative climate stress breakdown based on the IPCC's reasons for concern including the distribution of impacts (and risks) on actor interests.

12.2.1.2 Physical signal strength

To understand the strength of the climate change signal, a qualitative analysis was made of IPCC assessment report summaries for policy makers, as well as the IPCC's projections regarding reasons for concern and the risk of impacts. From Section 2.2.2 and Appendix B, it's possible to get a qualitative sense of the strength of the climate change signal, by focusing on impacts on human and managed systems. For example, the IPCC's first assessment did not identify any impacts, and the Second Assessment Report stated, "Unambiguous detection of climate-induced changes in most ecological and social systems will prove extremely difficult in the coming decades." (IPCC 1995, p. 6). It was not until the Fifth Assessment Report published in 2014, that the IPCC stated, "Some impacts on human systems have also been attributed to climate change, with a major or minor contribution of climate change distinguishable from other influences." (IPCC 2014a, p. 6).

According to the IPCC's reasons for concern, with current levels of global warming at 1 °C, the risk of impacts is undetectable to moderate. From Figure 2-7 in Section 2.2.3, it's possible to get a sense of how the climate change signal might strengthen because the IPCC plotted the risk of impacts against global warming levels for the five reasons for concern as well as eight other concerns regarding natural, managed and human systems. While the IPCC (2018a) did not state which of these other concerns can be considered part of human or managed systems, small-scale low latitude fisheries, coastal flooding, fluvial flooding, crop yields, tourism, and, heat related morbidity and mortality are taken to be human and managed systems that collectively contribute to climate stress signals. As such, Table 12-2 is based on the IPCCs assessment and shows physical stress levels at 1°C, 1.5°C and 2°C.

Table 12-2: Summary of impact and risk levels on human and managed systems at 1°C, 1.5°C and 2°C of global warming, including generalised climate stress levels. Source: Author compiled from IPCC 2018a.

Reasons for concern:	Current risk of impacts (~1°C of global warming)	Risk level at 1.5°C	Risk level at 2°C
Coastal flooding	Moderate	High	High to very high
Fluvial flooding	Undetectable to moderate	Moderate	High
Crop yields	Moderate	Moderate	Moderate to high
Tourism	Undetectable to moderate	Moderate	Moderate to high
Heat-related morbidity and mortality	Moderate	Moderate to high	Moderate to high
Physical stress	**Undetectable to moderate**	**Moderate to high**	**Moderate to very high**

The results from Table 12-2 are presented together with climate stress levels (see first paragraph of this section) to create a qualitative time series of climate stress levels in Table 12-3, including past, present and projected estimates. Importantly, from the analysis, a definitive climate stress signal only emerged in 2014. There has been evidence since the IPCC started making assessments that the climate is changing and this constitutes a risk, but the signal most important to actors, in the form of impacts on human and managed systems, only emerged the year before the Paris Agreement was negotiated. Furthermore, the signal is expected to strengthen marking a fundamental and unprecedented shift in system conditions, one where the climate change phenomenon increasingly and directly affects actors and their interests. The implications of a strengthening climate change signal, from Table 12-3, are discussed further in Section 13.6.

Table 12-3: Qualitative assessment of climate change signal strength to date and anticipated signal strength in the future. Sources: Author based on a qualitative analysis of IPCC assessment report summaries for policy makers and IPCC 1.5 Degree Report.

Year	Signal strength	Impacts on human and managed systems
1992	No signal	No impacts identified
1995	No signal	“Unambiguous detection of climate-induced changes in most ecological and social systems will prove extremely difficult in the coming decades.” (IPCC 1995, p. 6).
2001	Possible signal	“there are preliminary indications that social and economic systems have been affected.” (IPCC 2001, p. 6)
2007	Emerging signal	“There is medium confidence that other effects of regional climate change on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers.” (IPCC 2007, p. 3)
2014	A signal	“Some impacts on human systems have also been attributed to climate change, with a major or minor contribution of climate change distinguishable from other influences.” (IPCC 2014, p. 6).
2018*	Undetectable to moderate	Risk of impacts on human and managed systems undetectable to moderate at ~1°C of global warming (IPCC 2018a)
2030-2052*	Moderate to high	Risk of impacts on human and managed systems moderate to high at 1.5°C of global warming (IPCC 2018a)
Before 2100	Moderate to very high	Risk of impacts on human and managed systems moderate to very high at 2°C of global warming (IPCC 2018a)

* The IPCC 1.5 Degree Report stated “Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.” (IPCC 2018a, p. 4)

12.2.1.3 Transition risks

Transition risks and opportunities regard response-oriented options from the CCNIIC Model available to state and non-state actors (Section 3.3.2). Transition risks include changes in policy, consumer behaviour and economic activities. The influence transition risks have on climate ambition and related actions depends on the situation and perspective of the actor. If a transition is perceived to be a cost, then a transition is a risk to the actor and the actor's climate ambition levels may be supressed or be negative (e.g. cynical responses in Section 12.2.2). If a transition is perceived to be a benefit, then a transition is an opportunity and the actor's climate ambition levels may be enhanced (e.g. "winning team" in Section 8.4.4). As such, transition risks are contentious and can generate a mix of support for, and resistance to, climate action and consequently may enhance or suppress collective ambition levels (Figure 12-3).

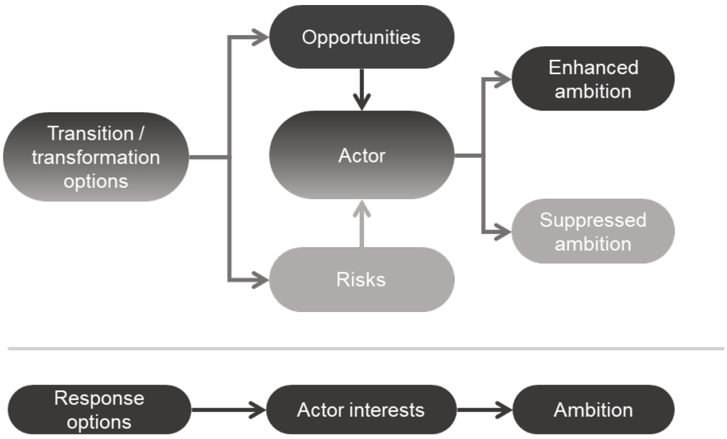

Figure 12-3: The influence of transition and transformation options and actor interests on climate ambition.

According to Rogelj et al. (2018), a transformation is required if adaptation and mitigation are to stabilise atmospheric concentrations of GHGs at safe levels with minimal GHG removals or risk of breaching tipping points. As such, there is a case for including "transformation risk" as a new category of risk, which is similar to transition risk, but much more disruptive to: businesses reliant on greenhouse gas emitting technologies or practices; and, consumers, individuals and households (including smallholder family farms) reliant technologies and practices that emit GHGs or reduce resilience. The possibility of unintended consequences of rapid climate action further amplifies risks associated with response options.

12.2.2 Responses

Understanding what makes an effective global response is a central part of this study. As such, it is important to understand the range of possible responses and which of these responses are more likely to be effective. Figure 12-5 highlights the global response system (Level 1), the "climate change signal" and "response" (Level 2). Level 3 shows the response has three parts consisting of "actor decision making", "actions" and "contributions to the global response". Level 4 is the most detailed level of the model and includes several variations depending on which elements of the system are being highlighted.

In Figure 12-4, at Level 4, actor decision making is made up of “triggers and drivers”, “attitudes” and “options considered” as well as other factors, specifically “actor capacity” to implement and develop “technologies and practices” and “actor power and influence” to change “institutions” and hence the options available for consideration. From Section 9.4, actor capacity and power are important elements of the global response. The capacity to develop and apply technologies and practices influences the technologies and practices available to an actor as well as other actors in the future. Meanwhile the power to influence other actors and institutional arrangements can influence which options are encouraged, regulated or even prohibited and as such also influences options available to other actors.

Figure 12-5 unpacks “actor decision making” including “triggers and drivers” (Section 7.4), response “attitudes” (Section 7.5), and “options considered”. Response triggers and drivers include “cost benefit responses”, “enlightened responses” or “emergency responses”. Meanwhile, no-trigger responses include “non-responses” for example due to hopelessness, apathy or hypocrisy, or “cynical responses” where special interests are privileged ahead of climate change. Response attitudes include “defensive”, “cooperative”, “technological” and “competitive” attitudes. Importantly, triggers and drivers are related to levels of ambition, with cynical responses consisting of negative ambition and emergency responses are very high ambition responses.

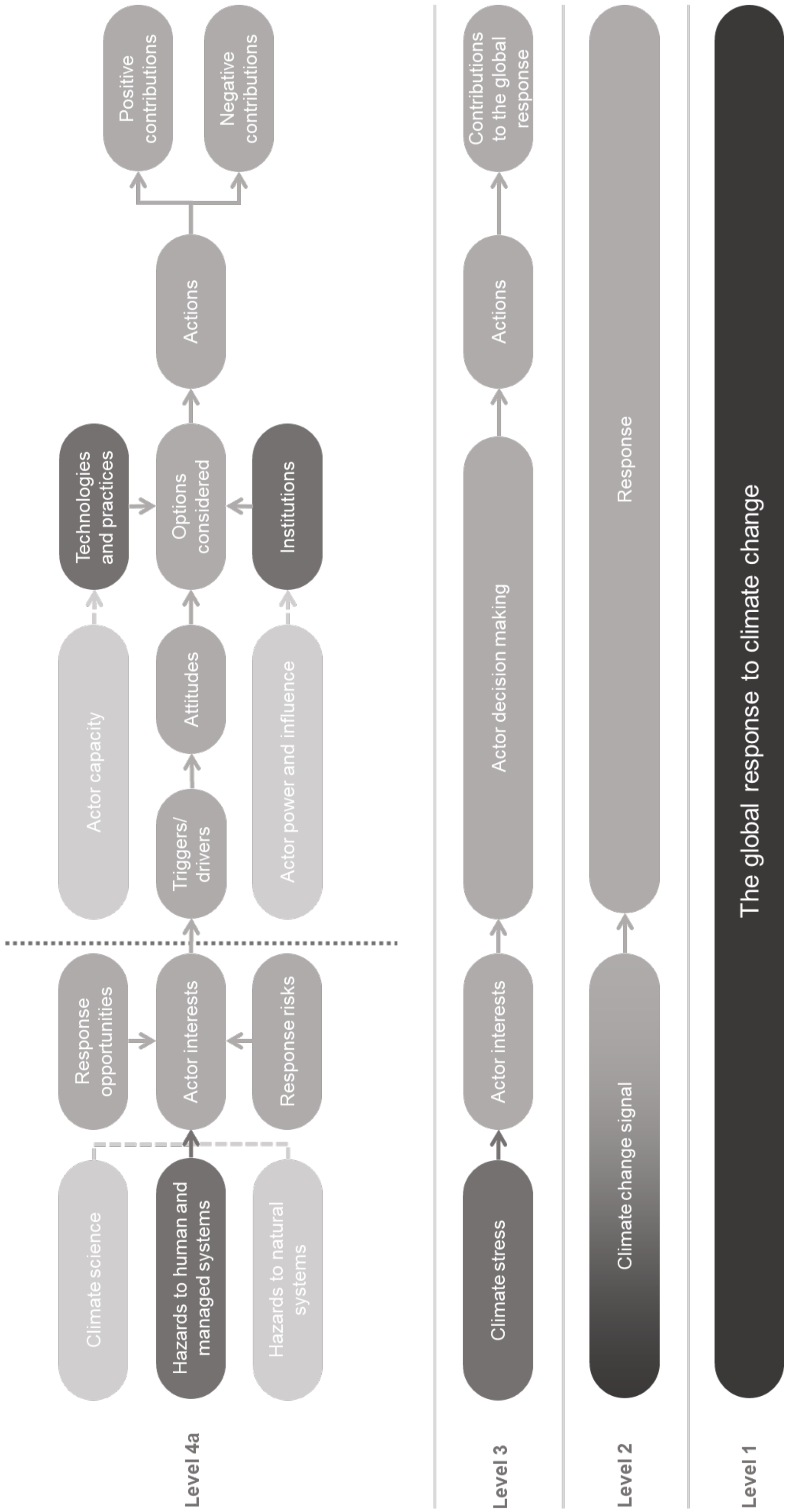

Figure 12-4: The global response presented as a climate change signal response system.

It is worth noting, triggers and drivers identified in Section 7.4 are related to Grubb's (2014) climate change risk conceptions and strategies (Section 3.2.3). These risk conceptions and strategies consist of: "indifferent or disempowered" which is a "non-response"; "tangible and attributed costs" where the "costs and benefits" of acting are weighed up; and, "disruption and securitisation" where there is a belief that there is a personal or collective "security" risk and climate change is seen as a threat multiplier (Grubb 2014). Importantly, "Tangible and attributed costs" of climate change involves technocratic valuation and responses happen when "impacts rise above the noise" (Grubb 2014, p. 48) i.e. when there's a discernible climate change signal. Meanwhile, Grubb's (2014) "disruption and securitisation" is equivalent to "emergency responses" identified from the scenarios, where there is urgency and ambition to address climate change. Grubb (2014) noted that disruption and securitisation involves "containment and defence" strategies with the aim of mitigating as much as possible and adapting to impacts.

The triggers and drivers identified from the sample of possible futures extend climate change risk conceptions and strategies from Section 3.2.3. For example, from Section 7.4 it's possible there could also be cynical responses to climate change, incidental positive contributions to the global response to climate change, enlightened responses, or security driven responses with the aim of "containment and fix". As such, Table 12-4 builds upon Grubb (2014) and Table 3-1 from Section 3.2.3, addressing: ambition levels; response triggers, drivers and related strategies; the justification and framing of decisions; decision criteria and the types of options considered; and, climate change related actions. Importantly, the distinction between cost benefit responses and emergency responses aligns with a discussion in the IPCC 1.5 Degree Report regarding decision criteria in the form of cost benefit analysis versus cost effectiveness analysis (Table 12-5) as well as work by Grubb (2014). Grubb (2014) highlighted that when actors conceive the climate change problem in terms of tangible and attributed costs, then these actors "act at costs up to the 'social cost of carbon'", reflecting a cost benefit analysis approach (i.e. economic response) to the problem of climate change. However according the Grubb (2014), when actors conceive of climate change in terms of "disruption and securitisation" then they follow a "containment and defence" strategy (see Table 3-1 from Section 3.2.3), which along with containment and fix constitute emergency responses (Table 12-4).

Importantly, emergency responses align with a cost effectiveness analyses, where the goal is set and any economic analysis is around how to achieve the goal for least cost, given acceptable levels of risk, rather than whether to act or not which is the question being addressed with cost benefit analyses. In such scenarios, "...the willingness to pay for imposing the goal..." can be interpreted as "...a political constraint." (Rogelj et al. 2018, p. 150). From the sample of possible futures, respondents indicated that it may not be until a warning light "starts flashing amber or red" that there is an effective global response (Section 8.3.2). It was also noted that responses to climate change will be inadequate if treated as a costs benefit analysis issue, but might be effective if climate change becomes a national security issue (Section 7.4.2.3). As such, an emergency (i.e. a crisis or catastrophe rather than a rhetorical emergency) may be a possible important precondition for an effective response to climate change.

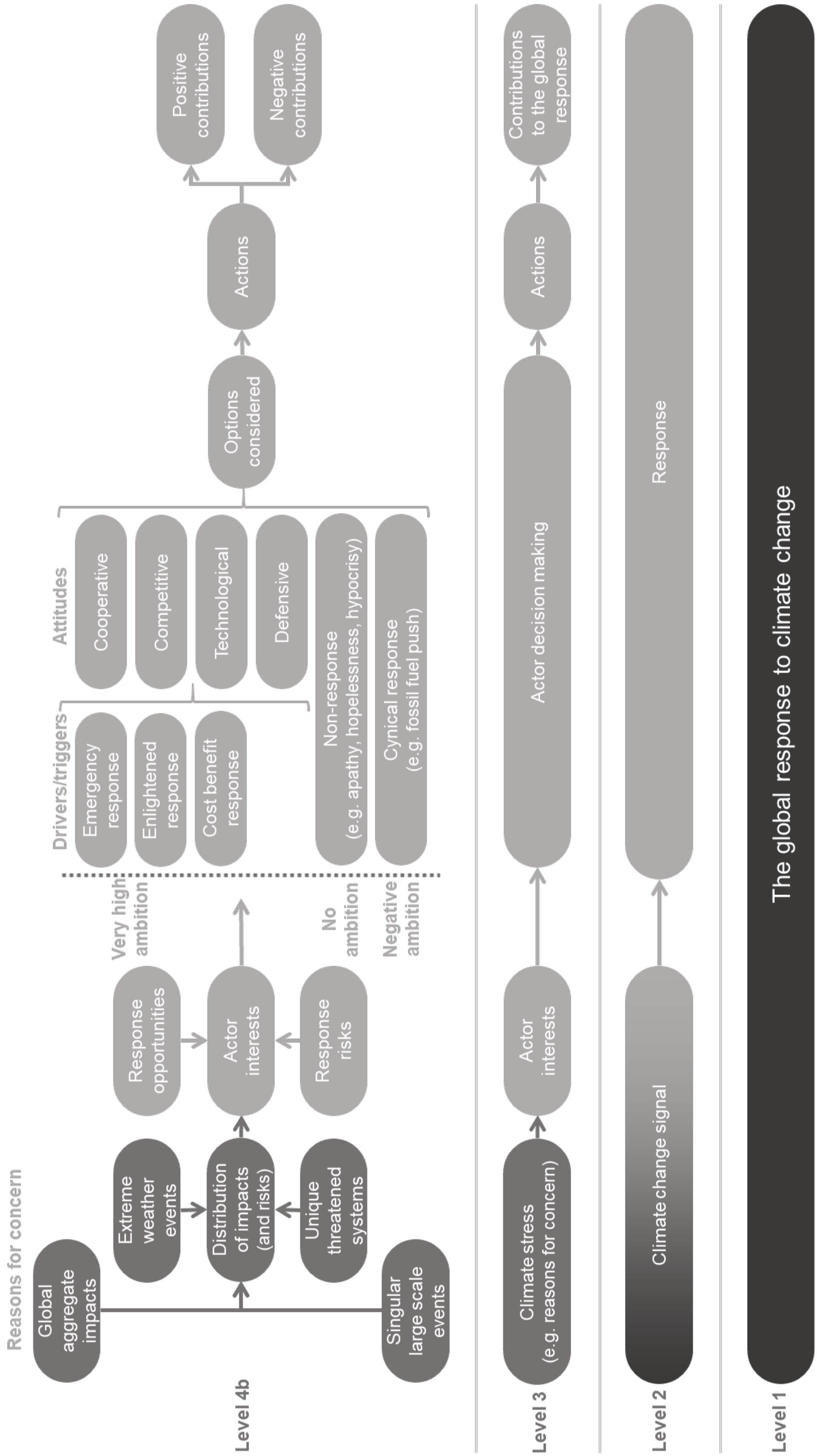

Figure 12-5: The global response to climate change with decision making including response triggers and drivers, and response attitudes unpacked.

From Section 7.3, the scale and timeliness of the global response is very important. Each of the response types in Table 12-4 have implications on the timeliness and scale of global response to climate change, due to strategies involved and related decision criteria.

Table 12-4: Climate change triggers and drivers, strategies, justifications, decision criteria and related actions. Source: Author building on the work of Grubb (2014).

Ambition	Trigger/driver (strategy)	Justification and framing	Decision criteria and types of options considered	Actions
Negative	**Cynical response** (non-cooperation)	**Special interests**: the extent to which special interests benefit	Special interests and the extent to which these can be enhanced regardless of climate change. Mitigation, removals and low carbon development options not considered	Deliberate negative contributions, "drill baby drill"
None	**Non-response** (free riding and no cost contributions)	**None**: Denial*, apathy or hopelessness leading to inaction or incidental helpful contributions to the global response to climate change.	Mitigation, removals and low carbon development options not considered. Adaptation to impacts are considered and only acted upon for reasons of self-preservation.	Incidental negative contributions to the global response, "ignorance is bliss"*
				Incidental positive contributions to the global response
Low to high	**Cost benefit response** (competition and cooperation)	**Cost benefit analysis**: Decisions to act on climate change are based on costs and benefits of the options being considered	Low ambition criteria NPV (climate action) > 0	"Act at costs up to social cost of carbon"*
			Moderate ambition criteria NPV (climate action) ~ 0	
			High ambition criteria NPV (climate action) < 0	
High to very high	**Enlightened response** (cooperation)	**Evidence** of impacts, risks and need to limit climate change and its impacts	The extent to which collective action, including behavioural changes, will fulfil the objective of limiting climate change and its impacts.	Collective action on adaptation and mitigation
Very high	**Security response** (cooperation and coercion)	**Security**: Climate change is a clear and present danger. It has been decided that climate change needs to be acted upon and now it is a question of what can be achieved with the resources available	A decision is made on a defensive outcome or approach (e.g. adaptation) taking into account willingness to pay for (and afford) the options available. Once an outcome or approach is decided, the most cost-effective options for achieving this within an acceptable level of risk are assessed and selected.	"Containment and defence"*
			A decision is made on an outcome or approach including containment (e.g. adaptation) and a fix (e.g. mitigation, removals or other geo-engineering interventions) taking into account willingness to pay (and afford) the options available. Once an outcome or approach is decided, the most cost-effective options for achieving this within an acceptable level of risk are assessed and selected.	Containment and fix

** Grubb 2014*

With regards to "no trigger" cynical and non-responses, the key issue for the global response is that other actors have to do more to compensate for negative contributions to the global response (Appendix T). However, it is important to note, incidental positive contributions to the global response are also possible due to changing incentives. For example, when it comes to the decreasing cost of renewable energy, it is possible that non-responses could make a very large positive incidental contribution to the global response to climate change, if actors engage in these technologies due to low costs rather than climate change considerations.

Table 12-5: Cost benefit analysis, cost effectiveness analysis and social cost of carbon from the IPCC 1.5 Degree Report. Source: Rogelj et al. 2018.

Concept	Purpose
Cost benefit analysis	Identify the optimal emissions trajectory minimising the discounted flows of abatement expenditures and monetized climate change damages (Boardman et al., 2006; Stern 2007)
Social cost of carbon	The total net damages of an extra metric ton of CO_2 emissions due to the associated climate change (Nordhaus 2014; Pizer et al. 2014; Rose et al. 2017)
Cost effectiveness analysis	Identifying emissions pathways minimising the total mitigation costs of achieving a given warming or GHG limit (Clarke et al. 2014)

Trigger responses include risk responses, impact responses, cost benefit responses, enlightened responses (including cooperation responses) and emergency responses. If all other factors are equal, then a risk response is more timely than an impact response (Appendix T). The lag in climate change impacts manifesting themselves is important in this regard, as a global impact response relying on mitigation will likely lock in the range of hazards being experienced as well as the risk of other changes in conditions and hazards. Global risk responses relying on mitigation could limit the lock in of future risks, as the response is ahead of impacts being manifested. Likewise, a global emergency risk response is much better than global emergency impact response, where the conditions generating the emergency may already represent the new normal, unless there is substantial adaptation and measures to improve resilience, coupled with mitigation and greenhouse gas removals. Cost benefit responses weight impacts and the immediate cost of responding higher than risks or the benefits of limiting future climate change.

Response attitudes can also influence the timeliness and scale of the global response as they have a strong bearing on the options likely to be considered, as well as the coherence of a global response (Appendix T). From the sample of possible futures, defensive response attitudes seemed likely to result in fragmented and ineffective responses to climate change (Section 7.5.1.1). Cooperative responses have the potential to generate coherent effective responses but only if there is participation, compliance and stringency (Bodansky 2012, Bodansky and Diringer 2010, Wilson 2015, Stavins et al. 2014) (Section 3.3.3). Interestingly, competitive responses could generate coherent effective responses to climate change, due to a common focus for example on a technology or business model (Section 7.5.1.2). However, whether competition makes positive or negative contributions depends upon the technologies and practices being incentivised and the extent to which these things make positive or negative contributions to the global response. Technological response attitudes tend to see every problem as being something technology can solve, but concerns were raised around the extent to which such attitudes simply drive greater consumption (Section 9.2.4) and wastes related to production.

It should be noted here that Table 12-4 presents the widest possible range of strategies, decision criteria and actions. These strategies, decision criteria and actions are framed as “responses to climate change” and the language used reflects this i.e. is biased by the framing.

12.3 Actors, interests and actions

Given the availability of options to address climate change, one of the research questions from Section 1.6 regarded the conditions under which actors would act on these options. As such, actors, their interests and actions are an important part of the study. From the thematic analysis of scenarios in Chapter 8, three broad categories of actors with coupled options and actions were identified, consisting of social change and behaviour, political will and policy, as well as business and economic activity. By having a limited number of actors and interests identified, rather than multiple sectoral breakdowns for example related to energy, agriculture, industry, various populations or demographics, analysis of the global response system is kept manageable and the main features of the global response systems can be identified.

Figure 12-6 presents actor-interest themes (i.e. social change, political will and business) as centres of decision making with related option-action themes in the form of behaviour, policy and economic activity. From Chapter 9, technologies and practices featured in many scenarios as they provide actors with options. In addition to the availability of options, there are a range of other factors that influence decision making, including prices, the costs of different options, the availability of finance or even contractual and legal arrangements. In addition to these things, there is the issue of leadership, for example from civil society, government or business, that can reframe and link issues, and influence which options are considered.

Table 12-6: Types of actors, interests, options that collectively form national interests, along with the actions that collectively constitute the domestic response to climate change.

Domestic actors in a 2-level game	Actors mentioned in scenarios	Actor-action themes	
		Actor-interests	Options/actions
State	Central government	Political will	Policy
Domestic non-state actors	Local government		
	Business, private sector, shareholders, investors, finance	Business	Economic activity
	Society, people, individuals, households, groups, civil society	Social change	Behaviour

Drawing on themes and scenarios from the sample of possible futures, a thematic chain analysis was conducted (Section 5.4) with possible preconditions mapped, along with possible responses and follow on conditions, related to social change and behaviour (Section 12.3.1), political will and policy (Section 12.3.2) as well as business and economic activity (Section 12.3.3). These maps show possibilities which could happen in various combinations. These maps generally don’t attempt to show the level at which these possibilities might happen, for example at national or subnational levels. Furthermore, these maps don’t attempt to contextualise or anticipate which combinations might happen in particular jurisdictions. Interactions between actors and interests are also analysed (Section 12.3.4) along with incentives, ambition and related responses (Section 12.3.5).

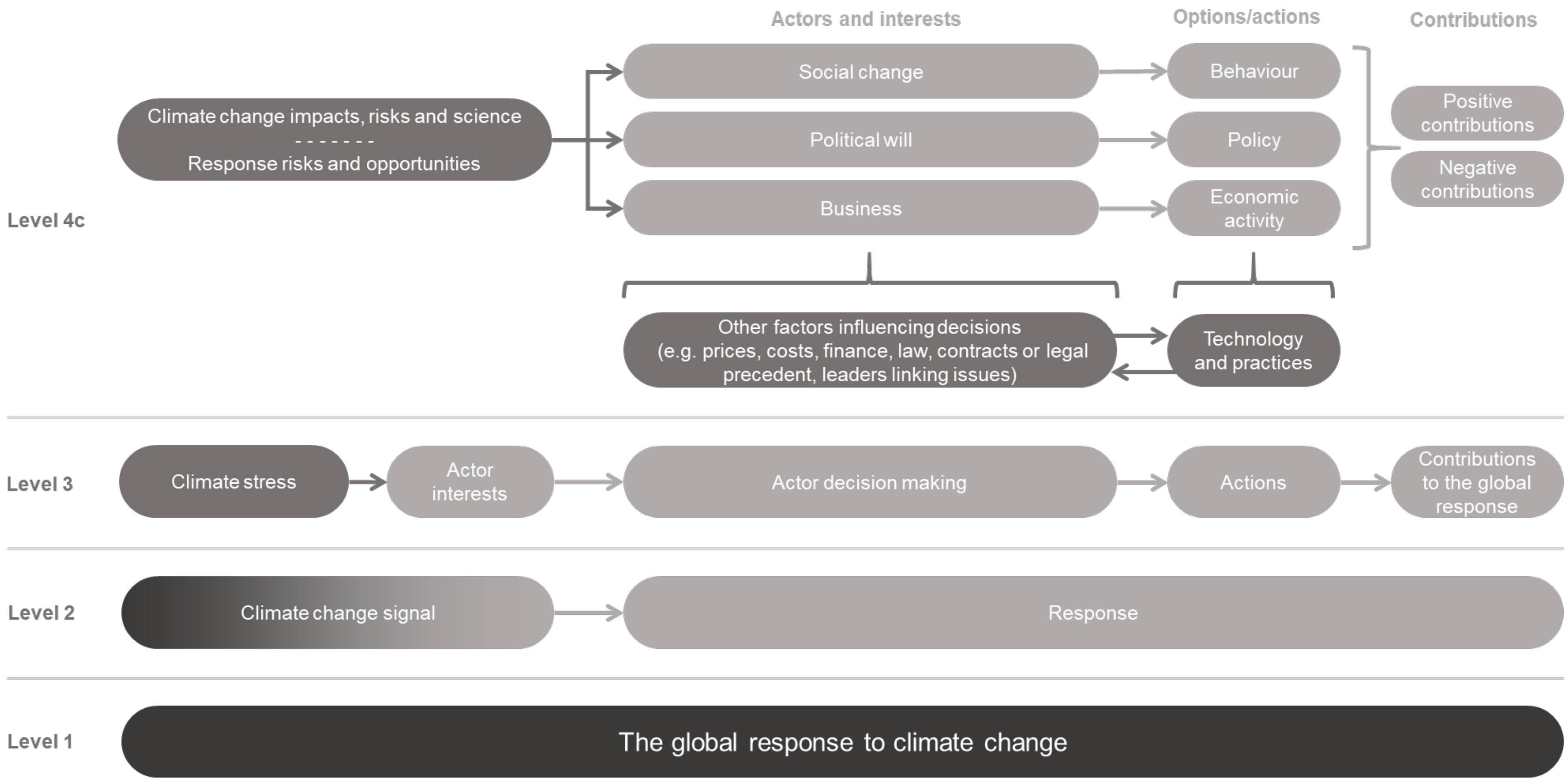

Figure 12-6: Other factors, technologies and practices and the influences these things can have on actors and interests as well as options and actions.

12.3.1 Socially driven responses

Social change and behaviour regards the interests of people, as individuals, households and communities, and the actions, or inactions, these people might individually or collectively take. Figure 12-7 maps social change and behaviour related themes and scenarios from Section 8.2, including climate change signals and preconditions for social change and behaviour, as well as follow on conditions influenced by social change and behavioural responses.

Social change and behaviour scenarios include impacts and risks to human systems as triggers and drivers (Section 8.2.1). The distribution of impacts could be an important influence with regards to social change and behaviour, for example if wealthier people are impacted, then they might influence institutions and political will more effectively than poorer populations affected. It is possible that social change and behaviour could be driven by information on climate risks in a risk response scenario. Leadership, including political leadership, could help drive social change and behaviour, as well as movements for example youth led movements (Sections 8.2.2 and 8.2.4). Enlightenment could either happen in advance of climate change impacts or as a response to climate change impacts (Section 8.2.3). It is also possible that enlightenment might be influenced or driven by other issues, for example responding effectively to some other crisis, as well as climate change.

In various scenarios, social change and behaviour influenced political will and policy as well as business and economic activity. For example, social change and behaviour included changes in consumption, demanding accountability of businesses and their activities in relation to climate change, as well as other influences on businesses and economic activity for example through shareholders or changes in business culture reflecting societal changes (Section 8.2.5).

With regards to behaviour and consumption, from Section 8.2.5 it was noted that behaviourally virtuous acts (with positive contributions to the global response) tend to be followed by wicked acts (with negative contributions), undermining the global response. Furthermore, any money that is saved by these virtuous behaviours may be spent on things that emit greenhouse gases, hence the “rebound” effect discussed in economic literature (e.g. Wei and Liu 2017). As such, there was a view that individual behaviours have limited influence on global responses to climate change and scepticism that behavioural change can lead to systemic change at scale.

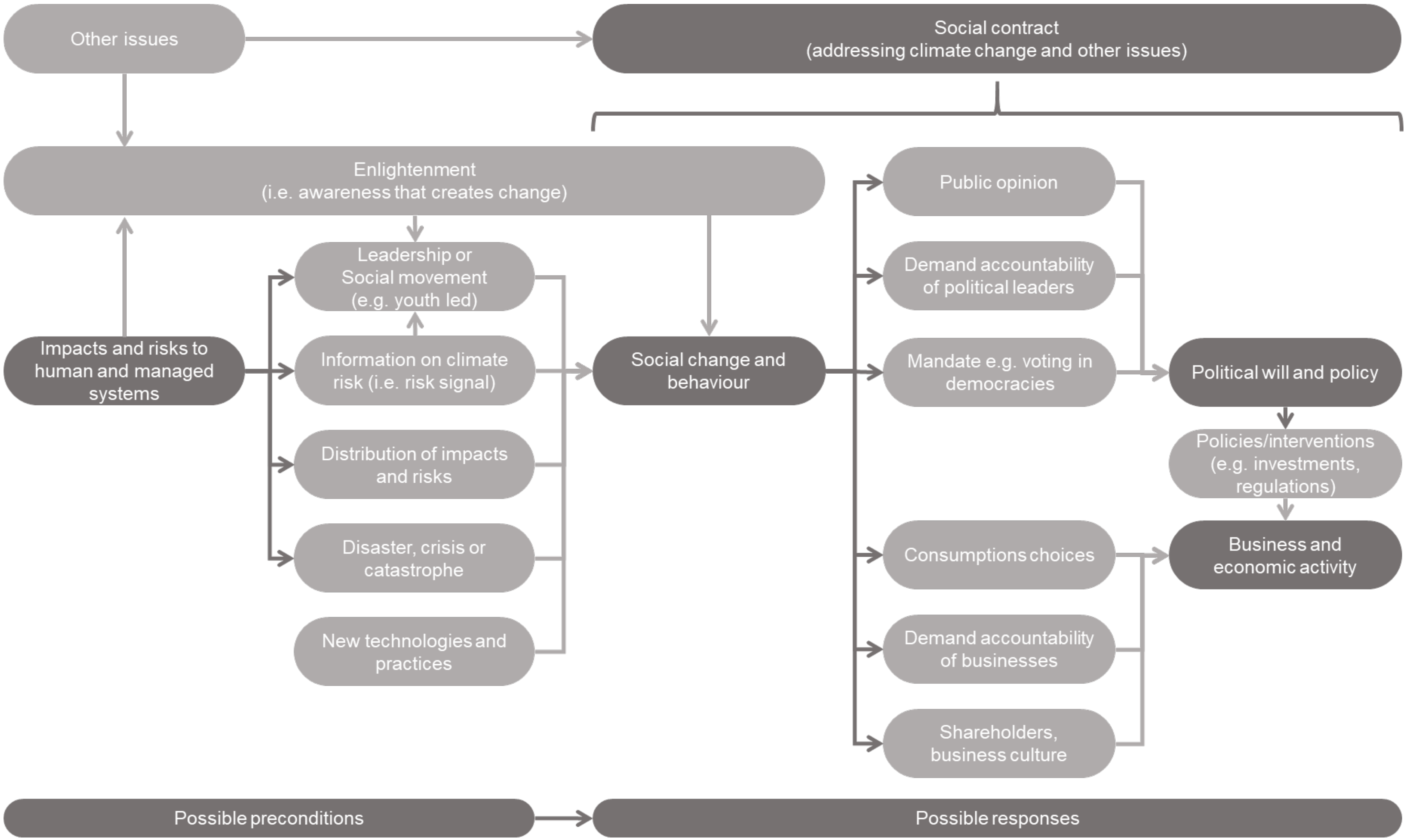

Figure 12-7: Preconditions for social change and behaviour, as well as the influences social change and behaviour might have on political will and policy, business and economic activity.

An important set of behaviours influencing political will and policy were also found in the sample of possible futures, that could help create the systemic changes needed to complement behavioural changes. Specifically, social change and behaviour also included changes in public opinion, demand for accountability of political leaders, or mandates for institutions including governments, for example through voting in democracies (Section 8.2.5). Such changes can influence political will and policy, drive policies and interventions, and could create systemic changes towards climate resilient low emissions development.

For there to be effective global responses to climate change, social change and behaviour, coupled with political will and policy, and changes to business and economic activity requires a fundamental change in what is acceptable and what is not, at an institutional or constitutional level following the distinctions made by Ostrom (1990). From Section 8.2.9, a notional social contract was identified as being an essential part of the global response to climate change and it was noted that social permissions for an effective global response don't exist yet. Interestingly, during the course of the study, the Green New Deal was published in the United States (Friedman 2019) and could be said to constitute a proposal for a new social contract.

12.3.2 Politically driven responses

Political will and policy regard the ambition level of government leaders, and others in government when it comes to positions on climate change, and the interventions they make. Figure 12-8 maps political will and policy related themes and scenarios from Section 8.3, including climate change signals and preconditions for political will and policy, as well as follow on conditions influenced by political will and policy responses.

Political will and policy includes social change and behaviour as possible preconditions along with business and economic activity related lobbying, as well as impacts on human and managed systems and related disasters, crises or some catastrophe (Sections 8.3.1 to 8.3.3). With regards to social change and behaviour, institutional capacity and processes may be important, including having ways for social change to translate into governance and policy (Section 8.3.4). Social change and behaviour can also create mandates as well as public pressure, that can drive political will and policy (Section 8.3.3). New technologies and practices can also influence political will and policy, for example changes in costs and prices may make some options more politically viable (Section 8.3.6).

The capacity and level of development within a jurisdiction could also influence political will and policy in particular the ability to deliver climate resilient low emissions development and related interventions (Section 8.3.4).

With regards to political will and policy, there are many options identified in the sample of possible futures (Sections 8.3.7 to 8.3.13). These include the possibility of having a stringent policy regime, governments creating technology related incentives, investments, and supporting research (Section 8.3.7). Policies might include the forced retirement of GHG emitting technologies (Section 8.3.8) or investments in climate resilient low emissions infrastructure (Section 8.3.9).

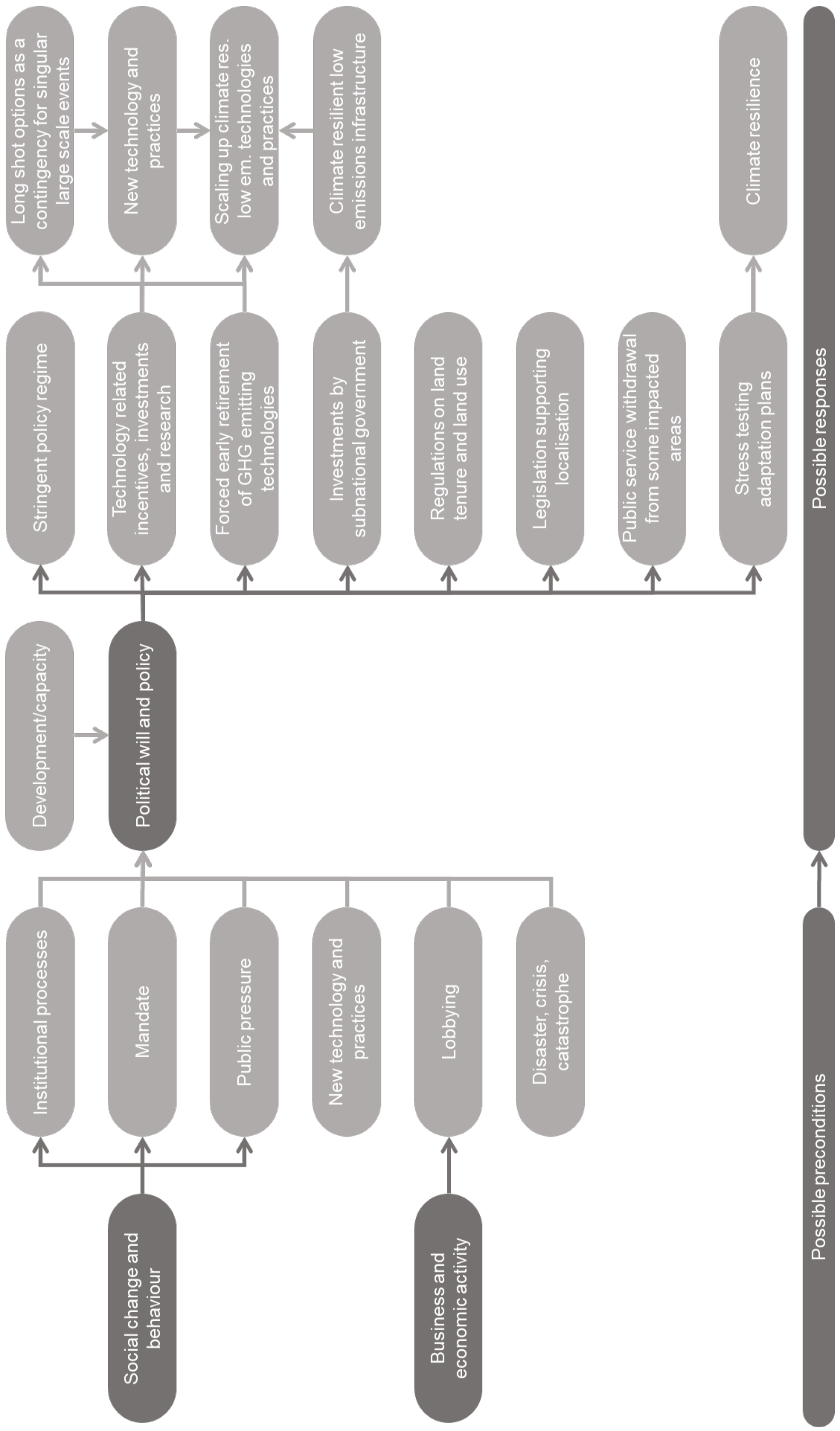

Figure 12-8: Preconditions for climate change related political will and policy and the influence political will and policy might have on responses.

At the subnational level, local government might invest in climate resilient low emissions infrastructure. Governance might include regulations on land use and related practices, as well as land tenure (Section 8.3.12), legislation supporting localisation (Section 8.3.11), or even public service withdrawal from impacted areas (Section 8.3.10). Stress testing of adaptation plans could also be important, contributing to improved resilience (Section 8.3.13).

12.3.3 Business driven responses

Business and economic activity regard actions, or inaction, by individuals or groups undertaking productive activities, in many cases driven by a profit motive. Figure 12-9 maps business and economic activity related themes and scenarios from Section 8.4, including climate change signals and preconditions for business and economic activity, as well as business and economic activity related responses and subsequent conditions.

Possible preconditions for business and economic activity to respond to climate change and related impacts, include social and change and behaviour, political will and policy as well as impacts and risks to human and managed systems affecting business interests such as supply chains or stock valuations (Section 8.4.1). Social change and behaviour could include changes in consumption. Political will and policy could include subsidies, incentives, regulations, or legislative support for localisation (Section 8.4.7). Meanwhile climate finance can change the incentive structure for businesses looking for sources of finance, while new climate resilient, low emissions technologies and practices that are proven to work or become cheaper than alternatives might also drive business and economic activity to be climate resilient and have low emissions. Alternatively, there may be enlightenment of shareholders or those that work in a business resulting in changes in business ethos (Section 8.4.5).

Business and economic activity could also include coalitions of big business or others lobbying governments for political leadership, especially if businesses are directly affected by climate change. Business could lobby for a carbon price or world trade rules that provide a basis for addressing climate change and providing certainty regarding regulations (Section 8.4.1). It is even possible that business and economic activity could end up having a re-industrial revolution (Section 8.4.5).

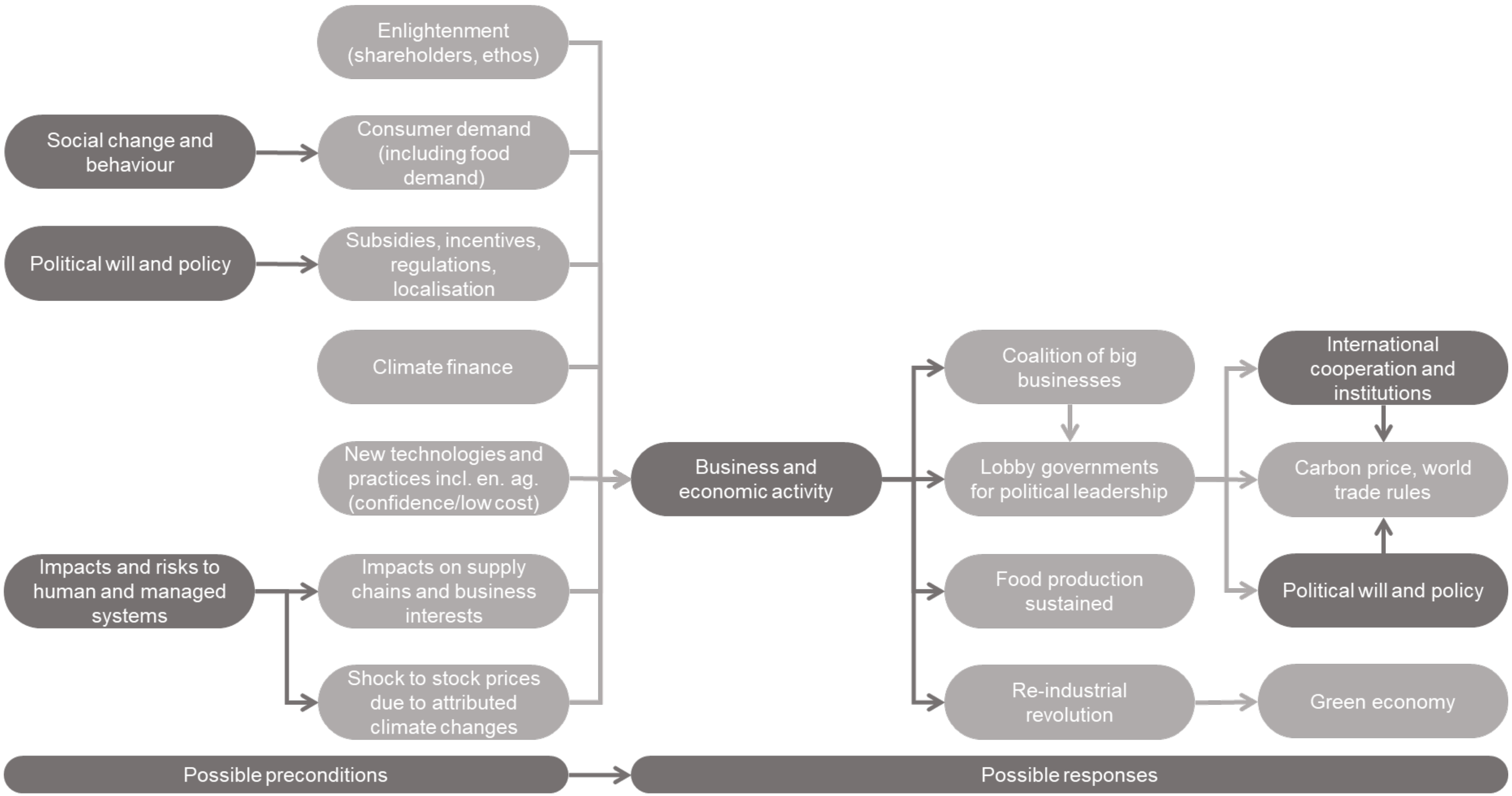

Figure 12-9: Preconditions for business and economic activity related responses to climate change as well as possible influences business and economic activities might have on the wider response to climate change.

12.3.4 Interactions between actors and interests

The global response to climate change relies on contributions from all types of actors in society. Importantly political will and policy as well as business and economic activity are parts of social change and behaviour. Based on the signals and responses mapped in Section 12.3.1, Section 12.3.2 and Section 12.3.3, there are many possible interactions between social change and behaviour, political will and policy as well as business and economic activity and these are summarised in Figure 12-10. These interactions include public opinion, special interests, laws and regulations, investments, consumption, goods services and prices.

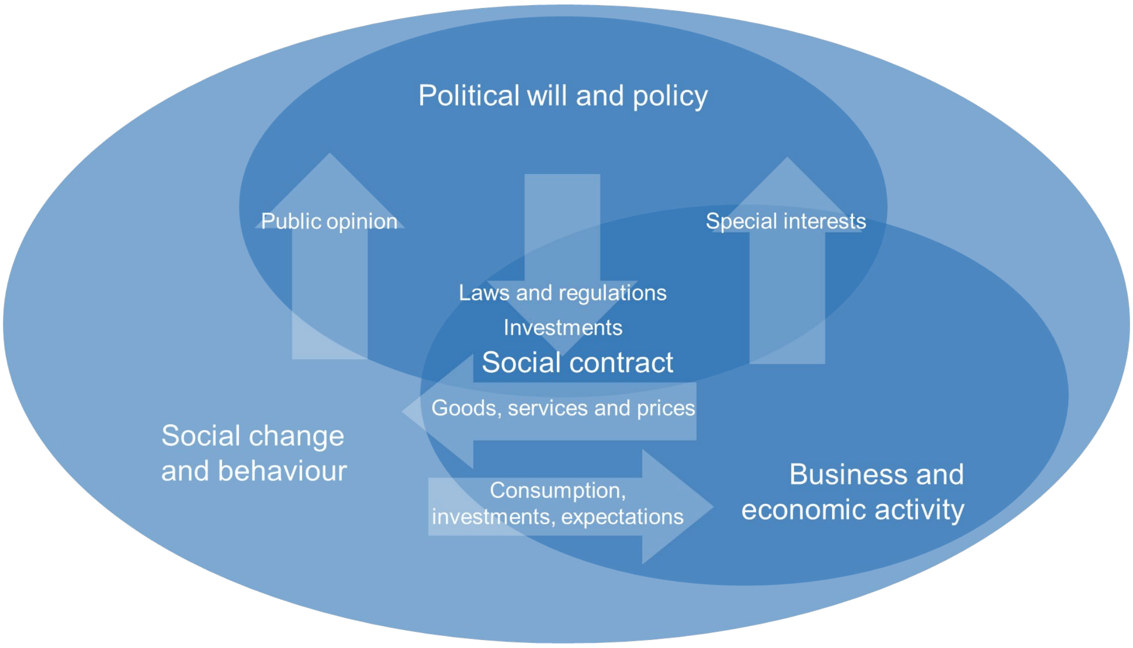

Figure 12-10: Venn diagram showing political will and policy as well as business and economic activity as a subset of social change and behaviour, including important interactions between these sets of actors and interests.

From Figure 12-10, political will and policy has an important role in shaping the social contract, for example through laws and regulations. However, climate change is not the only problem on the policy agenda. As such, climate change cannot be addressed in isolation, but needs to be addressed with other problems. This includes coalitions of actors and interests, linking different problems with common responses, for example following the “garbage can” method of policy making (Enserink et al. 2013), or “growing the pie” when it comes to international cooperation (Wetlaufer 1996). For such coalitions to form, actor interests and incentives are important.

12.3.5 Actor incentives

An important gap in the literature identified in Section 1.4, was the lack of investigation into actor incentives and decision making. From the sample of possible futures, the extent to which options are commercially viable, and the extent to which actors have ambition has a bearing on social, political and business responses. Table 12-7 presents a matrix of possible responses where climate ambition is high or low, and the options available are commercially viable or non-commercial (i.e.

not commercially viable without government or other support). Non-commercial options are immediate response risks meanwhile commercial options are immediate response opportunities.

Arguably, under the Kyoto Protocol climate change was a problem without commercially viable options (Section 8.3), hence the need to assign responsibility and determine which governments would support climate action and the global response. With commercially viable renewable energy options, electricity storage and transport options (IRENA 2019), the response regime has changed dramatically from the time of the Kyoto Protocol. In many cases, mitigation technologies are commercially viable and the most cost-effective option. However, for scale to be achieved, it is essential to have high ambition responses, creating competition and strategic interests.

In high ambition scenarios where commercial options are available, response options are an opportunity that can generate strategic interests, competition and “winning teams” (i.e. coalitions) as described in Section 7.5.1.2, Section 8.4.4 and Section 9.2.2. If there is low ambition and commercial options are available, then commercial opportunities are forfeited for political or social reasons, for example due to a cynical response (Section 7.4.1.1). This suppresses competition for market share and profits which are essential drivers for rapid scaling of commercially viable response options, including for example renewable energy generation or technologies related to energy storage and the electrification of transport. For the global response to climate change, it would be ideal if there was high ambition competition between the United States and China for market share and value when it comes to renewable energy technologies, the electrification of transport and energy storage options, including research and development. Meanwhile leadership on sustainable land use practices and related research could also be helpful.

Table 12-7: Possible responses based on climate change ambition levels and the availability of commercially viable options.

Climate ambition	Non-commercial response options	Commercial response options
High ambition	**The climate change problem is too difficult to ignore but responding is a risk** Responses could include governments providing unilateral, bilateral or multilateral investments, grants, and subsidies. Responses could also include coordinated policy interventions. Business and social leaders might also undertake research and development of long shot technologies or practices.	**The climate change problem is an opportunity** Commercial response opportunities create strategic interests in expanding markets, gaining market share, establishing industries, generating employment and profits. Business competition drives innovation in new technologies and practices, accelerated with subsidies and other forms of government support. The options available meet the needs of society.
Low ambition	**The climate change problem is too difficult to solve** Limited cooperation on research and development of technology and practices Information sharing on research, and experimentation with technologies, markets and policies.	**The climate change problem is politically or socially unattractive** Commercial opportunities are forfeited for political or social reasons. Business competition drives innovation and the development of technologies and practices with little or no government support.

However, commercial interests are not the only incentive or possible drivers for responses to climate change. From the sample of possible futures, it's possible there could be climate change related catastrophes, disasters or crises (Section 7.2.2). The intensity of loss and damage constitutes climate stress to actors and their interests. Once loss and damage becomes perceptible (i.e. attributable to climate change), then there may be an influence on behaviour at the societal level. With increased stress, climate change may be severe but endurable or terminal to various actors and their interests. Catastrophes can happen at different scales from personal to global or transgenerational, affect specific regions or geographic groupings such as SIDS. As such, Figure 12-12 adapts Figure 3-2 addressing geographic categories relevant to climate change and the global response. States with similar geographies and hazards may also share national interests and be potential allies when it comes to international cooperation and negotiations.

Scope	Imperceptible	Perceptible	Severe but endurable	Terminal
Trans-generational	Not relevant	Influence on behaviour		Global existential risks
Global	Not relevant	Influence on behaviour	Global catastrophic	risks
Regional or similar national geographies (e.g. SIDS)	Note relevant	Influence on behaviour	Shared catastrophic	risks to national interests
National	Not relevant	Influence on behaviour	Catastrophic risks to	national interests
Local	Not relevant	Influence on behaviour	Catastrophic risks to	non-state actors
Personal	Not relevant	Influence on behaviour	Catastrophic risks to	individual interests

Intensity of losses and damage (i.e. climate stress)

Figure 12-11: Qualitative categories of risk. Source: Author adapted from Bostrom and Cirkovic 2008.

However, one area of the global response to climate change where it is difficult to imagine how actors incentive might align creating cooperation, is GHG removals.

12.4 Greenhouse gas removals

A research question from Section 1.6 regarded the preconditions for actors to undertake atmospheric GHG removals. From the analysis of scenarios involving atmospheric GHG removals in Section 9.3, several themes emerged. The first was the need for GHG removals. It was noted that GHG removals should be a supplement to mitigation of the large quantities GHG emissions into the atmosphere (Figure 12-12). Once these quantities have been reduced then GHG removals become more viable. Some respondents suggested GHG removals should be kept as a contingency option in case climate sensitivity is higher than expected or some threshold is passed, and a feedback mechanism is activated.

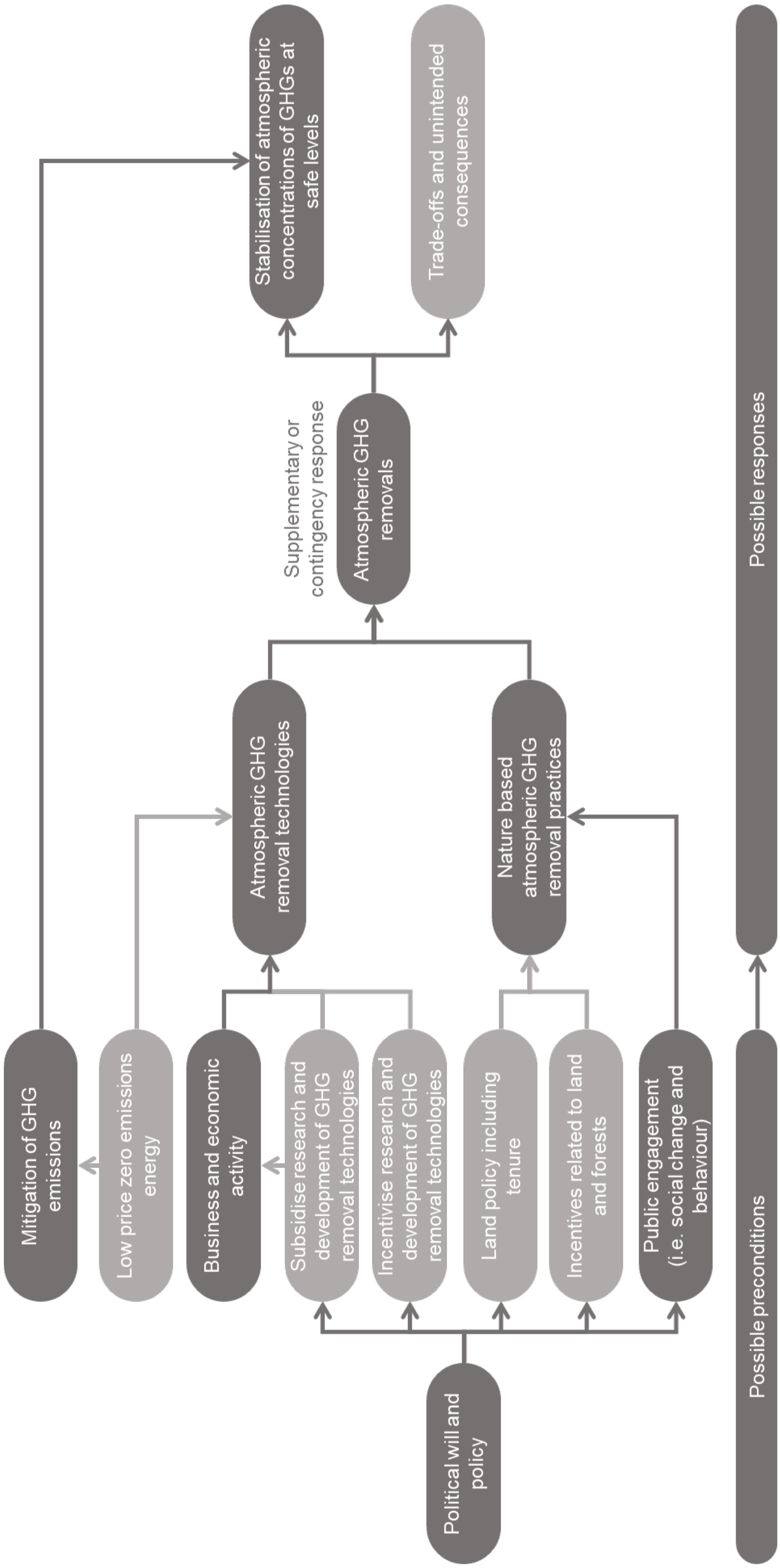

Figure 12-12: Preconditions for GHG removals from the atmosphere.

There are a range of practical limitations to atmospheric GHG removals for example related to the energy required to power technology-based options or the amount of land required to support natural removal options. If energy became sufficiently cheap, it was suggested that maybe other uses of the same energy could be found that help with adaptation rather than removing GHGs from the atmosphere (Section 9.3.4). There were also concerns round the possibility of trade-offs or unintended consequences, for example related to land or where captured carbon might be stored.

The need for political will and policies supporting GHG removals was noted, including land policies, or research and development support for atmospheric GHG removal technologies. The timing of the GHG removals is an important issue, with one respondent suggesting it would not be until the end of the century before atmospheric GHG removals would be viable. However, this would most likely lead to a very significant overshoot, assuming the budget for GHG emissions is used up in the first half of this century.

12.5 International cooperation

One of the research questions for this study regarded preconditions for effective international cooperation on climate change. However, from the scenarios and themes regarding international cooperation in Chapter 10, it can’t be taken for granted that there will be an rules-based international order. It was noted that there is tension between nationalism on the one hand and internationalism on the other. It was also noted that some leaders are sceptical of the rules-based international order and whether it is in their national interests or domestic political interests, to support or undermine the rules-based international regime.

From the sample of possible futures, as the climate change signal increases it is possible that climate change could become the premier international issue and a focus of international cooperation (Section 10.2.2). This might include an emergency response with climate change elevated to the United Nations Security Council. In such scenarios, there is a stringent enforced global response to climate change but the UNFCCC is not the lead institution. The UNFCCC would likely also have an advisory and coordination role along with an information gathering and verification role, including the possibility of county inspections like the IAEA. Meanwhile, institutions such as the World Bank and other multilateral development banks could provide climate finance while institutions such as the World Trade Organisation could help facilitate trade penalties and sanctions related to climate change.

Other triggers and drivers for international cooperation on climate change could include business interests being adversely affected by climate change, international leadership and enlightenment (Figure 12-13). It is also possible that some States advocate for international cooperation on climate change due to an interest in sustaining a rules based international regime.

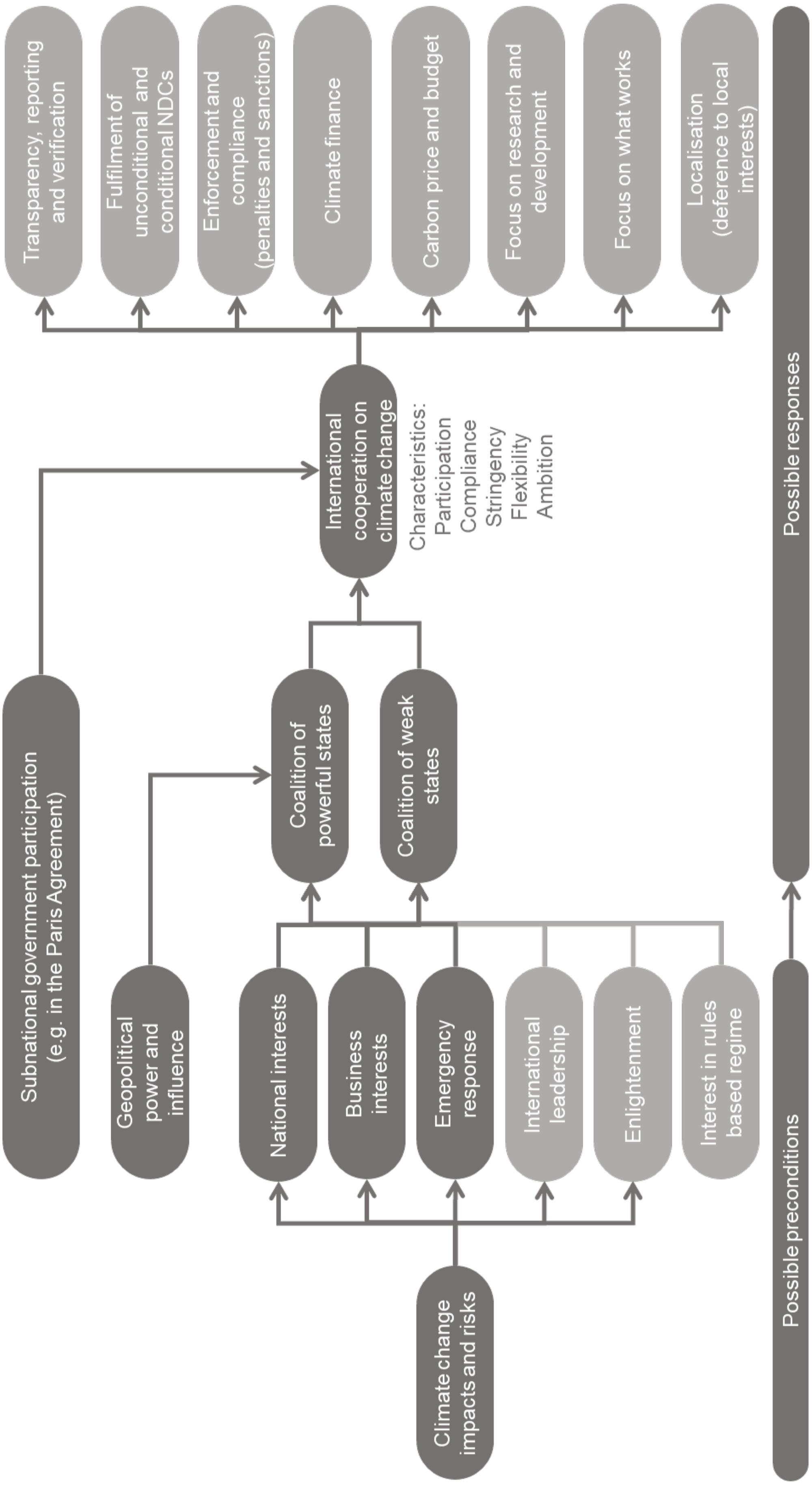

Figure 12-13: Possible preconditions for international cooperation on climate change and related international cooperation responses.

The effectiveness of international cooperation on climate change depends upon the power and influence of coalitions of states. From Section 10.3.4.4, it is possible that powerful states could make offers that cannot be refused. In an emergency response scenario where there is very high ambition and powerful states form a coalition, then it is likely there would be a stringent enforced international agreement and global response to climate change (Figure 12-14). Low to high ambition cost-benefit based agreements would be unlikely to result in a global response with sufficient scale and timeliness given the current situation and the dramatic greenhouse gas emissions reductions needed between 2020 and 2030 (Section 2.2.4). Even with commercially viable response options increasingly available to governments (Section 12.3.5) it would take very high levels of ambition for governments to shift investment patterns sufficiently (Section 7.3.2), abandon infrastructure that otherwise locks-in GHG emissions (Section 2.3.2, Section 8.3.9 and Section 8.4.6), and have businesses respond to climate change rather than treating effective responses as being optional (e.g. Shell's Sky Scenario in Section 2.3.1). These factors all influence the cost benefit analyses that governments make meanwhile the costs of future climate change impacts (Section 2.2.3) are discounted. Given lags in the climate change system (Section 2.2.1), overshoot (Section 2.2.4 and Section 7.3.1) is more likely than not when states make decisions based on cost benefit analyses. It is debatable whether cost benefit analyses are even the right type of analysis for addressing potentially catastrophic risks such as climate change (Appendix U). Regardless of what analyses are made, coalitions of weak states would struggle to generate a global response of sufficient scale and timeliness.

With regards to areas and approaches for international cooperation, the importance of transparency, reporting and verification was highlighted by respondents. Some scenarios have fulfillment of unconditional and conditional NDCs. The possibility of enforcement and compliance related measures were explored too. Climate finance served to help facilitate, or at least encourage, the global response to climate change. Carbon prices and budgets were discussed, but would be complicated given range of distribution issues, including winners and losers under any scheme. The possibility of transfer payments and compensation were also discussed, but the criteria for such transfers would likely be contentious (Section 9.4.3).

Some respondents suggested international cooperation could focus on things such as what works when it comes to policies, practices or technologies. Likewise, it could be possible to focus on research and development, for example monitoring research and development expenditure or the development of contingency options in the form of geo-engineering technologies.

The possibility of having local government involved and formally becoming a part of the Paris Agreement including self-determined contributions (akin to NDCs) and related monitoring and reporting and verification processes was raised. Another approach suggested, was localization where deference is given to local interests when it comes to the movement of goods, services and wastes (Section 8.3.11). Essentially, local communities and areas would be empowered, including through horizontal diplomacy.

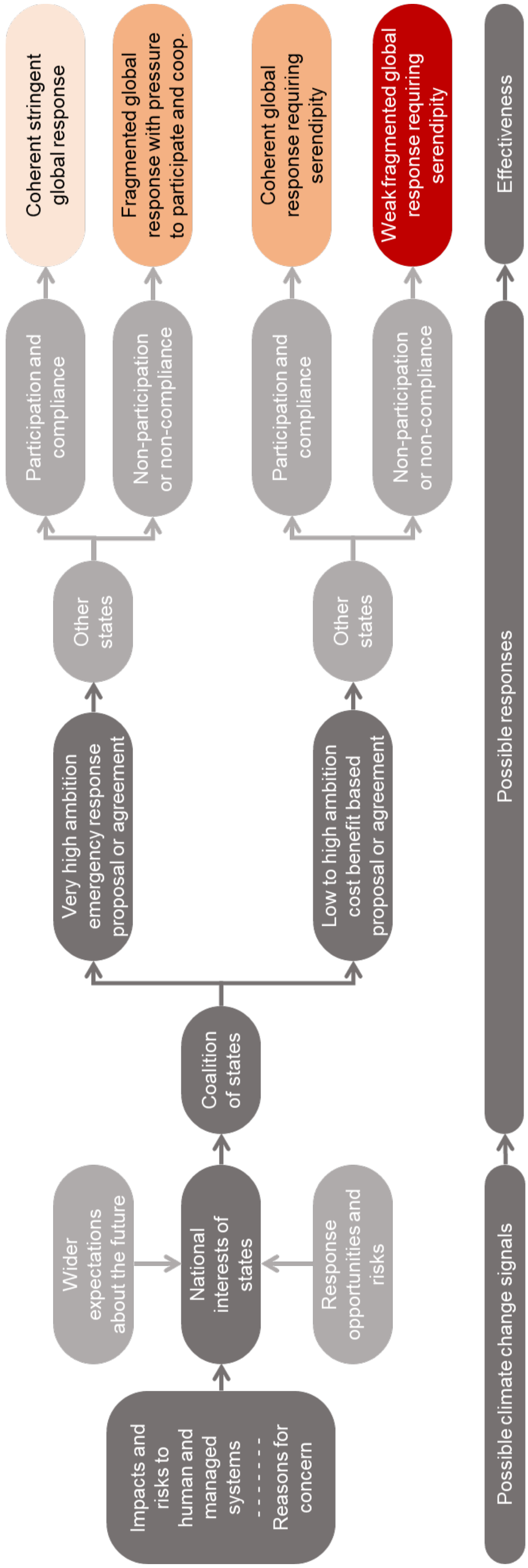

Figure 12-14: The effectiveness of international cooperation depending on coalitions and levels of ambition.

Chapter 13 Exploring preconditions for effective responses

13.1 Introduction

This chapter brings together the themes, scenarios and analyses from previous chapters, discusses the conditions necessary for effective global responses to climate change, and addresses the five research questions from Chapter 1, specifically:

> **What influence might climate change have on actors and the global response to climate change?**
>
> **What are the preconditions for effective international cooperation on climate change?**
>
> **What are the preconditions for actors to remove greenhouse gas from the atmosphere at a scale required to limit climate change to safe levels?**

And most importantly:

> **What are the preconditions for effective global responses to climate change?**
>
> **Under what conditions would actors act on effective response options?**

The discussion starts with preconditions for effective global responses to climate change from the Paris Agreement in Section 13.2, and preconditions from the literature including from the IPCCs 1.5 Degree Report in Section 13.3.

Section 13.4 highlights the many elements that make up the global response system, including gaps in knowledge regarding preconditions, for example not addressed by the Paris Agreement or IPCC's 1.5 Degree Report. Climate change signals and the scale of the climate change problem is discussed in Section 13.5. The question of how climate change might influence actors and their responses is discussed in Section 13.6, including the distinction between problems and conditions (Section 13.6.1) and possible signal response combinations (Section 13.6.2). Actors, interests and social permissions are discussed in Section 13.7.

The question of preconditions for effective international cooperation is addressed in Section 13.8 along with the issues of coalitions, power and capacity. Then the question of preconditions for effective greenhouse gas removals is addressed in Section 13.9. Given the long period of time being considered, other possible changes and scenarios that could influence climate or the global response are discussed in Section 13.10.

Effective global responses are discussed in Section 13.11. The question of preconditions for effective global responses to climate change is addressed in Section 13.12. The question of conditions under which actors would act on effective response options is addressed in Section

13.13 including a discussion on definition of the climate change problem. Lastly, Section 13.14 addresses existential risks related to climate change and the infinite game.

13.2 Preconditions for effective responses from the Paris Agreement

An important part of the global response to climate change is the Paris Agreement. The Paris Agreement operationalises the UNFCCC, sets out actions for the global response, and by extension the conditions for effective global responses to climate change. From Table 5-1 in Section 5.2.2.1, the Paris Agreement purpose includes 7 "actions" for the global response to be effective and achieve the "outcome" of limiting global warming to well below 2°C from pre-industrial times. From these actions, six conditions for an effective global response are derived in Table 13-1. For example, "increasing the ability to adapt to the adverse impacts of climate" implies "capability to adapt to the adverse impacts of climate change" is a condition for effective global responses to climate change.

Table 13-1 shows that effective global responses must be transformational, including for example: all financial flows being consistent with climate resilient and low greenhouse gas emissions development; and, development being climate resilient with low greenhouse gas emissions. Furthermore, there should be capability to adapt to the adverse impacts of climate change. The global response should be equitable with common but differentiated responsibilities and the response should be strengthened through efforts to limit global warming to 1.5 degrees from preindustrial times. Importantly, food production should not be threatened by the global response to climate change.

Table 13-1: Preconditions for an effective global response to climate change based on the Paris Agreement purpose.

Paris Agreement actions	Conditions for effective global responses (i.e. preconditions)
Strengthen the global response to the threat of climate change	A stronger global response to climate change through the pursuit of efforts to limit global warming to 1.5 degrees
Pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels	
Increasing the ability to adapt to the adverse impacts of climate change	Capability to adapt to the adverse impacts of climate change
Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate- resilient development	Finance flows consistent with climate resilient and low greenhouse gas emissions development
Foster climate resilience and low greenhouse gas emissions development	Development is climate resilient with low greenhouse emissions
In a manner that does not threaten food production	Food production not threatened by the global response to climate change
Equity in the light of different national circumstances	The global response is equitable with common but differentiated responsibilities
Source: Paris Agreement	*Source: Author*

13.3 Preconditions for effective responses from the literature

In addition to international agreements, there is a vast body of literature regarding the climate change problem, options for addressing climate change and required global responses. For example, the IPCC's Fifth Assessment included over 9,200 references regarding the physical science basis (IPCC 2014e), over 12,000 references regarding impacts, adaptation and vulnerability (IPCC 2014f), and close to 10,000 references regarding the mitigation of climate change (IPCC 2014g). From Chapter 2, Project Drawdown provided a list of 100 options for addressing climate change (Hawken 2017), meanwhile Figueres et al. (2017) addressed the timing and scale required of the global response to climate change based on a carbon budget. Blok et al. (2018) and van Vuuren et al. (2018) each made assessments of options for limiting global warming to 1.5°C. Blok et al. (2018) focused on energy related mitigation options and highlighted the need for massive investments, meanwhile van Vuuren et al. (2018) provided a set of scenarios and highlighted the need for carbon dioxide removals. Shell (2018b), the oil and gas company, prepared a "Sky" Scenario that highlighted the need for energy and development to support the sustainable development goals and carbon dioxide removals to limit global warming to 2°C. All of Shell's other scenarios exceeded 2°C of global warming. In many ways each of these publications is like a pair of hands feeling the proverbial elephant from Section 1.2, each describing something different, but collectively help describe the global response system (i.e. the elephant) and possible futures (i.e. how the elephant might move).

IPCC reports stand out from the literature, as they synthesise knowledge and describe the main features of the global response system including possible responses. The IPCC's 1.5 Degree Report is especially important, as it brought together the results of over 6,000 publications to assess global responses capable of limiting global warming 1.5°C and compared these with responses that limit global warming of 2°C. Importantly, Chapter 2 of the IPCC's 1.5 Degree Report addressed mitigation pathways compatible with 1.5°C and noted "There is a diversity of potential pathways consistent with 1.5°C, yet they share some key characteristics" (Rogelj et al. 2018, p. 129). By definition, these "key characteristics" are preconditions for effective global responses to climate change, that limit global warming to 1.5°C. Table 13-2 presents key characteristics (i.e. conditions) of 1.5°C pathways in the left-hand column, while the right-hand column shows related preconditions for effective global responses from the Paris Agreement (Section 13.2 above).

From Table 13-2, the key characteristics of 1.5°C pathways focused on things that help limit GHG emissions, which makes sense given that GHGs drive global warming. Key characteristics also included shifts in investment which is consistent with eventually having economies where finance flows are consistent with climate resilient low GHG emissions development. Low emission development also requires a rapid and profound decarbonisation of energy supply and comprehensive emissions reductions in the coming decade, greater mitigation efforts on the demand side including switching from fossil fuels to electricity (Rogelj et al. 2018).

Table 13-2: Key characteristic of 1.5°C pathways and related effective response criteria from the Paris Agreement purpose.

Key characteristics of 1.5°C pathways (i.e. preconditions)	Related preconditions from the Paris Agreement
Considerable shifts in investment patterns	Finance flows consistent with climate resilient and low greenhouse gas emissions development
Rapid and profound near-term decarbonisation of energy supply	Development is climate resilient with low greenhouse emissions
Greater mitigation efforts on the demand side	
Switching from fossil fuels to electricity in end-use sectors	
Comprehensive emission reductions are implemented in the coming decade	
CDR at scale before mid-century	NA - Not mentioned in Paris Agreement purpose
Source: IPCC 1.5 Degree Report (Rogelj et al. 2018)	*Source: Author*

Importantly, GHG removals in the form of CDR are needed at scale before mid-century but such removals were not in the Paris Agreement purpose (Section 13.2).

13.4 Other system elements and possible conditions

Despite the large and growing body of literature, there remain gaps in the literature when it comes the global response to climate change especially at the systems level. For example, the term “global response to climate change” had not been defined in the literature prior to this study (Section 1.2). From the analysis of the sample of possible futures in Chapter 12, there are many elements to the global response system that might have a bearing on effective global responses, including: climate change signals including climate change impacts, risks and concerns as well as the extent to which response options are perceived as opportunities or threats; ambition levels; the actors and interests involved; coalitions of actors; their power to influence other actors and capacity to develop and apply response options; response triggers, drivers and attitudes; the extent to which various options are considered; the actions taken including adaptation, mitigation, GHG removals or other actions; the contributions these actions make to the global response; system dynamics including unintended consequences and other social, economic or environmental changes; and, the extent to which other events influence climate or affect the global response. For each element of the global response system, different conditions are possible, for example, the themes and scenarios from Chapters 7 to 11 each represent different combinations of conditions.

The preconditions from the Paris Agreement purpose addressed issues of ambition, resilience, low emissions development, the avoidance of unintended consequences on food production, and fairness, meanwhile the IPCC’s 1.5 Degree Report focused on actions, technologies and practices that contribute towards climate resilient low emissions development. As such, only part of the global response system is addressed. The sections below discuss global response system elements and related conditions needed for effective global responses.

13.5 Climate change signals and scale of the problem

The extent to which climate change is a problem that might generate a response, is uncertain. From Section 7.2.2, many respondents said climate change and related impacts on human and managed systems could be a "disaster", "crisis", "catastrophe" and "emergency" or “threat multiplier”. However, not all respondents expected such severe climate change impacts and risks. It was noted that there are a mix of positive and negative climate change impacts, and at an aggregate level climate change is only estimated to limit global economic growth by only 2 to 4% by 2100. This estimate is consistent with the literature (Tol, 2009) however most estimates of economic costs and benefits were made before impacts on human and managed systems became discernible (Section 12.2.1). More recently Burke et al. (2015) have shown temperature effects on productivity are non-linear, meanwhile there are concerns that economic estimates fail to adequately address the full range of climate change and related risks, (e.g. DeFries et al. 2019).

With regards to limiting the impact on Gross Domestic Product or Gross World Product, this doesn’t mean climate change related disasters, crises or emergencies will be avoided. For example, these aggregate economic indicators obscure the distribution of costs and benefits (Tol 2009, Tol et al. 2004). The distribution of impacts and risks is important as it creates issues of equity (Dietz et al. 2007). In some scenarios, the distribution of impacts raises the possibility of actors needing to migrate due to climate change (Section 9.4.6). It was noted that climate driven migration could create domestic and international tensions, and in some scenarios conflict if other actors respond to migration defensively (Section 9.4.6 and Section 9.4.7). Meanwhile, attempting to balance costs and benefits, or limit the need for migration, through transfers or compensation is very difficult (Section 9.4.3). In short, limiting aggregate economic impacts of climate change at the global level, or national level, may not be sufficient to limit social and political tensions or conflict due to distributional issues.

13.6 The influence of climate change on responses

From Chapter 1, an important research question was: What influence might climate change have on actors and the global response to climate change? From Section 12.2.1, the emergence of an attributable climate change stress signal represents a fundamental shift in the “global response system”, where climate change can less easily be ignored because costs and benefits are more apparent. However, the divergence in climate change scenarios from Section 13.5 highlights uncertainty regarding the extent to which climate change is a “problem” that needs to be solved versus a “condition” society can live with (see Section 13.6.1). Meanwhile, from the sample of possible futures a range of climate change signal and response combinations were identified, including likely ambition levels and contributions to the global response (see Section 13.6.2).

13.6.1 Problems versus conditions

Kingdon (1995) noted that there are many conditions, including “bad weather” that while undesirable, society lives with. Only some conditions are considered problems where people believe something should be done about the condition (Section 2.2). Applying this to climate stress signals from Section 12.2.1, it is possible that some climate stress signals may be considered conditions society can live with, while other climate change signals may be considered problems society needs to solve (Figure 13-1). For example, the fact that respondents did not anticipate effective global responses to impacts on natural systems (Section 7.2.3) suggests that impacts on natural systems, including unique and threatened systems (RFC1), are conditions society is collectively willing to live with, even though these impacts and risks are a problem to some actors, for example indigenous peoples living in the arctic (IPCC 2018). It is an important question as to which impacts and risks to human and managed systems might be considered conditions versus problems.

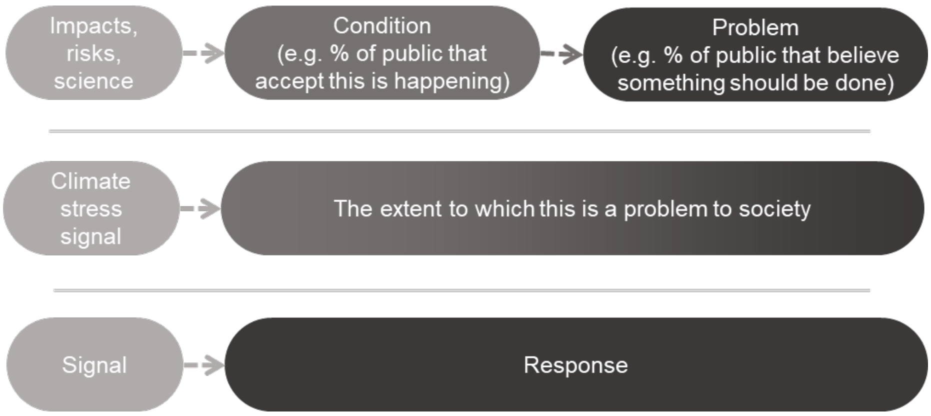

Figure 13-1: The extent to which climate change is a problem to society, applying distinctions from Kingdon (1995).

With regards to extreme weather events (RFC2) from Section 2.2.3, Kingdon (1995) noted such events typically only generate periods of interest in a problem, although these periods may constitute political or policy windows for responses. From the sample of possible futures, it may take a succession of distributed events to generate effective global responses (Section 7.2.4). The distribution of impacts (RFC3) in relation to power and capacity of actors to respond is also important (Section 12.2.1 and Section 7.2.4).

Global aggregate impacts (RFC4) such as “global monetary damage, global-scale degradation and loss of ecosystems and biodiversity” (IPCC 2018, p. 11) would constitute a "disaster", "crisis", "catastrophe" or "emergency". However, an emergency response consisting of “containment and defence” (Grubb 2014) would involve adaptation to the climate change problem and living with some of the hazards and impacts, essentially treating them as conditions. An emergency response consisting of “containment and fix” on the other hand, involves a mix of adaptation to immediate impacts, with mitigation and removals to solve the long term climate change problem in a way that gets closer to fulfilling the UNFCCC objective (Section 12.2.2).

Large-scale singular events (RFC5), include large, abrupt or irreversible changes in systems caused by global warming, such as tipping points, feedback mechanisms or cascade effects, can also be characterised as a “disaster” or “catastrophe”. However, the extent to which large-scale singular events constitute a “crisis” or “emergency” depends on the speed of change. For example, an important distinction can be made between fast feedbacks and other feedbacks (Section 11.10.3). Given the magnitude of large-scale singular events, such as passing a tipping point making the collapse of ice sheets in Antarctica or Greenland inevitable, an apathetic or hopeless non-response is possible (Section 7.4.1.4). In such a scenario, there may be acceptance that sea levels will rise and scheduled retreat from coastal areas is required (Section 8.3.10 and Section 8.4.9). As such, tipping points, slow feedbacks or cascade effects could constitute “conditions” rather than “problems” that are reversible. Even fast feedbacks or cascade effects may constitute “conditions” that are accepted if the scale is too large to be solved with available technologies and practices. The problem becomes one of adaptation to immediate impacts and risks, while mitigation and removals are used to limit other long-term climate change related risks rather than reversing the sea level rise.

13.6.2 Signals and responses

Conceptually, the global response to climate change, including levels of ambition, are influenced by the climate change signal (Section 12.2.1) including climate stresses along with response risks and opportunities (Figure 13-2). From the sample of possible futures, climate change signals may or may not influence contributions to the global response to climate change (Section 12.2.2). For example, there are scenarios (Figure 13-2) where there are high levels of climate change stress followed by non-responses due to apathy or a sense of hopelessness (Section 7.4.1.4). Scenarios also include cynical responses for example a fossil fuel push where climate change stress is ignored for the benefit of special interests (Section 7.4.1.1). Given the current situation, with regards to technologies reliant on fossil fuels and land use practices, non-responses and cynical responses constitute negative contributions to the global response (Figure 13-2).

From the sample of possible futures, not all non-responses make negative contributions to the global response. In some scenarios, where renewable energy and storage become cheap much quicker than expected, these technologies are taken up at scale and in a timely manner, for commercial reasons rather than climate change related reasons (Section 9.4.2). As such, actors can make incidentally positive contributions to the global response to climate change (Figure 13-2), although in such a scenario land use related emissions would also need to be addressed along with aviation and marine GHG emissions sources.

From Section 12.2.2, climate change signals could trigger low to high ambition cost benefit based responses, high to very high ambition enlightened responses or very high ambition emergency responses (Figure 13-2). However, responding to climate change with ambition does not necessarily mean that positive contributions will be made to the global response in the form of adaptation, mitigation and GHG removals. Response attitudes also influence the options considered, actions taken and contributions to the global response. For example, a very high ambition emergency response involving a defensive response attitude could result in containment and defence with adaptation to impacts and limited mitigation or GHG removals (Section 12.2.2 and Section 7.5.1.1). It is also possible that a cost benefit response coupled with a defensive attitude could result in the selection of defensive adaptation responses while largely ignoring mitigation or GHG removal options. As such, Figure 13-2 shows defensive response attitudes are likely to make very negative contributions to the global response to climate change. Meanwhile, if actors don't act on mitigation or GHG removal options, it is expected they will adapt to some extent (Section 7.4.2.1, Section 8.3.4).

Other response attitudes identified from the sample of possible futures include cooperative, competitive, and technological attitudes. Given that climate change can be framed as a collective action problem, it would seem cooperative response attitudes are essential to make positive contributions to the global response. However, waiting for global decisions on how to cooperate may not be timely (7.5.1.1). Importantly, when options that make positive contributions to the global response are anticipated to be commercially viable, then competitive attitudes can help rapidly scaling up relevant technologies and practices making a positive contribution to the global response (Section 7.5.1.2). Technological response attitudes can also make a positive contribution to the global response (Section 7.5.1.3). However, from the sample of possible futures, technological attitudes also include risks with regards to the possibility of unintended consequence, trade-offs, levels of consumption, resource use and related wastes (Section 9.2.4).

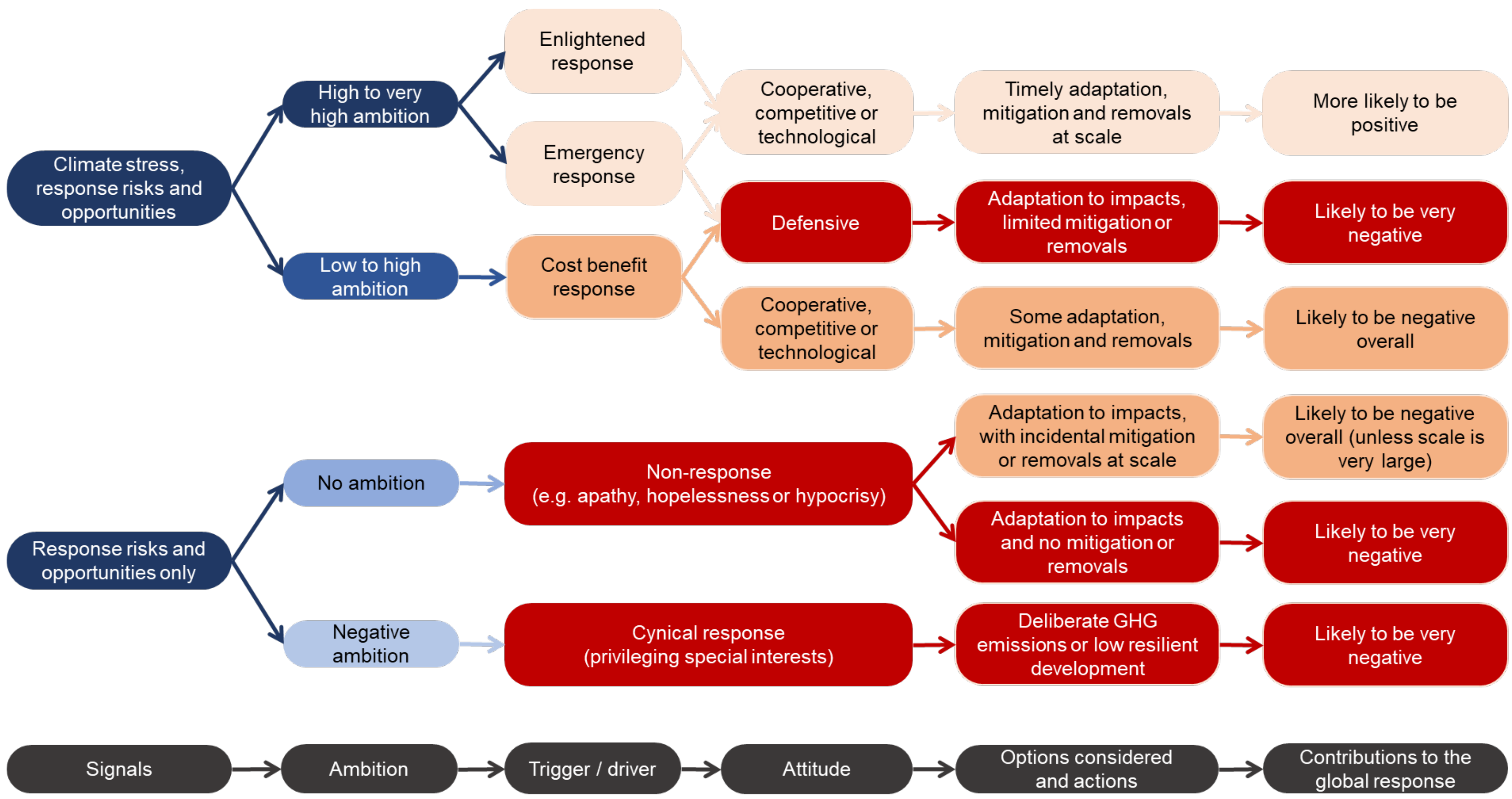

Figure 13-2: Climate change signals and other factors affecting the responses to climate change and contributions to the global response.

Table 13-3 simplifies Figure 13-2, and groups response triggers, drivers and attitudes into three categories, based on likely contributions to the global response to climate change. With regards to signals in Table 13-3, climate change signal strength also depends on the actors and interests affected including the extent to which response options are an opportunity or risk (Section 12.2.1). As such, actors and interests are an important part of the global response system.

Table 13-3: A simplified summary of climate change related signals, responses and contributions.

Signals	Response		
	Trigger or driver	Attitude	Contribution to global response
Climate stress, response risks and opportunities	Enlightenment or emergency	Cooperative, competitive or technological	More likely to be positive
	Cost benefit	Cooperative, competitive or technological	Likely to be negative overall
	Cost benefit or emergency	Defensive	Likely to be very negative
Response risks and opportunities only	No trigger e.g. non-response or cynical		

Figure 13-2 can also be simplified into the "competing angels" of individual and collective action. In his first inauguration speech, Abraham Lincoln referred to "better angels" (Lincoln 1861) a metaphor that simultaneously addresses positive and negative influences on individual and collective choices. With this in mind, it is possible to borrow the metaphor and consider the "competing angels" and in doing so better communicate the influence that interests, ambition levels, triggers and drivers, as well as attitudes and inclinations, can have on individual and collective actions and the global response to climate change. Importantly, the "competing angels" highlight contrasting elements of Figure 13-2, and the climate change signal response models from Section 12.2.2, including the angels of wider concerns versus self-interest, ambitious and unambitious angels, enlightened and cynical angels as well as cooperative and defensive angels (Figure 13-3).

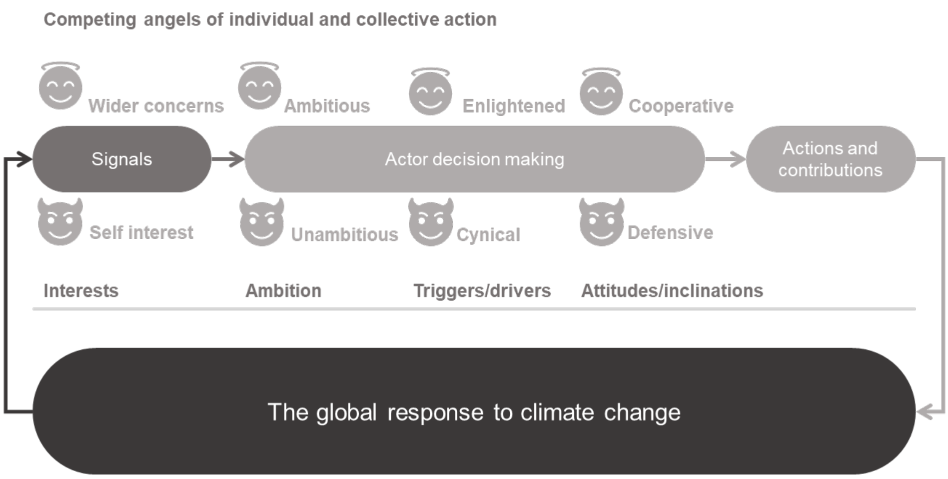

Figure 13-3: The "competing angels" of individual and collective action.

13.7 Actors, interests and social permissions

From the analysis in Chapter 8, three broad groups of actors, interests and actions were identified consisting of social change and behaviour, political will and policy as well as business and economic activity. While there are many other more detailed breakdowns of actors and interests, including demographic, political or sectoral breakdowns, this study focused on the main features of the global response system (Section 1.2), and as such limits the breakdown of actors, interests and related actions to three categories.

From the sample of possible futures, political actors and business actors are part of society and as such, are influenced by social change (Section 12.3.4). Furthermore, business and political actors need social permissions if they are to make timely responses at the scales needed to address climate change (Section 8.2.9). As such, social permissions and related social contracts are central to interactions between domestic social, political and business actors (see Figure 12-10 in Section 12.3.4) forming the rules of the game that guide responses to climate change in combination with other issues and norms. Several respondents noted that the global response cannot be done in isolation but must be part of a wider set of considerations. An important part of defining and redefining social contracts, national interests and the global response to climate change, are coalitions. This includes coalitions in support of international cooperation.

13.8 Coalitions and effective international cooperation on climate change

It’s been acknowledged by the IPCC and others that international cooperation is an important part of the global response to climate change (e.g. Stavins et al. 2014). As such, an important research question from Chapter 1, was: What are the preconditions for effective international cooperation on climate change?

From Section 7.2.4, coalitions of both state and non-state actors were identified as being important for international cooperation. However, for these coalitions to be effective, the actors participating need the capacity to develop and apply necessary technologies and practices, and the power to influence other actors and institutional arrangements i.e. “the rules of the game”. Having this capacity and power means the coalition can influence the options available and limit the chances of other actors undermining the global response.

From Section 7.2.4, the distribution of climate change signals within states as well as between states was identified as being important for international cooperation. Applying Putnam’s (1988) two level game (Section 3.3.2.3) the distribution of climate changes and related impacts and risks within a state, coupled with the extent to which response options are perceived as risks or opportunities by various actors, can affect coalitions of domestic actors and hence the national interests of the state, for example when it comes to international cooperation on climate change.

From Section 10.2.2, if the climate stress signal, in the form of impacts on human and managed systems, gets strong enough, then it is possible that climate change could become the premier international issue and an issue of international security. As such, climate change could be addressed in the United Nations Security Council, in which case the permanent members with veto power, which currently consist China, France, Russia, United Kingdom and United States of America, would need to agree if there is to be an effective global response. From Section 10.3.3, it is anticipated that if powerful states backed a stringent international climate agreement, then other states would comply rather than dare upset the powerful states.

An important question when it comes to the effectiveness of international cooperation is whether capable and powerful coalitions of States will respond to climate change risk signals (e.g. respond to climate change as a “threat multiplier”) or whether such coalitions will only form once there are attributable climate change and related impacts on human and managed systems. If capable and powerful coalitions do not form until there are impacts, then the climate change and related hazards precipitating a response will likely be part of the new range of normal conditions. In such a scenario, climate change will need to be reversible for GHG mitigation and removal responses to be effective. All other things being equal, a response to climate change risk signals would be timelier than a response to impacts (Section 7.4.2.2).

Table 13-4 builds on Table 13-3 from Section 13.6.2, and includes the distribution of climate change signals on actors and coalitions with power and capacity versus actors and coalitions with limited power and capacity. Like in Table 13-3, actors and coalitions can either make positive or negative contributions to climate change, but actors and coalitions with power and capacity have much more influence on whether the global response is likely to be effective or not. For example, if actors and coalitions with power and capacity engage in responses that make a positive contribution to the global response, then the global response is more likely the be effective. Conversely, if actors and coalitions with power and capacity engage in responses that make negative contributions to the global response, then the global response is much more likely to be ineffective. Actors and coalitions with limited power and capacity have limited positive or negative influence on effectiveness of the global response.

Table 13-4: Climate change related signals, actors, responses, contributions and likely effectiveness of global responses.

<table>
<tr><th rowspan="2">Signals</th><th rowspan="2">Actors and coalitions</th><th colspan="3">Possible responses</th><th rowspan="2">Effectiveness of global response</th></tr>
<tr><th>Trigger or driver</th><th>Attitude</th><th>Contribution</th></tr>
<tr><td rowspan="6">Climate stress, response risks and opportunities</td><td rowspan="4">With power and capacity</td><td>Enlightenment or emergency</td><td>Cooperative, competitive or technological</td><td>More likely to be positive</td><td>More likely to be effective</td></tr>
<tr><td>Cost benefit</td><td>Cooperative, competitive or technological</td><td>Likely to be negative overall</td><td>Unlikely to be effective</td></tr>
<tr><td>Cost benefit or emergency</td><td>Defensive</td><td rowspan="2">Likely to be very negative</td><td rowspan="2">Very unlikely to be effective</td></tr>
<tr><td colspan="2">No trigger e.g. non-response or cynical</td></tr>
<tr><td rowspan="2">With limited power and capacity</td><td>Cost benefit, enlightenment or emergency</td><td>Cooperative, competitive, technological or defensive</td><td rowspan="2">Positive or negative contributions</td><td rowspan="2">Limited influence on effectiveness. Unlikely to be effective</td></tr>
<tr><td colspan="2">No trigger e.g. non-response or cynical</td></tr>
</table>

13.9 Preconditions for atmospheric greenhouse gas removals

From Chapter 1, an important research question was: What are the preconditions for actors to remove greenhouse gas from the atmosphere at a scale required to limit climate change to safe levels? This is important, because the budget available for more GHG emissions to accumulate in the atmosphere, while limiting climate change, is rapidly running out (Section 2.2.4). From Section 13.3, the IPCC's 1.5 Degree Report noted carbon dioxide removals are needed at scale before 2050 if the global response to climate change is to be effective.

From Section 9.3.1, an important precondition for GHG removals and stabilising atmospheric concentrations of GHGs at safe levels is mitigation. Given the large quantity of GHG emissions being emitted when interviews were being conducted, it was generally considered unfeasible to use GHG removals alone to stabilise atmospheric concentrations of GHGs at safe levels. Instead, mitigation is required to dramatically lower GHG emissions and as such, reduce the quantities of GHGs that need to be removed from the atmosphere to stabilise concentrations at safe levels. Meanwhile, from Section 12.4, the availability of cheap low emissions energy is a very important factor for both mitigation and technology based atmospheric GHG removals. One thing that was not addressed in the sample of possible futures is the possibility that if some actors are emitting GHGs into the atmosphere, other actors may not want to remove GHGs.

Given that there are large stores of carbon in the biosphere, including forests, soils and the sea life, practices are going to be an important part of limiting GHG emissions, and could be an important part of GHG removals, in particular carbon dioxide removals. This includes community engagement, institutional arrangements especially when it comes to land tenure.

From the sample of possible futures, atmospheric GHG removals are not without risks or possible unintended consequences, including for example the large amounts of energy or land required by some GHG removal methods (Section 9.3.4). Other concerns include the duration of GHG storage and the risk of releases of carbon from the biosphere or geosphere back into the atmosphere (Section 9.3.5). An important condition for effective GHG removals is that GHGs remain out of the atmosphere.

13.10 Other changes that could influence climate or the global response

The questions from Chapter 1 did not include: What are the other changes that could influence climate or the global response to climate change? However, the stress test principles from Section 4.3.5 include "Address all possible risks (including implausible but possible risks)". This is especially important in the context of climate change which is a long-term problem. In any given decade, or century there will be unexpected "historic" events. From Chapter 11, there are a range of possible social, economic or environmental changes that could help or hinder the global response to climate change.

Unexpected events can interact with political will and policy in unexpected ways, for example in Section 7.4.2.5 it was noted that a global pandemic might demonstrate the value of international cooperation, and once the pandemic is addressed, actors might also work together to address climate change. Another scenario is a volcanic eruption emitting large quantities of sulphates creating a natural experiment informing solar radiation management policies (Section 11.5). As such, any response, or response strategy, should be aware that other things could happen and acknowledge the need for contingencies in case of other scenarios rather than relying on serendipity[18] or chance.

From the sample of possible futures, it is arguable that people interested in climate change focus too much on climate change, meanwhile there are many problems and conditions that affect people (Section 11.1), some of which may have more influence on the global response to climate change than so called “climate action” where climate change is a central concern. From the sample of possible futures, scenarios include volcanic eruptions, environmental feedbacks and catastrophic cooling events. Meanwhile, social and economic scenarios include cyborgization of humanity exacerbating inequities, enlightenment, population decline, conflict including nuclear war, as well as the possibility of solar radiation management technologies being deployed and possible geopolitical ramifications.

13.11 Effective global responses

From Section 5.2.2.1, an effective global response is one that fulfils the UNFCCC objective of stabilising atmospheric concentrations of GHGs at levels that allow ecosystems to adapt naturally, food production not be threatened and economic development to proceed in a sustainable manner. Given the legitimacy of the UNFCCC and the fact that the UNFCCC is the framework convention under which the global response to climate change is broadly organised, the UNFCCC objective was used to define the conditions that constitute effective global responses to climate change.

With regards to scenarios, Table 13-4 from Section 13.8 only addressed the influence actors might have on the effectiveness of global responses to climate change. Based on the CCNIIC Model in Section 3.3.2, the environment is an important part of the global response system (also see Appendix D). However, one of the complicating issues when attempting to identify effective response scenarios, is uncertainty in our understanding of natural systems and the environment, especially when it comes to radiative forcing and climate sensitivity. From Section 2.2.1 there’s a considerable range of uncertainty when it comes to levels of anthropogenic radiative forcing (Figure 2-1). Similarly, from Section 2.2.3 there is a very remote chance that global warming could be limited below 1.5°C or 2°C even with much higher atmospheric GHG concentrations (Table 2-1). Meanwhile, from Section 9.4.2, it is conceivable that technologies change much quicker than

[18] The Oxford Dictionary defines serendipity as “the occurrence and development of events by chance in a happy or beneficial way”. In the context of this study, serendipity refers to: the occurrence and development of events that by chance, rather than intent, contribute towards fulfilling the UNFCCC objective.

expected and serendipitously make it commercially viable to scale up mitigation or even remove GHGs from the atmosphere. As such, it is conceivable, but very unlikely that a blind luck non-response, or even a failed cynical response could still result in limited climate change and related impacts. However, this would require incredible levels of serendipity (Figure 13-4).

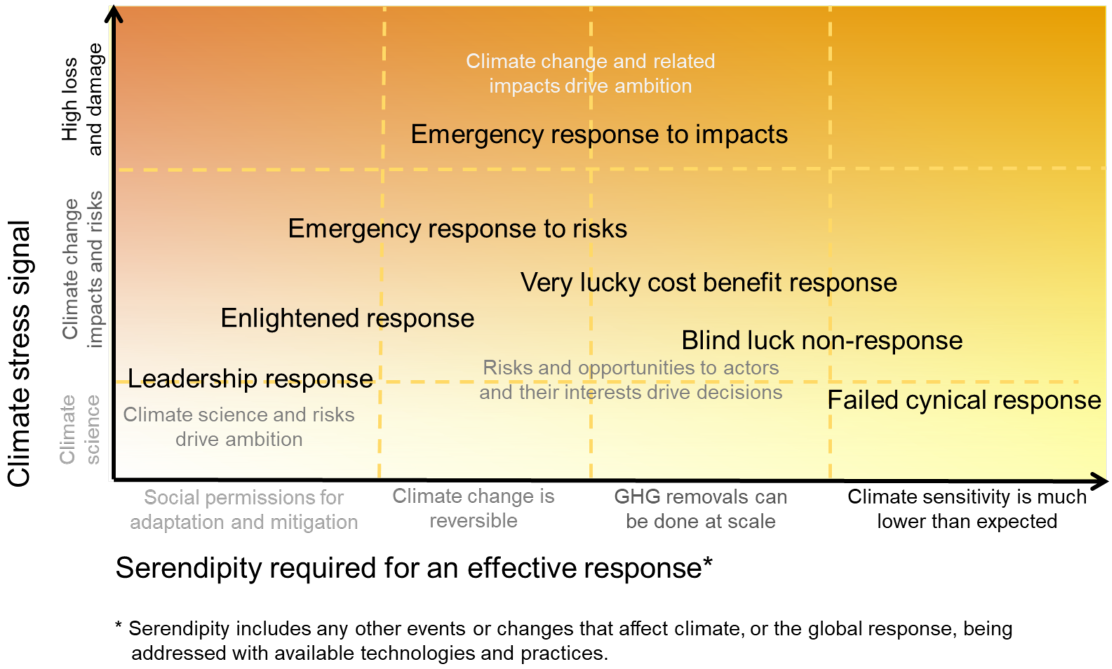

Figure 13-4: Schematic plot of effective response scenarios relative to climate stress signals, and what it would take for these response scenarios to be effective in terms serendipity.

Figure 13-4 schematically plots the strength of the climate stress signal (vertical axis) against the level of serendipity required for effective global responses to climate change (horizontal axis). These responses are divided into two categories, those that rely on ambition and high levels of serendipity (lower left quarter to upper middle), and those that require incredible levels of serendipity relative to ambition (lower right quarter).

Table 13-5 builds on Figure 13-4 as well as Table 13-4 from Section 13.8, and presents the conditions under which responses relying on ambition (i.e. leadership, enlightened or emergency responses with cooperative, competitive or technological attitudes) and responses relying on serendipity (i.e. cost benefit responses, defensive responses, blind luck non-responses and failed cynical responses) could fulfil the UNFCCC objective. Importantly, leadership responses can help create the conditions needed for serendipity to arise, as do capable institutions. For example, leadership on technologies and practices including policies, mean there are experiences to draw upon, and options available, when there is the collective ambition to scale up responses to climate change. Meanwhile levels of development and capable institutions make it possible to act on response options (Section 8.3.4). Note: For more on the role of serendipity in effective responses, see Appendix V.

Table 13-5: The characteristics of effective global responses to climate change including effective non-responses and serendipity.

Signals	Types of global responses Trigger or driver	 Attitude	Serendipity
Climate science, risks and impacts	Leadership response		**Creating the preconditions for serendipity** Leadership influencing social change and behaviour, policy, business, technologies, practices, and coalitions, can help generate social permissions, negotiate social contracts and create response options needed for effective global responses
Climate stress, response risks and opportunities	Enlightenment or emergency	Cooperative, competitive or technological	**High levels of serendipity needed**, including: Climate sensitivity is no higher than anticipated Climate change and related impacts can be halted GHG removals can be done at scale if needed Other unexpected changes do not hinder the global response to climate change
	Cost benefit	Cooperative, competitive or technological	**Very high levels of serendipity needed**, including: Climate sensitivity is lower than anticipated Climate change and related impacts are reversible Climate resilient low emissions technologies and practices become cheap quicker than expected GHG removals technologies and practices are available and done at scale Other unexpected changes help the global response to climate change
	Cost benefit or emergency	Defensive	**Incredible levels of serendipity needed**, including: Climate sensitivity is much lower than anticipated Climate change and related impacts are reversible Climate resilient low emissions technologies and practices become very cheap very quickly GHG removals technologies and practices are available and are eventually applied at scale Other unexpected changes help the global response to climate change
Response risks and opportunities	Blind luck non-response		
	Failed cynical response		

Armed with a knowledge of possible effective global responses to climate change, it is possible to identify preconditions for effective global responses to climate change.

13.12 Preconditions for effective global responses

The primary research question from Section 1.6 is: What are the preconditions for effective global responses to climate change? Rather than mapping reference pathways and discussing milestones towards effective global responses, preconditions for fulfilling the UNFCCC objective are organised into interrelated themes and tiers. From Table 13-5 and the descriptions of serendipity in Section 13.11, characteristics of effective global responses can be divided into three themes, consisting of:

- Climate change related preconditions;
- Global response related preconditions; and
- Other scenario related preconditions.

Of these, the Paris Agreement purpose and IPCC's 1.5 Degree Report addressed response related preconditions. While it is important to understand response related preconditions over which actors and coalitions have an influence, given the importance of serendipity in effective global responses to climate change (Section 13.11), it is essential to consider climate change related preconditions a well as other scenario related preconditions.

With regards to tiers (i.e. the organisation of preconditions into rows), essential preconditions are described in Tier 1, meanwhile other preconditions needed to support Tier 1 preconditions, are described in Tier 2. Different combinations of Tier 2 preconditions could contribute to Tier 1 preconditions and fulfilment of the UNFCCC objective. In addition to preconditions, other factors are highlighted that could influence preconditions and the global response.

Climate change related preconditions regard the scale and reversibility of climate change. A Tier 1 precondition for effective global responses to climate change is that the scale of climate change, and related impacts, be limited (Table 13-6). At Tier 2, this could be due to mitigation of GHG emissions limiting the accumulation of GHG's in the atmosphere, GHG removals, or climate sensitivity being much lower than expected. Given the likelihood of overshoot scenarios, another Tier 1 precondition is that climate change is reversible or can be quickly stabilised. At Tier 2 this means not passing thresholds such as tipping points or cascade effects.

Response related preconditions have been identified from the sample of possible futures as well as the Paris Agreement and IPCC's 1.5 Degree Report. Tier 1 response related preconditions derived from the sample of possible futures consist of: the global response being timely and at scale most likely involving a transformation; and contingencies being available to address any extreme climate changes or other scenarios that might influence the global response. The likely need for a transformational global response is consistent with the Paris Agreement and IPCC 1.5 Degree Report's preconditions (Table 13-7). The need for finance and development that is climate resilient with low greenhouse emissions constitutes a transformation of finance and development as we know it.

Tier 2 response related preconditions from the sample of possible futures include leadership, research and development, technologies and practices (including policies), and for effective ambition driven responses, social permissions. Leadership includes social, political and business leadership. This leadership can generate response options and opportunities including technologies, practices including policies (Section 13.11). Cost-benefit based responses and blind luck non-responses rely on climate sensitivity being much lower than expected (see climate change related preconditions, Table 13-6) coupled with relevant technologies and practices becoming cheaper much quicker than expected. In this scenario, climate resilient, low emissions and GHG removal technologies and practices are adopted at scale for commercial reasons with limited consideration of climate (i.e. a limited social cost of carbon applied) or no consideration of climate change. Even in blind luck scenarios, it is important to have contingencies available, in the form of technologies and practices, in case of other changes.

Table 13-6: Preconditions for fulfilling the UNFCCC objective.

Objectives	Success criteria				
UNFCCC objective	Stabilising atmospheric concentrations of greenhouse gases at levels that allow ecosystems to adapt naturally, food production is not threatened, and economic development can proceed in a sustainable manner.				
Tiers	Preconditions for effective global responses				
	Climate change related		Response related		Other scenario related
Tier 1	Scale of climate change is limited.	Climate change and related impacts are reversible or can be quickly stabilised.	The global response is timely and at scale (i.e. constitutes a transformation). This includes adaptation, mitigation and atmospheric GHG removals.	Contingencies are available for addressing extreme climate change or other scenarios.	Other social, economic or environmental changes don't negatively influence climate or the global response to climate change at scale.
Tier 2	The scale of climate change can be addressed by technologies and practices. The accumulation of GHGs in the atmosphere is limited. Climate sensitivity is much lower than expected, or not much higher than expected.	Not passing thresholds such as negative tipping points or cascade effects.	Social, political and business leadership generating response options and opportunities. For non-defensive ambition reliant responses, preconditions include social permissions for climate action, as well as domestic and international coalitions with sufficient capacity and power to ensure responses are timely and at scale.	Research and development of technologies, practices and policies, so these things can be deployed quickly and at scale if needed.	The scale of other negative social, economic or environmental changes can be addressed by technologies, practices, institutions or policies. Other social, economic or environmental changes limiting climate change or helping the global response to climate change.
Factors	Climate change related		Response related		Other scenario related
Other factors	Ecological and environmental processes and dynamics, e.g. the carbon cycle and carbon balance between the atmosphere, biosphere, hydrosphere and geosphere.		Social change and behaviour, political will and policy, business and economic activity; distribution of impacts and risks; response triggers, drivers and attitudes of actors; domestic, national and international actors; prices, taxes and subsidies, markets, support for research, development of technologies and practices; and institutions.		Ecological, environmental and cosmological processes and dynamics, social, political and business processes and dynamics.

Effective (i.e. non-defensive) ambition driven responses include enlightened or emergency responses with cooperative, technological and competitive attitudes. To a lesser extent, cost benefit responses with the same attitudes might also be included in this category. Ambition driven responses need social permissions allowing climate action and any necessary trade-offs. Social permissions are based on local and domestic coalitions of actors (Section 13.7) which then translates into national interests, coalitions and agreements at the international level (Section 13.8). For such coalitions to be effective, the actors participating need the capacity to develop and apply technologies and practices and the power to influence other actors and institutions (Section 13.8) so they also participate and comply in the global response. Institutions are an important factor contributing to the capacity and power of government actors.

Importantly, the IPCC's 1.5 Degree Report provides some guidance on the specific technologies and practices needed for limiting global warming to 1.5°C. This includes switching from fossil fuels to electricity in end-use sectors coupled with greater mitigation efforts on the demand side (Table 13-7). With regards to timeliness, decarbonisation of energy supply needs to be rapid and profound (i.e. in the near-term) and part of a wider set of comprehensive emission reductions to be implemented in the coming decade. Investment priorities and patterns will need to change even quicker to finance this transformation (Table 13-7). With regards to GHG removals, the 1.5 Degree Report stated CDR needs to be at scale before 2050.

Table 13-7: Preconditions for effective global responses from the Paris Agreement and IPCC's 1.5 Degree Report.

Tier	Response related preconditions
Tier 1	**Ambition** A stronger global response to climate change through the pursuit of efforts to limit global warming to 1.5 degrees*
	Resilience (including avoidance of unintended consequences) Capability to adapt to the adverse impacts of climate change* Food production not threatened by the global response to climate change*
	Transformation (finance and development) Finance flows consistent with climate resilient and low greenhouse gas emissions development* - Considerable shifts in investment patterns^ Development is climate resilient with low greenhouse emissions* - Rapid and profound near-term decarbonisation of energy supply^ - Greater mitigation efforts on the demand side^ - Switching from fossil fuels to electricity in end-use sectors^ - Comprehensive emission reductions are implemented in the coming decade^
	GHG removals - CDR at scale before mid-century^
	Fairness The global response is equitable with common but differentiated responsibilities*

** Paris Agreement*
^ IPCC 1.5 Degree Report

With regards to the levels of global warming that might be allowed while fulfilling the UNFCCC objective, scenarios included stabilisation of global warming at levels greater than 1.5°C or even 2°C from pre-industrial times (Section 7.3.1). In such scenarios, the question of what fulfilling the UNFCCC objective looks like in an overshoot scenario becomes important. These scenarios involve loosing ecosystems and it is an open question as to whether society attempts to limit climate change or focuses on adaptation (Section 13.13 and Appendix W).

Response related preconditions from the sample of possible futures do not always align with preconditions from the Paris Agreement purpose. For example, the Paris Agreement purpose highlights fairness, equity and common but differentiated responsibilities as important conditions. From the sample of possible futures, enlightenment scenarios also included issues of humanity and economic distribution at the same time as addressing climate change (Section 7.4.2.4). In enlightenment scenarios these issues cannot be addressed separately. However, enlightenment scenarios were not the only scenarios that could lead to effective global responses and it is conceivable that powerful business interests might drive political coalitions and effective emergency responses while privileging business interests (Section 8.4.1). In these scenarios, fairness is not a precondition for an effective global response but rather, coalitions of powerful and capable actors is the defining precondition.

While the UNFCCC objective includes making sure food production is not threated by climate change, the Paris Agreement highlights food production should not to be threatened by the global response (Section 13.2). The risk of unintended consequences comes with any social, political or business changes and as such it is important to be mindful of these response risks (e.g. see Section 13.6.2 and Section 13.9) in the same way it is important to ensure resilience and have contingencies.

The Paris Agreement highlighted the need for resilience (Table 13-7), while analysis of the sample of possible futures demonstrated the need for contingencies related to climate change as well as other social, economic or environmental changes (Section 13.10). Contingencies and capacity are important elements of resilience. Adaptation also contributes to resilience and from the analysis in Section 13.6.2, adaptation is included in non-responses, as actors are expected to make changes when impacts arise, regardless of whether they attribute them to climate change or not (Figure 13-2). Of course, there is always the chance of maladaptation (Section 2.2.3).

Other scenario related preconditions rely on serendipity (see Table 13-5 in Section 13.11). Tier 1 other scenario preconditions consist of other changes, including unexpected social, economic and environmental changes, not exacerbating climate change and related impacts, or hindering the global response to climate change. For serendipity reliant scenarios, any other social, economic or environmental changes need to help the global response to climate change rather than hinder it. Even ambition driven responses need to avoid social, economic or environmental changes that negatively affect climate or the global response to climate change. With regards to the literature, Kerr (2007) noted “Serendipity is not a strategy” in the title of their paper regarding national climate programmes from 21 countries. Worryingly, Kerr (2007) found serendipity was a key factor towards improving GHG emissions trends, rather than policy or some deliberative response.

See Appendix X for more information on the role of serendipity with regards to Tier 1 preconditions.

13.13 Preconditions for action

An important research question is: Under what conditions would actors act on effective response options? While it is good to know the preconditions for effective global responses to climate change, it would be reassuring to know the conditions under which actors would actually act on effective response options.

Collective action depends, in part, on the extent to which society treats climate change and related impacts as a problem that needs to be solved or a condition that can be lived with (Section 2.2). Kingdon (1995) highlighted that the problem definition has politically high stakes, as it has implications regarding the options considered, with some actors and their interests potentially “helped” while others may be “hurt”. The extent to which climate change is defined as a problem depends in part on the climate change signal and climate stress levels, as well as the extent to which response options are an opportunity (Section 13.6.1). These factors also influence actor ambition and how high climate change is ranked on the public policy agenda (Figure 13-2). However, individual and collective responses to climate change also depend on the availability of options that simultaneously address climate change and actor interests.

The availability of commercially viable technology options fundamentally changes the climate change problem. It was noted in Section 8.3 that the climate change was a problem without technological solutions, and Section 12.3.5 noted these conditions characterised the Kyoto era. Now climate change is a problem requiring political ambition (Section 8.3) because commercially viable technologies and practices exist (Section 12.3.5). With ambition it is possible that zero emissions technologies and practices could be scaled up through political and business coalitions driven by competitive and technological response attitudes (e.g. Section 7.5.1.2, Section 8.4.4 and Section 9.2.2). For such a scenario to happen, it is important that capable and powerful actors do not pursue cynical responses privileging special interests. Furthermore, cooperative attitudes and high ambition are needed on a mix of low and negative emissions agriculture, forestry, and land use practices (policies included) for there to be an effective global response that is not overly reliant of serendipity.

Enlightened responses featured strongly in the sample of possible futures. As such, it is possible that awareness creates change in society, including social change and behaviour, political will and business responses that make positive contributions to the global response to climate change. Such a scenario might be driven by an unambiguous climate risk signal (Section 7.4.2.2) or some other global event such as a pandemic that generates awareness of the value of collective action (Section 7.4.2.5). However, the extent to which global events such as a pandemic might contribute to an enlightened response is an open question.

Emergency responses involve very high ambition and urgency, which Beck (2006) described as being “involuntary enlightenment” where climate change impacts and risks force awareness and change. Like with enlightened responses, it is difficult to envisage scenarios where an unambiguous climate risk signal would generate collective action capable of limiting climate change and its impacts. Meanwhile, emergency impact responses may not be effective at limiting climate change and impacts due to locked in of climate change and related physical hazards.

Given the scale of the climate change problem and long-term lock in of climate change and related hazards, it is conceivable that societies collectively treat impacts and risks to natural systems as “conditions” that can be lived with. From the sample of possible futures it seemed unlikely that actors with power and capacity would willingly let food production be threatened (Section 7.3.2), however defensive responses to climate change and other social, economic or environmental scenarios could still result in food insecurity, for example due to food exports being banned in some countries. Likewise, it seems unlikely actors with power and capacity will willingly forgo economic development (e.g. see Section 10.3.3). Hence actors are anticipated to adapt to climate change and related impacts, even if climate change is not acknowledged as a driver.

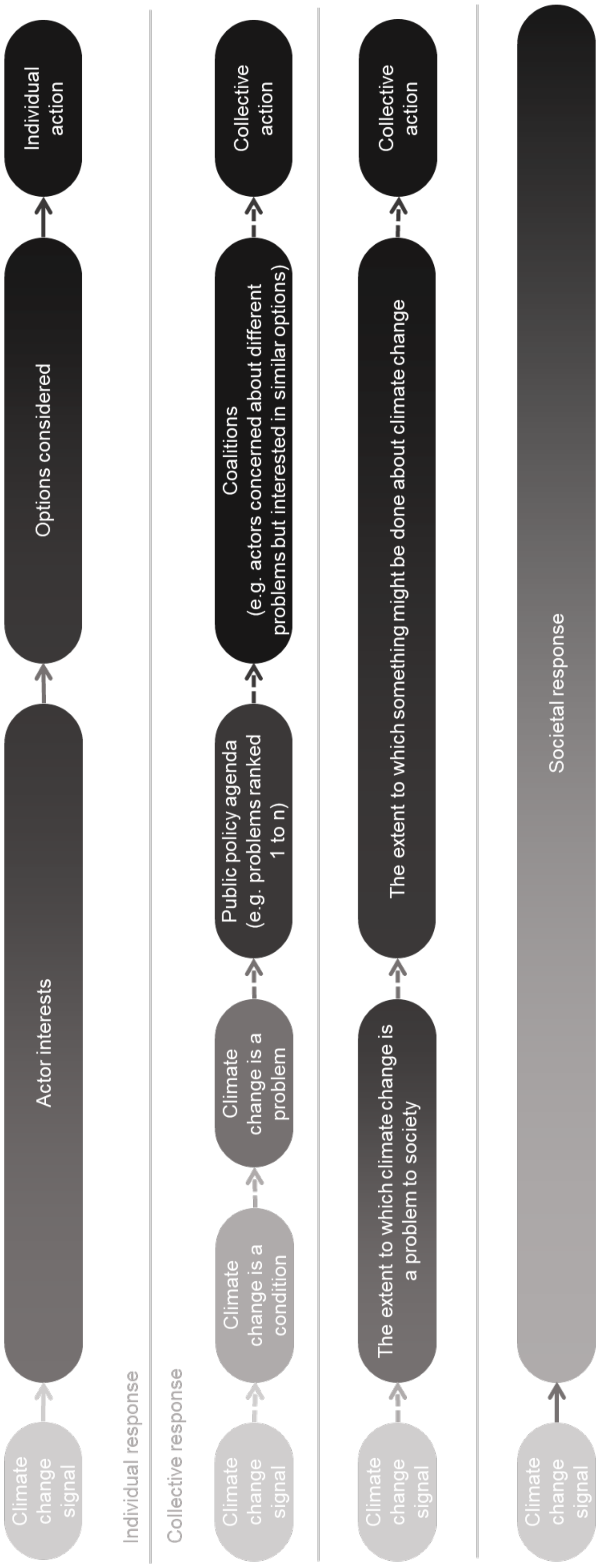

Figure 13-5: Preconditions for individual and collective action on options.

If climate change impacts and risks are primarily addressed through adaptation, then the climate change problem will have changed from one of stabilising atmospheric concentrations of GHGs to a problem of resilience (i.e. reducing vulnerability and exposure to climate change and related hazards). In such a scenario, the UNFCCC objective is essentially abandoned.

13.14 Existential risk

If the UNFCCC objective is abandoned, or fails to be achieved, then for some actors climate change could be catastrophic at personal, local or national levels (Section 12.3.5). For example, actors in unique and threatened systems may not be able to continue cultural practices (Section 2.2.3), meanwhile low-lying small island developing states may not remain viable as states with further climate change and sea level rise (Section 7.2.2). This highlights the fundamental nature of the climate change problem, as an "infinite" game, where the aim is to stay in the game i.e. "continuing the play" (Carse 1986). So while this study implicitly framed the climate change problem as a "finite game" where it is possible to solve climate change by fulfilling the UNFCCC objective, the UNFCCC objective has the characteristics of an "infinite game", e.g. ecosystems being able to adapt naturally, food production not being threatened and economic development being able to proceed in a sustainable manner (Section 2.5.1). An effective global response to climate change is not a one-off event, and there is no finish line, instead it is something that requires vigilance and effort. Failure on the other hand creates existential risks and questions of climate justice for all of us.

Note: See Appendix W for more on UNFCCC objective, success and failure, Appendix U for more on catastrophic climate change and Appendix Y for more on the strategic implications of success, failure and the possibility of catastrophic climate change.

Chapter 14 Conclusions and recommendations

14.1 Introduction

“Who are the main actors?” I asked.

“We are all actors” responded the climate veteran over the noise of negotiators and observers shuffling past.

I was up to my 24th interview and a theme was emerging. Climate change is about you, me and everyone else, as individuals and in whatever capacities we have in society, business or government.

This study was conceived in the shadows of the Paris Agreement and the IPCC’s Fifth Assessment Report, while the 1.5 Degree Report was being prepared. Climate change was increasingly being referred to as a “crisis” (Section 2.2.3) and recognised as a problem requiring collective action (Section 1.1). It is in this context that I wanted to “solve” the climate change problem[19]. Initially, I wanted to find options for limiting climate change and its impacts; fulfilling our internationally agreed objectives of stabilising atmospheric concentrations of GHGs while allowing ecosystems to adapt naturally, ensuring food production is not threatened and economic development can proceed in a sustainable manner. I quickly realised there are adaptation, mitigation and GHG removal options, they have been studied, peer reviewed and assessed by the IPCC and other United Nations bodies (Section 2.3). The question is not whether we have options, it is under what conditions might we act on these options? These “conditions” are “preconditions” for effective global responses.

This study explored preconditions for effective global responses to climate change. Helping to unpack these preconditions, the study also addressed: the influence climate change might have on us and our responses; the preconditions for effective international cooperation by state and non-state actors; the conditions under which governments, businesses or others would remove GHGs from the atmosphere at scale; and, the conditions under which we would actually do what it takes to limit climate change and the related impacts. Exploration involves the act of travelling through an unfamiliar place (Appendix A). Given that the past is unlikely to be representative of the future under climate change (Section 1.4, Section 12.2.1.2), this study explored the future, with a focus on “pathways” towards fulfilling the UNFCCC objective.

[19] Wanting to “solve the climate change problem” was wilfully naïve but regardless, this aspiration triggered the study and drove important choices throughout the study, for example broadening the focus from effective “international cooperation” options to effective “global responses”. Both are research worthy, but the focus on effective global responses allowed for a first principles driven search for climate change “solutions” in the form of effective response scenarios and related preconditions, rather than restricting the study to a limited set of scenarios that happen to involve international cooperation.

14.2 Preconditions for effective global responses to climate change

In public and academic discourse, the expression “climate crisis” has been used to describe the current climate change situation (Section 2.2.3). This study finds the climate issue to date is largely a “crisis of response” rather than a “crisis of impacts”. For example, impacts on people, property and livelihoods were largely undetectable until the period 2010-2020 (Section 12.2.1.2) unless you were living in “unique and threatened systems”[20] (Section 13.6.1). However, climate change lock-in means global warming and other climatic changes will persist for long periods (Figure 2-5, Section 2.2.3), meanwhile the risk of impacts increases markedly with global warming above 1°C (Section 12.2.1.2), making the need for timely climate responses critical.

Timely responses at scale are preconditions for effective global responses (Section 7.3). Our response to date is anything but timely or at scale. Underscoring the “crisis of response” is the fact that atmospheric GHG removals are almost certainly required to limit climate change to well below 2°C of global warming (Section 2.2.4).

In addition to timeliness and scale, effective global responses to climate change involve a combination of serendipity and ambition (Section 13.11). Ambition driven responses consist of leadership, enlightened responses, and emergency responses. Serendipity driven responses consist of very lucky cost-benefit based responses, blind luck non-responses, and failed cynical responses.

Leadership is a prerequisite for any effective global response. Social, political and business leaders create the conditions for effective global responses, for example by researching and developing technologies and practices when others don’t, developing policies and business models when others won’t, and forming coalitions in support of climate action and wider social change when others resist. Leadership creates the options and coalitions needed for effective global responses (Section 13.12).

Enlightened responses (i.e. awareness that creates change) and emergency (i.e. security) responses involve high to very high ambition levels where the decision to solve the climate change problem is made and the main economic question regards “cost effectiveness” i.e. how to best use available resources to limit climate change and related impacts (Section 12.2.2). By comparison, cost-benefit based responses, non-responses and cynical responses each rely on very high to incredible levels of serendipity if they are to be effective (Table 13-5, Section 13.11). Of all the options required to limit climate change and related impacts, cost-benefit based responses only consider the options that have a positive net present value (Section 12.2.2). Only some of these will actually be implemented. Blind luck non-responses involve incidental adaptation, mitigation and GHG removals driven by commercial or other considerations rather than climate change related considerations (Section 12.2.2). Failed cynical responses involve the failure of special interests to inhibit the global response to climate change.

[20] For people living in unique and threatened systems, climate change may already be a “crisis of impacts”.

It would be reassuring to think ambition driven responses (e.g. leadership, enlightened and emergency responses) could drive effective global responses without serendipity, but this is not true. Due to current levels of climate change and GHG emissions, even ambition driven responses rely on high levels of serendipity if they are to limit climate change and related impacts (Section 13.11). So, while Kerr (2007) noted “serendipity is not a strategy”, serendipity is a precondition for effective global responses to climate change.

Serendipitous conditions required for effective global responses include: climate sensitivity being the same or lower than expected; not breaching climate system thresholds, tipping points or triggering cascade effects (including so call “large scale singular events”); the accumulation of GHGs being kept below what can be addressed with available technologies and practices; other unexpected social, economic or environmental changes helping limit climate change and related impacts; and, other unexpected changes helping (or at least not hindering) the global response. These are “climate change” and “other scenario” related preconditions are essential for any “response” to be effective (Section 13.12).

According to the IPCC’s 1.5 Degree Report, “response” related preconditions consist of timeliness and scale nothing short of a transformation including adaptation, mitigation and atmospheric GHG removals (Rogelj et al. 2018, Table 13-7). From the scenarios compiled as part of this study, preconditions for such a transformation include: social permissions for adaptation, mitigation and GHG removals at scale; domestic and international coalitions forming around climate resilient low emissions technologies and practices (including policies); coalitions forming with the capacity and power to ensure these technologies and practices are adopted at scale and in a timely manner; social, political and business leadership on technologies and practices, social, political and business leadership creating domestic and international coalitions in support of the global response to climate change; and, availability of contingencies in case of extreme climate change or unexpected social, economic or environmental events (given the long periods of time being considered) (Section 13.12).

From the literature, “response” related preconditions derived from the Paris Agreement purpose include: ambition in the form of a stronger global response to climate change through the pursuit of efforts to limit global warming to 1.5°C; resilience including the capability to adapt to the adverse impacts of climate change; and changes in finance and development that are nothing short of what’s required to achieve climate resilient low greenhouse gas emissions development (Table 13-7, Section 13.12). While fairness featured in Paris Agreement based preconditions, it did not feature in scenarios collected as part of this study. Instead, the capacity and power of coalitions featured as preconditions (Section 13.12). Preconditions from the Paris Agreement and IPCCs 1.5 Degree Report focused on technologies and practices including finance for example, rather than the social, political or business actors and interests that might develop or apply these technologies and practices.

14.3 Other conclusions

IPCC assessments coupled with the searchable sample of possible futures provide rich datasets for exploring preconditions for effective global responses to climate change. As such, the study includes a number of other conclusions. For example, the study finds there have been two fundamental shifts in the global response system in the period 2010-2020. The first is the climate change signal has shifted from a mix of “climate science” and “risks” in the future, to a signal where there are “impacts” on people, property and livelihoods (i.e. human and managed systems) (Section 12.2.1.2).

An important question addressed by the study regarded the influence climate change itself might have on our global response to climate change (Section 1.6). From the sample of possible futures, there were no effective global response scenarios based on concerns about the environment, for example regarding impacts and risks to “natural systems”. As such, an important finding of the study is only impacts and risks to people, property and livelihoods drive effective global responses (Section 7.2.3). At the same time, the extent to which response options are a risk (i.e. transition risk) or an opportunity also influences actors and their decision making (Section 12.2.2).

The second fundamental shift regards incentives and the availability of commercially viable response options (Section 12.3.5). In the past, many mitigation options were not commercially viable and as such the development of these options required a mix of social, political or business leadership, and adoption at scale required political will and government support. Thanks to this leadership, there are now a suite of commercially viable renewable energy, energy storage, and transportation technologies that mitigate GHG emissions. These technologies can drive the formation of coalitions i.e. “winning teams” involving social, political and business actors. Importantly, competition between businesses and between governments can drive research and development as well as production and adoption of these technologies at scale. However, the United States government’s low ambition under President Trump has dampened national competition for market share or dominance in these technology categories (Section 12.3.5). It should also be noted that even with these technologies, there still needs to be changes in land use and marine practices, in support of adaptation, mitigation and GHG removals (Section 9.4.2).

When stepping back and looking at the main features of the global response system (Section 12.2), several categories of actors were identified as being important when it comes to decision making and the structure of the global response system (Section 12.3). With regards to international cooperation, the distinction between “state” (i.e. central government) and “non-state” actors is very important, as state actors have primacy defining the national interests of “sovereign states” and can enhance or inhibit international cooperation between non-state actors (Section 3.3.2.2). At the domestic level (i.e. within states), three overarching categories of actors were identified consisting of social, political and business actors. Each of these actors influence the global response to climate change differently, for example social actors drive social change and behaviour, political actors decide on policy, meanwhile business actors are focused on economic activities (Figure 12-6, Section 12.3). Importantly, each of these actors have interests influencing decision making and their contributions to climate change.

When it comes to decision making, this study borrows Abraham Lincoln's metaphor of "better angels" and identified "the competing angels of individual and collective action" based on the climate change signal response models developed earlier in the study (Section 12.2.2). The competing angels include among others, the angels of self-interest and wider concerns, unambitious and ambitious angels, cynical and enlightened angels, defensive and cooperative angels. These "angels" compete within us whenever we make decisions. Meanwhile, each angel is competing and cooperating with other angels when it comes to our collective response to climate change. The extent to which any "angel" influences the effectiveness of the global response to climate change depends on the actors and coalitions being influenced, the options available, and the capacity and power of actors and coalitions. From the sample of possible futures, the angels of cooperation, competition and technological attitudes can all have a role in effective global responses (Section 13.11). However, scenarios where defensive angels prevail fail to limit climate change and related impacts (Section 13.6.2).

From the literature, an important "reason for concern" in successive IPCC assessments has been the "distribution of impacts" (Section 2.2.3). From the sample of possible futures, the distribution of impacts was also important. For example, preconditions for effective international cooperation on climate change include the distribution of climate change and related impacts. If powerful countries such as China, France, Russia, the United Kingdom, and the United States of America each suffer a "crisis of impacts" then it is possible climate change could become the premier international issue, elevated from being an issue of "environment and development" to one of "security" for example in the United Nations Security Council (Section 13.8). Given the power and capacity of these countries, the expectation is that other states would participate in the global response and comply with whatever agreements these powerful countries reach. The distribution of climate change and related impacts within states and on different groups can also influence the extent to which climate change is seen as a "condition" that can be lived with versus a "problem" that needs to be solved in the national interest (Section 13.8).

Preconditions for actors to remove GHGs from the atmosphere starts with mitigation at scale limiting the quantities of GHGs that need to be removed. Land management practices, policies and governance processes need to be in place for carbon storage in terrestrial ecosystems meanwhile very cheap renewable energy is essential, simultaneously contributing to mitigation while making technology based GHGs removals economically viable (Section 13.9). From the literature, the IPCC's 1.5 Degree Report stated removals would need to start before 2050 if global warming is to be limited to 1.5°C (Rogelj et al. 2018, Section 13.3).

Institutions (i.e. the "rules of the game") are an important part of the global response to climate change (Section 2.5). This includes formal institutions such as laws, regulations and contractual arrangements as well as informal institutions for example notional "social contracts" (Section 12.3.1). As already noted, social permissions are a precondition for government actors and business actors to do what it takes to limit climate change and related impacts (Section 14.2). Many effective global response scenarios involve social change and behaviour as a factor (Section 12.3.2, Section 12.3.3), however dystopian business driven scenarios are also possible where the global response is driven by special interests rather than public opinion (Section 10.2.5). Institutional capacity, particularly in less developed countries or jurisdictions, can be a limiting factor when it comes to adopting and applying technologies and practices including policies (Section 12.3.2). Other institutional factors that can influence the global response to climate change include the availability of finance to scale up technologies and practices as well as legal precedent limiting the availability of options harmful to climate and the global response (Section 12.2.2).

With regards to the conditions under which you, me and everyone else (i.e. actors) would actually do what is takes to limit climate change and related impacts, there was no definitive finding. While it is expected people will adapt to climate change as impacts become prevalent (Section 13.6.2), it is unclear whether people will mitigate or remove GHGs at scale. It is even possible that apathy or hopelessness could drive the global response (Section 7.4.1.4). In such scenarios, climate change is redefined from being a “problem” that needs to be solved, to being a “condition” that we collectively decide to live with (Section 13.13). Already the climate change “problem” has been simplified by the Paris Agreement, from being a problem of stabilising atmospheric concentrations of GHGs at levels that allow ecosystems to adapt naturally, food production not to be threatened and economic development to proceed in a sustainable manner, to a problem of limiting global warming to well below 2°C from pre-industrial times (Section 5.2.2.1). Meanwhile, there is evidence that with 1°C of global warming, we have already failed to fulfil the UNFCCC objective, given that risk of impacts to coral ecosystems is already high (Figure 2-7, Section 2.2.3).

The extent to which societies, political leaders and businesses collectively treat climate change impacts on natural, managed or human systems as “conditions” that can be lived with versus “problems” that need to be solved, will be an important part of the global response (Section 13.13). Complicating the situation is that fact that climate change has the characteristics of an “infinite game” where the aim of actors, including Small Island Developing States for example, is “continuing play” and “staying in the game” i.e. survival (Section 13.14). Climate change is not “finite game” that can be won or solved, but rather effective responses involve continuous effort limiting risks at individual and collective levels including existential risks (Section 12.3.5).

14.4 Gaps and contributions to knowledge

This study has benefited greatly from the research of others including IPCC and other United Nations assessments. Like IPCC assessments, the global response to climate change has many facets and disciplinary perspectives. To the extent possible, this study focused on fundamental concepts, regardless of discipline, understanding how each element of a system is related to other elements and what this means for the global response. As such, the study is interdisciplinary, integrative and exploratory. The most important gaps and contributions to knowledge are briefly highlighted below.

As noted already, this study explores and identifies preconditions for effective global responses to climate change, including response related preconditions as well as climate change and other scenario related preconditions (Section 14.2). The study also made a number of other findings (Section 14.3), for example regarding: fundamental shifts in climate change signals and response options; influences on decision making and the effectiveness of the global responses; the influence climate change impacts on geopolitically powerful countries can have on the global response; and, the conditions needed for effective GHG removals.

Despite there not being single overarching model of climate change and global response system or definition of “global response to climate change” (Section 1.2), many elements of the global response system have already been described in the literature (Chapter 2 and Section 3.2). Like in the parable involving the elephant (Section 1.2) these elements can be taken together to describe the global response system as a whole. The CCNIIC Model (pronounced “scenic”) integrates the IPCC’s conceptual model for understanding climate change related risks (Oppenheimer et al. 2014) with Keohane and Victor's (2011) climate regime complex, Putnam's (1988) two level game, Stavins et al. (2014) and IEGL's (2017) descriptions of actors involved in international cooperation on climate change, and Hermwille's (2018) structuration model of climate negotiations. By integrating these concepts and models, the CCNIIC Model provides a panoramic perspective of the global response system and its main features including how climate change and related hazards influence national interests and international cooperation, and how international cooperation influences the options available to state and non-state actors (Section 3.3.2).

From the literature review, the focus on economic decision making when modelling mitigation and other climate change related scenarios meant there has been limited exploration of other decision-making influences on the global response to climate change (Section 1.4). The SSPs go some way towards acknowledge there are wider socio-economic and political considerations that influence the global response to climate change, but the reasons why particular socio-economic or political responses might arise were not adequately explored or unpacked. However, Grubb (2014) does contextualise the weighing up of costs and benefits as part of a spectrum of possible climate change risk and response strategies (Section 3.2.3). This study builds on Grubb (2014) and extends the range of response types, including cynical responses through to emergency responses (Table 12-4, Section 12.2.2). Furthermore, this study integrates these responses into climate change signal response models addressing the breadth of climate change related signals, triggers, drivers, attitudes, inclinations, options and actions (Figure 12-5, Section 12.2.2), which in turn form a basis for understanding “the competing angels of individual and collective action” (Section 13.6.2) and the influence these things have on the effectiveness of the global response (Section 13.11). As such, this study provides a basis for understanding the many influences on global responses and the range of possible responses that might arise.

While there are RCPs, SSPs and other climate change and response related scenarios, the sample of possible futures in the literature was limited (Section 1.4). To methodically explore preconditions for effective global responses it was important to collect a representative sample of possible futures. From a literature review of methodologies, there was limited guidance on how to collect and compile representative samples of possible futures. Many scenario studies consist of four or five reference scenarios (e.g. RCPs Section 2.2.3 and SSPs Section 2.2.4). Based on the literature review, backcasting, reverse stress testing, theory of change and thematic analysis methods were integrated, showing how a representative and diverse sample of possible futures can be collected and compiled using qualitative methods (Chapter 5). Substantively, Chapters 7 to 11 provide a summary of the sample of possible futures that can be used by researchers and others working on climate change and related responses.

While each of the success scenarios collected and compiled as part of the study highlighted possible pathways towards fulfilling the UNFCCC objective, it was important to systematically explore all possible pathways towards fulfilling the UNFCCC objective. To do this, theory of change was combined with thematic analysis methods to create "thematic chain analysis" (Section 5.4). Using this method, the range of possible pathways related to social change and behaviour, political will and policy, business and economic activity, atmospheric GHG removals, and effective international cooperation were mapped including preconditions and responses. As such, this study makes methodological contributions when it comes to systematically exploring multiple possible pathways related to a theme or leading to an objective. Substantive contributions include maps of possible pathways for social change and behaviour (Figure 12-7), political will and policy (Figure 12-8), business and economic activity (Figure 12-9), atmospheric GHG removals (Figure 12-12), and effective international cooperation (Figure 12-13).

To keep things as simple as possible, the study used simple English, deliberately avoided jargon and pre-exiting terms unless a term is well defined and essential to the study. Given the interdisciplinary nature of the research and number of disciplines that might be interested in the findings, it was important to clearly define each term used in the study ensuring consistency with all other terms and definitions used (Section 1.3). As such, the comprehensive glossary (Appendix A) is a contribution to knowledge, building on IPCC definitions and supplementing these with definitions from other sources and the author, each edited for consistency.

14.5 Practical applications, limitations, and future research

There are a mix of practical and academic applications for the conceptual models, substantive findings, qualitative methods, and scenarios compiled in this study.

The study includes conceptual models that can be used to describe the global response system to strategists including social, political and business leaders. The CCNIIC Model allows us to see where we fit in the global response system. Meanwhile, the climate change signal response models allow us to see how our decisions might contribute to the global response and provides a basis for understanding how other people, organisations or states with different interests might respond to climate change.

With regards to the substantive findings of the study, any group or business preparing a climate change strategy, or government preparing their NDC, should be clear about their assumptions regarding "preconditions for effective global responses" including: the scale of climate change relative to technologies and practices required to limit climate change and its impacts; the reversibility of climate change and related impacts; the global response in terms of other actors and their contributions; contingencies in case of unexpected events; and the other things that may or may not affect the strategy. The extent to which a strategy relies on serendipity ahead of ambition is also something to consider. In addition to these things, any climate change response strategy should also consider coalitions, and working with other actors with common interests. Coalitions can help address issues of capacity, for example to develop and implement technologies and practices, as well as power to influence institutions and the rules of the game. Importantly, the study provides models and scenarios that can help us think about climate change and our strategies. It is also possible to "stress test" strategies by considering scenarios from the sample of possible futures described in Chapters 7 to 11.

The climate change signal response model provides an overarching frame for organising information and monitoring climate change and responses. Much of the information needed to fill the framework is already reported. As trends change, it will be possible to distinguish which scenarios appear to be playing out, and as such, adjust response strategies.

Further research on each of the sub-sectors in this study would be valuable, including scenarios for social change and behaviour, political will and policy, business and economic activity, GHG removals and international cooperation. It is important to note here that the sample for this study lacked respondents with business backgrounds, and more people could have been interviewed from developing countries. Any new data collected can be processed using the methods from this study and results from new studies can be integrated using the overarching models of the global response system.

Interestingly, the most comparable scenarios in the literature are from non-peer reviewed sources such as blogs, opinion pieces and popular media. There is scope for research of this literature for example using qualitative methods developed in this study to identify themes and analyse conditions that contribute to effective global responses. Important scenarios that are missing from the sample of possible futures include momentum scenarios where the Paris Agreement drives momentum and ratcheting of climate action (Rockstrom 2017), or a "Marshall Plan" for climate change scenarios where vast sums or money, expertise and resources are thrown at the climate change problem, with the intention of "solving" it (Carlin 2020, Massara 2020). There is scope for more scenarios to be added to the sample of possible futures.

Three sources of bias need to be acknowledged, consisting of: the framing of the study in relation to the UNFCCC objective rather than human development or some other overarching frame (Section 12.2.2); the selection of respondents and the extent to which the sample of possible futures they provided reflect the full range of possible scenarios (Section 5.2.3.1 and Section 6.2); and lastly the fact that failure scenarios, while thematically analysed, did not feature in the analysis due to limited space in the thesis document (Section 5.4). Framing biases the results of the study including the language and models used to describe results. The selection of respondents may bias the sample of possible futures collected, and it is possible that with a wider set of respondents an even wider set of scenarios might have been identified. Meanwhile there could be further analysis of failure scenarios.

Related to the issue of framing, the biggest weakness of the signal response model is that it focused on decision making from a climate change perspective, rather than the perspective of the actors making the decisions. Most of us are not focused on climate change when we make most of our decisions, but rather we are focused on fulfilling needs, meeting expectations or aspirations with the means and options available to us. Climate change is just one of many signals or concerns we may or may not take into account when making decisions. In many cases, other factors will generate incentives and disincentives influencing our decisions. As such, an important area of research is to understand decision making processes from an actor perspective, including the processes and considerations that go into economic, political and social decisions.

With these limitations in mind, the qualitative models developed in this study could be developed into quantitative models. For example, the CCNIIC Model and climate change signal response models could be used as a basis for developing agent-based models. This could include modelling multiple agents, each with different situations and interests when it comes to climate change impacts, options available, response risks and opportunities, triggers and drivers, attitudes and inclinations, capacities to develop and apply technologies and practices, and levels of power to influence other actors and the rules of the game.

An important issue that deserves more research is the extent to which climate change might collectively be treated as a “condition” that can be lived with versus a “problem” that needs to be solved, drawing on concepts from Kingdon (1995). If the problem definition changes from stabilising atmospheric GHG concentrations at levels that allow ecosystems to adapt naturally, food production not being threatened and economic development being able to proceed in a sustainable manner, then this raises questions of climate justice including which of these things we are collectively willing to abandon and who will be impacted.

At the same time, it is important to remember climate change is not the only challenge that affects people, our planet or collective prosperity (Section 11.1). Climate change needs to be addressed simultaneously with other challenges facing individuals, communities and states (Section 13.10). At the time of writing these conclusions, the COVID-19 pandemic is sweeping the world (Section

4.2.1), and like climate change, requires collective action coupled with technologies and practices applied at scale in a timely manner for there be effective responses. The CCNIIC Model, climate change signal response model and competing angels of individual and collective action can each be adapted and used as frames to explore effective global pandemic responses by substituting COVID-19 hazards and signals for climate change in these models.

The extent to which models developed in this study are generalisable and can be applied to other global response problems will be an interesting area of future research. It may be that the conceptual models developed in this study can be generalised and used to rapidly assess issues and options when new global hazards arise requiring coherent responses from all actors.

Lastly, with regards to “solving” climate change and other challenges, it is important to recognise that the world we live in today has changed dramatically from 10, 20 or 30 years ago, and the world in 10, 20 or 30 years time will be very different from the world today. The question is not whether the world will change, but rather, what do you want the world to be like in 10, 20 or 30 years time? What are you going to do to make this a reality? Which technologies and practices, including policies, will you and others support? What coalitions can we form? And perhaps most importantly, which of the competing angels of individual and collective action will we listen to? Hopefully, it’s our better angels and serendipity follows.

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Appendix A: Glossary

Where-ever possible the study uses existing definitions from the IPCC or widely used and reputable dictionaries, but not at the expense of internal consistency. As such, definitions are modified in many cases to ensure internal consistency between terms and the concepts they represent.

Abrupt irreversible change: A large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems. *Source: Collins et al. 2013, p. 1114.*

Actor: Individuals or groups with the ability to make decisions and influence the system. *Source: Author*. This is consistent with the definition of actor from the Oxford Dictionary: "A participant in an action or process". The Cambridge Dictionary noted in its examples, that actors can include "individuals, communities, and states". For this study, actors include all types of groups including all types of organisations.

Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects. *Source: IPCC 2014b*.

Adoption (of a treaty): The formal act by which the form and content of a proposed treaty text are established. As a general rule, the adoption of the text of a treaty takes place through the expression of the consent of the states participating in the treaty-making process. Treaties that are negotiated within an international organization will usually be adopted by a resolution of a representative organ of the organization whose membership more or less corresponds to the potential participation in the treaty in question. A treaty can also be adopted by an international conference which has specifically been convened for setting up the treaty, by a vote of two thirds of the states present and voting, unless, by the same majority, they have decided to apply a different rule. *Source: UNTC 2019.*

Adverse effects of climate change: Changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare. *Source*: *Article 1, UNFCCC 1992.*

Adverse side-effects: The negative effects that a policy or measure aimed at one objective might have on other objectives, without yet evaluating the net effect on overall social welfare. *Source: IPCC 2014b.* Potential adverse side effects are transition risks.

Agreement: See international agreement and treaty.

Ambition: The level of determination, and action required, to fulfil an agreement and achieve its goals, objectives or purpose. *Source: Generalised from Cameron and DeAngelis 2012.*

Apathetic or hopeless response: A lack of interest, ambition or concern for climate change and related issues or despair regarding the possibility of addressing climate change. *Source: Author.*

Approach: A way of dealing with a situation or problem. *Source: Oxford Dictionary.*

Approval (of a treaty): An instrument that has the same legal effect as ratification of a treaty and consequently express the consent of a state to be bound by a treaty. In the practice of certain states acceptance and approval have been used instead of ratification when, at a national level, constitutional law does not require the treaty to be ratified by the head of state. *Source: UNTC 2019.*

Architecture: Structure of an international agreement on climate change. *Source: Modified from Stavins at al. 2014, p. 1054*.

At scale: At the required size to solve the problem. At scale typically refers to handling larger volumes. *Source: PCMag Encyclopaedia 2020*.

Baseline scenarios: Scenarios that are based on the assumption that no mitigation policies or measures will be implemented beyond those that are already in force and/or are legislated or planned to be adopted. Baseline scenarios are not intended to be predictions of the future, but rather counterfactual constructions that can serve to highlight the level of emissions that would occur without further policy effort. Typically, baseline scenarios are then compared to mitigation scenarios. that are constructed to meet different goals for greenhouse gas (GHG) emissions, atmospheric concentrations or temperature change. The term baseline scenario is used interchangeably with reference scenario and no policy scenario. In much of the literature the term is also synonymous with the term business-as-usual (BAU) scenario, although the term BAU has fallen out of favour because the idea of business as usual in century-long socio-economic projections is hard to fathom. *Modified from: IPCC 2014b.*

Behaviour: Actions, and inaction, by individuals and households. This includes purchasing choices as a consumer. This can also be thought of as the options taken or not taken by individuals and households. *Source: Author.*

Biological system: A group of lifeforms that interact to form a larger entity with its own defining characteristics. *Source: Author*.

Biological systems: Any system in which organisms play a major role. This includes terrestrial ecosystems, wildfire and marine ecosystems. *Source: Author.*

Black swan: An unforeseeable or unforeseen, low probability but high impact event. *Source: Modified from Taleb 2007 and Oxford Dictionary.*

Business and economic activity: Actions, or inaction, by individuals or groups undertaking productive activities, in many cases driven by a profit motive. *Source: Author.*

Business: Actions, or inaction, by individuals or groups undertaking productive activities, in many cases driven by a profit motive. This includes finance and investment and decisions by business leaders and shareholders. Source: Author.

Carbon dioxide removal (CDR): Carbon Dioxide Removal methods refer to a set of techniques that aim to remove CO_2 directly from the atmosphere by either (1) increasing natural sinks for carbon or (2) using chemical engineering to remove the CO_2, with the intent of reducing the atmospheric CO_2 concentration. CDR methods involve the ocean, land and technical systems, including such methods as iron fertilization, large-scale afforestation and direct capture of CO_2 from the atmosphere using engineered chemical means. Some CDR methods fall under the category of geoengineering, though this may not be the case for others, with the distinction being based on the magnitude, scale and impact of the particular CDR activities. The boundary between CDR and mitigation is not clear and there could be some overlap between the two given current definitions. *Source: IPCC 2014b*.

Catastrophe: An event with serious impacts on affected actors. This could include endurable but serious or terminal impacts. *Source: Author adapted from Bostrom and Cirkovic 2011.* Also see global catastrophic risk.

Climate change stressor: Manifestations of climate change in specific systems (for example, rainfall variability, droughts, floods, cyclones and tropical storms, glacial melt, sea-level rise, etc.). This could involve extreme weather-related events and more gradual changes. *Source: adapted from Warner and van der Geest 2013.*

Climate change: A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes. See also Detection and Attribution. *Source: IPCC 2014b*.

Climate change as a collective action problem: Most GHGs accumulate over time and mix globally, and emissions by any actor (e.g., individual, community, company, country) affect other actors. Effective mitigation will not be achieved if individual actors advance their own interests independently. Cooperative responses, including international cooperation, are therefore required to effectively mitigate GHG emissions and address other climate change issues. The effectiveness of adaptation can be enhanced through complementary actions across levels, including international cooperation. The evidence suggests that outcomes seen as equitable can lead to more effective cooperation. *Source: Adapted from (i.e. the word actor has substituted agent) IPCC 2014a, p. 17*.

Climate club: Any international actor group that (1) starts with fewer members than the UNFCCC has and (2) aims to cooperate on one or more climate change-related activities, notably mitigation, adaptation, climate engineering or climate compensation. *Source: Hovi et al. 2016, p. 2.*

Climate feedback: An interaction in which a perturbation in one climate quantity causes a change in a second and the change in the second quantity ultimately leads to an additional change in the first. A negative feedback is one in which the initial perturbation is weakened by the changes it causes; a positive feedback is one in which the initial perturbation is enhanced. In the Fifth Assessment Report, a somewhat narrower definition is often used in which the climate quantity that is perturbed is the global mean surface temperature, which in turn causes changes in the global radiation budget. In either case, the initial perturbation can either be externally forced or arise as part of internal variability. *Source: IPCC 2014b*.

Climate hazard: The potential occurrence of a weather event or trend with physical impacts that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. *Source: Adapted from IPCC 2014b*.

Climate projection: The simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which is in turn based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realized. *Source: IPCC 2014b.*

Climate regime: The set of international, national and sub-national institutions and actors involved in addressing climate change. *Source: Moncel et al. 2011*. Also see regime complex.

Climate scenarios: Plausible representations of future climate conditions (temperature, precipitation and other climatological phenomena). They can be produced using a variety of approaches including: incremental techniques where particular climatic (or related) elements are increased by plausible amounts; spatial and temporal analogues in which recorded climate regimes that may resemble the future climate are used as example future conditions; other techniques, such as extrapolation and expert judgment; and techniques that use a variety of physical climate and Earth system models, including regional climate models. *Source: Moss et al. 2010, p. 749.*

Climate science: The study of relatively long-term weather conditions, typically spanning decades to centuries but extending to geological timescales. *Source: Nature 2019.*

Climate stress signal: Information that both indicates the extent to which climate change is a problem and elicits a response. *Source: Author.*

Climate stressor: Manifestations of climate variability and climate change in specific ecosystems (for example, rainfall variability, droughts, floods, cyclones and tropical storms, glacial melt, sea-level rise, etc.). This could involve extreme weather-related events and more gradual changes. *Source: Warner and van der Geest 2013.*

Climate system: The totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions. *Source: Article 1, UNFCCC 1992.*

Co-benefit: The positive effects that a policy or measure aimed at one objective might have on other objectives, thereby increasing the total benefits for society or the environment. *Source: IPCC 2018c.* Note: Potential co-benefits are transition opportunities.

Collective action problems: Issues for which coordinated responses are likely the have better outcomes for all actors, but where actor interests create incentives to act independently of other actors. *Source: Adapted from IPCC 2014a*. According to Holzinger 2003, collective action can be divided into two main categories of problem, consisting of: problems of coordination and problems involving conflict. Problems of coordination may be addressed politically (e.g. through institutions), while problems involving conflict may addressed by coalitions and coercive means. Ostrom 1990 set out the conditions under which collective action and the formation of institutions can help address collective action problems.

Competitive response: Actors have expectations of some reward, which drives activities for engaging in technologies or practices that make a positive contribution to the global response. *Source: Author.*

Compliance: A matter of whether and to what extent countries do adhere to the provisions of the accord. The concept of compliance includes implementation, but it is generally broader. Compliance focuses not only on whether implementing measures are in effect, but also on whether there is compliance with the implementing actions. Compliance measures the degree to which the actors whose behaviour is targeted by the agreement (whether they be local government units, corporations, organizations, or individuals) conform to the implementing measures and obligations. *Source: Toth et al. 2001.*

Compliance: The degree to which Parties fulfil their obligations under an agreement. *Source: Author.*

Conceptual framework: A logic for organising related ideas. *Source: Author.*

Conceptual model: A representation of a system including related ideas. *Source: Author*.

Condition: Issues actors are willing to live with. *Source: Adapted from Kingdon 1995*.

Contingency plan: A management process that analyses specific potential events or emerging situations that might threaten society or the environment and establishes arrangements in advance to enable timely, effective and appropriate responses to such events and situations. *Source: UNISDR 2016*.

Contingency: A provision for a possible event or situation. *Source: Oxford Dictionary*.

Contingent aspirations: Aspirations that would be realistic and desirable under a particular scenario. *Source: Author.*

Contingent strategies: A whole class of planned actions that are contingent on conditions in the world. *Source: Ostrom 1990, p. 36.*

Contingent visioning: The identification of vision(s) that would be realistic and desirable under a particular scenario. *Source: Author*.

Cooperation response: International cooperation on other issues leads to a realisation that international cooperation could help limit climate change and its impacts. *Source: Author.*

Cooperative response: Actors work together to address climate change and related impacts. *Source: Author.*

Crisis: A time of intense difficulty, trouble, or danger, and a time when a difficult or important decision must be made. *Source: Oxford Dictionary.*

Cynical response: Action based on self-interest that disregards evidence on climate change and related issues that make negative contributions to the global response to climate change. *Source: Author.*

Defence: The ability to protect against harm, or something used to protect against harm. *Source: Modified by author from Cambridge definition for "defense" i.e. defence spelt using the United States spelling*.

Defensive response: Actors attempt to preserve what they have and limit loss and damage. *Source: Author.*

Disaster: A sudden accident or a natural catastrophe that causes great damage or loss of life. *Source: Oxford Dictionary*

Distribution of impacts: Risks/impacts that disproportionately affect particular groups due to uneven distribution of physical climate change hazards, exposure or vulnerability. *Source: IPCC 2018a*. Also see "reasons for concern" (RFCs).

Economic activity: Production and consumption of goods and services by individuals and groups. *Source: Author.*

Effective: Successful in producing a desired or intended result. *Source: Oxford Dictionary*.

Effectiveness: Measures the degree to which international environmental accords lead to changes of behaviour that help to solve environmental problems, that is the extent to which the commitment has actually influenced behaviour in a way that advances the goals that inspired the commitment. *Source: Toth et al. 2001.*

Emergency response: Emergency response is an urgent reaction to climate change and related impacts or risks. *Source: Author.*

Emissions scenarios: A plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g., greenhouse gases (GHGs), aerosols) based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socio-economic development, technological change, energy and land use) and their key relationships. Concentration scenarios, derived from emission scenarios, are used as input to a climate model to compute climate projections. *Source: IPCC 2014b.*

Emissions: The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time. *Source: Article 1, UNFCCC 1992*.

Emergency: A serious, unexpected, and often dangerous situation requiring immediate action. *Source: Oxford Dictionary.*

Enforcement: The actions taken once violations occur. It is customarily associated with the availability of formal dispute settlement procedures and with penalties, sanctions, or other coercive measures to induce compliance with obligations. Enforcement is part of the compliance process. *Source: Toth et al. 2001.*

Enlightened response: Enlightened responses come about from awareness that creates change. Enlightened responses can be driven by awareness of climate change and related impacts and risks as well as awareness of other things not directly related to climate change, for example the value of international cooperation. *Source: Author.*

Environment: Physical surroundings. *Source: UN 2012, p. 16*.

Environmental scenarios: Analysis of the potential impact of a particular climate scenario requires environmental scenarios of ecological and physical conditions at greater detail than is included in climate models. These scenarios focus on changes in environmental conditions other than climate that may occur regardless of climate change. Such factors include water availability and quality at basin levels (including human uses), sea level rise incorporating geological and climate factors, characteristics of land cover and use, and local atmospheric and other conditions affecting air quality. *Source: Moss et al. 2010, p. 749.*

Explore: Travel through (an unfamiliar area) in order to learn about it. *Source: Oxford Dictionary*.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected. *Source: IPCC 2014b*.

Extreme weather events: Risks/impacts to human health, livelihoods, assets and ecosystems from extreme weather events such as heat waves, heavy rain, drought and associated wildfires, and coastal flooding. *Source: IPCC 2018a*. Also see “reasons for concern” (RFCs).

Facilitative model: International agreements that start from what countries are doing on their own, and seeks to find ways to reinforce and encourage these activities. *Source: Modified from Bodanski 2012, p. 2*.

Failure scenario: In the context of this study, a failure scenario is: a possible set of conditions or sequence of events that either result violation of the UNFCCC objective or contribute towards violation of the UNFCCC objective. *Source: Author*.

Failure: In the context of this study failure: is violation of the UNFCCC objective. This means not stabilising atmospheric greenhouse gas concentrations; or ecosystems unable to adapt naturally to anthropogenic climate change; or food production threatened by anthropogenic climate change; or economic development not able to proceed sustainably due to anthropogenic climate change. *Source: Author*.

Finance: A supply of money. *Source: Cambridge Dictionary.*

Flexibility: Adjustable institutional arrangements. *Adapted from Stavins et al. 2014, p. 1010.*

Food and nutrition security: When all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life. *Source: CFS 2012, p. 8*.

Food security A state that prevails when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development, and an active and healthy life. *Source: IPCC 2014b.*

Foresight: Methodologies and approaches that explore the future and alternative actions taking into account complexity and uncertainty. *Source: Modified from UNDP 2014, p. 5.*

Framework convention: A legally binding treaty (Treaties) of international law that establishes broad commitments for its parties and a general system of governance, while leaving more detailed rules and the setting of specific targets either to subsequent agreements between the parties, usually referred to as protocols, or to national legislation. *Source: OPIL 2011*. Generally speaking: a framework convention serves as an umbrella document which lays down the principles, objectives and the rules of governance of the treaty regime. *Source: adapted from UNECE 2011*.

Geoengineering: Geoengineering refers to a broad set of methods and technologies that aim to deliberately alter the climate system in order to alleviate the impacts of climate change. Most, but not all, methods seek to either (1) reduce the amount of absorbed solar energy in the climate system (Solar Radiation Management) or (2) increase net carbon sinks from the atmosphere at a scale sufficiently large to alter climate (Carbon Dioxide Removal). Scale and intent are of central importance. Two key characteristics of geoengineering methods of particular concern are that they use or affect the climate system (e.g., atmosphere, land or ocean) globally or regionally and/or could have substantive unintended effects that cross national boundaries. Geoengineering is different from weather modification and ecological engineering, but the boundary can be fuzzy. *Source: IPCC 2014b*.

Global aggregate impacts: Global monetary damage, global-scale degradation and loss of ecosystems and biodiversity. *Source: IPCC 2018a*. Also see “reasons for concern” (RFCs).

Global catastrophe: An event with serious impacts on actors around the world. *Source: Modified from Bostrom and Cirkovic 2011.*

Global commons: Resource domains that do not fall within the jurisdiction of any one particular country, and to which all nations have access – make individual States more susceptible to policies adopted by others. *Source: UN 2013, p. 3.*

Global governance: The totality of institutions, policies, norms, procedures and initiatives through which States and their citizens try to bring more predictability, stability and order to their responses to transnational challenges. *Source: CDP 2014, p. vi.*

Global response to climate change: Working definition: a. All human actions and inaction, influencing achievement of the UNFCCC objective. This working definition reflects how the global response to climate change is measured. Note: it would be semantically correct if the global response was defined as: All reactions to climate change; or, all human actions and inaction, where climate change was a factor in the decision to act or not. However, these definitions do not reflect how the global response to climate change is measured in practice, for example emissions inventories or the emissions gap includes all GHG emissions regardless of whether decisions that led to the emissions considered climate change or not. *Source: Author.*

Global warming: Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions. *Source: IPCC 2014b*.

Global: Relating to the whole world; worldwide. *Source: Oxford Dictionary 2019*.

Governance: The process of decision making on problems affecting groups of people. These processes may include formal or informal processes, formal or informal institutions, government, civil society, business, communities or individuals. *Source: Author.*

Government: Political body within a state which holds executive power to establish the general policy of the state and enforce the law. *Source: UNTERM 2019a*.

Greenhouse gas emissions: See Emissions.

Greenhouse gas removals: The extraction of chemicals that drive global warming and climate change, from the atmosphere. *Source: Author.*

Greenhouse gases: Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation. *Source: UNFCCC Article 1.*

Greenhouse gases: Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth’s surface, the atmosphere itself and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary GHGs in the Earth’s atmosphere. Moreover, there are a number of entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. *Source: IPCC 2018c.*

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts. *Source: Oppenheimer et al. 2014.*

Human security: A condition that is met when the vital core of human lives is protected, and when people have the freedom and capacity to live with dignity. In the context of climate change, the vital core of human lives includes the universal and culturally specific, material and nonmaterial elements necessary for people to act on behalf of their interests and to live with dignity. *Source: IPCC 2018c.*

Human systems: Any system in which human organizations and institutions play a major role. *Source: IPCC 2018c.* This includes food production, livelihoods, health and economics.

Hypocritical response: Human actions or inaction that affect the climate, by an actor that has expressed concern about the very same actions or inaction. *Source: Author.*

Impact response: Impact response is a reaction to climate change and related effects on physical, biological or human systems. An impact response can also be defined as actions, or inaction, where climate change and related effects on physical, biological or human systems are a factor in the decision to act or not. *Source: Author.*

Impacts: Effects on natural and human systems. Source: Author. The IPCC defines Impacts as consequences or outcomes, specifically: The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives; livelihoods; health and well-being; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial. *Source: IPCC 2018c.*

Implementation: The actions (legislation or regulations, judicial decrees, or other actions) that governments take to translate international accords into domestic law and policy. It includes those events and activities that occur after authoritative public policy directives have been issued, such as the effort to administer the substantive impacts on people and events. It is important to distinguish between the legal implementation of international commitments (in national law) and the effective implementation (measures that induce changes in the behaviour of target groups). *Source: Toth et al. 2001*.

Institutions: Systems of established and embedded social rules that structure social interactions. *Source: Modified from Hodgson 2006, Duverger 1972 in Archer 2001*. These include formal and informal rules and structures. Ostrom defines institutions as the sets of working rules that are used to determine who is eligible to make decisions in some arena, what actions are allowed or constrained, what aggregation rules will he used, what procedures must be followed, what information must or must not be provided, and what payoffs will be assigned to individuals dependent on their actions. *Source: Ostrom 1990, p. 51.*

Interests: The things that an actor cares about. *Source: Author.*

Intergovernmental: Something between two or more sovereign states and their representatives. Synonymous with interstate. *Source: Modified from Archer 2001, p. 1.*

International agreement: An agreement between actors from more than one state or between an international organisation and other actors. In many cases international agreements refers to agreements between states or states and international organisations (see Treaty), but this study also includes agreements between non-state actors from different states or between non-state actors and international organisations. *Source: Author.*

International cooperation on climate change: Actors from different states acting together to address climate change. This includes state actors and non-state actors. *Source: Author.*

International cooperation: Actions or resources exchanged between actors from different countries, voluntarily and according to their own interests and strategies. *Source: Modified from Vázquez 2011.*

International institutions: Systems of established and embedded social rules that structure social interactions between actors from different sovereign states. This includes international organisations and international conventions. *Source: Adapted from the definition of "institutions".*

International organisation: Any entity established by actors from different states. This term commonly refers to intergovernmental organisations established by state actors, but in this study, it also refers to international non-government organisations and international corporations (i.e. multinational corporations) reflecting the fact that these entities are actors that can each engage in, and influence, international cooperation. *Source: Author*.

International regime: Sets of implicit or explicit principles, norms, rules, and decision making procedures around which actors' expectations converge in a given area of international relations. *Source: Krasner 1983, p. 2 in Archer 2001, p. 2*.

International regime: The rules and norms that guide interactions between actors from different states. This includes state actors and non-state actors. *Source: Author.*

International: Something involving more than one sovereign state including their governments, people, economy or environments, or something beyond the jurisdiction of sovereign states. *Source: Modified from Archer 2001.* Also see intergovernmental, interstate and transnational.

Interstate: Between governments. Synonymous with intergovernmental. *Source: Modified from Archer 2001.*

Intervention: The act or fact of becoming involved intentionally in a difficult situation. *Source: Cambridge Dictionary.*

Irreversibility: A perturbed state of a dynamical system is defined as irreversible on a given timescale, if the recovery timescale from this state due to natural processes is substantially longer than the time it takes for the system to reach this perturbed state. In the context of this report, the time scale of interest is centennial to millennial. See also Tipping point. *Source: IPCC 2014b*.

Issue: A vital concern or unsettled problem. *Source: adapted from Merriam-Webster Dictionary*.

Key factors: Characteristics, groupings and entities that best describe the situation and have a meaningful influence on events. *Source: Author.* Also see other factors.

Land use: The total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, conservation and city dwelling). In national greenhouse gas inventories, land use is classified according to the IPCC land use categories of forest land, cropland, grassland, wetland, settlements, other. *Source: IPCC 2018c.* See also Land-use change (LUC).

Land-use change (LUC) Land-use change involves a change from one land use category to another. *Source: IPCC 2018c.*

Large-scale singular events: Relatively large, abrupt and sometimes irreversible changes in systems that are caused by global warming. Examples include disintegration of the Greenland and Antarctic ice sheets. *Source: IPCC 2018a*. Also see “reasons for concern” (RFCs).

Legitimacy: The belief by sovereign states and others, that the institution is credible with some degree of authority. *Source: Adapted from Stavins et al. 2014.*

Liability risk: The potential for legal compensation claims based on attributable climate change impacts. *Source: Adapted from BOE 2015.*

Litigation risk: The potential for legal compensation claims related to climate change. *Source: Adapted from Carney 2015.*

Livelihood: The resources used and the activities undertaken in order to live. Livelihoods are usually determined by the entitlements and assets to which people have access. Such assets can be categorised as human, social, natural, physical or financial. *Source: IPCC 2018c.*

Loss and damage: Negative effects of climate variability and climate change that people have not been able to cope with or adapt to. *Source: Warner et al. 2012, p. 20.*

Measurable, reportable and verifiable (MRV): A process/concept that potentially supports greater transparency in the climate change regime. *Source: UNFCCC Glossary.*

Mitigation scenarios: Scenarios that are constructed to meet different goals for greenhouse gas (GHG) emissions, atmospheric concentrations or temperature change. *Modified from: IPCC 2014b.*

Mitigation: A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). This report also assesses human interventions to reduce the sources of other substances which may contribute directly or indirectly to limiting climate change, including, for example, the reduction of particulate matter emissions that can directly alter the radiation balance (e.g., black carbon) or measures that control emissions of carbon monoxide, nitrogen oxides, Volatile Organic Compounds and other pollutants that can alter the concentration of tropospheric ozone which has an indirect effect on the climate. *Source: IPCC 2014b*.

National interest: Things that the State, including domestic coalitions of actors, care about. *Source: Adapted from definition of interests based on the work of Putnam 1988.*

Non-response with negative incidental contributions: Human actions, and inaction, that affect the climate, where decisions to act were made for reasons other than climate change or related impacts. In this case the incidental contributions to the global response to climate change are unhelpful, for example reducing climate resilience and increasing atmospheric concentrations of greenhouse gases. *Source: Author.*

Non-response with positive incidental contributions: Human actions, and inaction, that affect the climate, where decisions to act were made for reasons other than climate change or related impacts. In this case the incidental contributions to the global response to climate change happen to be helpful, for example increasing climate resilience and limiting atmospheric concentrations of greenhouse gases. *Source: Author.*

Option: Some action or inaction that can be decided upon by an actor or set of actors. *Source: Author.*

Organisation: A unique framework of authority within which a person or persons act, or are designated to act, towards some purpose. *Source: OECD Glossary of Statistical Terms.*

Other factors: Other things that can influence the global response to climate change. *Source: Author.*

Other scenario: In the context of this study, an "other scenario" is: a possible set of conditions or sequence of events that highlight some issue or dynamic related to the global response to climate change without necessarily contributing to fulfilling or violating the UNFCCC objective; or, regards an extreme set of conditions or events that affect the climate or the global response to climate change. *Source: Author*.

Participation (official): Being a Party to an agreement. *Source: Author.* Furthermore: Participation in an international climate agreement might refer to the number of parties, geographical coverage, or the share of global GHG emissions covered. *Source: Stavins et al. 2014, p. 1010.*

Participation (unofficial): Conforming to the objective or purpose of an agreement between sovereign states, without being a party to the agreement. This might include sovereign states that are not parties or non-state actors that cannot be parties to the agreement. *Source: Author*

Physical risk: Potential physical impact of climate change. *Source: Adapted from Carney 2015.*

Physical stress test: An assessment with the purpose of understanding how something responds to the physical impact of climate change, informing risk mitigation and decision making. *Source: Author.*

Physical systems: Any system in which physical processes play a major role. This includes glaciers snow, ice, permafrost, rivers lakes, floods, drought, coastal erosion, and sea level effects. *Source: Author.*

Plain English: Clear and unambiguous language, without the use of unnecessary technical terms. *Source: Oxford Dictionary.*

Policy: A course or principle of action adopted or proposed by an organization or individual. *Source: Oxford Dictionary.*

Policy: Positions and interventions. *Source: Author.*

Political will and policy: The ambition level of government leaders, and others in government when it comes to positions on climate change, and the interventions they make that influence fulfilment of the UNFCCC objective. *Source: Author.*

Political will: The ambition level of government leaders, and others in government, to act on climate change and related options. *Source: Author.*

Power: The capacity or ability to direct or influence the behaviour of others, including institutions. *Source: Modified from Oxford Dictionary.*

Practices: Methods used when attempting to achieve something, that rely on properties of human, ecological or environmental systems. *Source: Author.*

Precondition: A state that must be fulfilled before other things can happen or be done. *Source: Modified from the Oxford Dictionary*.

Preconditions for an effective global response to climate change: the system characteristics necessary for achieving the UNFCCC objective under a given set of assumptions. *Source: Author.*

Problem: Something that actors find undesirable and want changed. *Source: Adapted from Kingdon 1995.*

Protocol: An additional legal instrument that complements and add to a treaty. A protocol is 'optional' because it is not automatically binding on States that have already ratified the original treaty; States must independently ratify or accede to a protocol. *Source: UNICEF 2017, p. 2.*

Public policy: A course or principle of action adopted or proposed by an organization or individual that has a bearing on wider societal wellbeing. *Source: Adapted from definitions of "policy" and "public policy" from the Oxford Dictionary.*

Rapid onset event: A single, discrete hazards that occurs in a matter of days or even hours. *Source: Adapted from UNFCCC 2012 and Siegele 2012.*

Ratification (of a treaty): the international act whereby a state indicates its consent to be bound to a treaty if the parties intended to show their consent by such an act. In the case of bilateral treaties, ratification is usually accomplished by exchanging the requisite instruments, while in the case of multilateral treaties the usual procedure is for the depositary to collect the ratifications of all states, keeping all parties informed of the situation. The institution of ratification grants states the necessary time-frame to seek the required approval for the treaty on the domestic level and to enact the necessary legislation to give domestic effect to that treaty. *Source: UNTC 2019.*

Reasons for concern: Unique and threatened systems; extreme weather events; distribution of impacts; global aggregate impacts; and, large-scale singular events. *Source: IPCC 2018a.*

Regime complex: A loosely coupled set of specific regimes. *Source: Keohane and Victor 2011, p. 7.* Regime complexes are marked by connections between the specific and relatively narrow regimes but the absence of an overall architecture or hierarchy that structures the whole set. *Source: Keohane and Victor 2011, p. 8.* Also see regime and climate regime.

Regime: A system or way of doing things, including interacting institutions at international, national and subnational levels. *Source: Adapted from Oxford Dictionary and definition of climate regime.*

Representative Concentration Pathways (RCPs): Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover. *Source: Moss et al., 2008*. The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome. *Source: Moss et al., 2010*. Representative Concentration Pathways (RCPs) Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover (Moss et al., 2008). The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome. *Source: Moss et al., 2010*.

Renewable resources: Stocks that are capable, under favourable conditions, of producing a maximum quantity of a flow variable without harming the stock or the resource system itself. *Source: modified from Ostrom 1990, p. 30.*

Reservoir: A component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored. *Source: Article 1, UNFCCC 1992.*

Response attitudes and inclinations: Ways of thinking about climate change and related issues, including predispositions influencing options considered and actions taken. *Source: Author.*

Response to climate change: Working definition: a. Any action and inaction affecting the achievement of the UNFCCC objective. *Source: Author*. Note this definition reflects the way the global response to climate change is assessed. Also see “global response to climate change”.

Responsiveness: The extent to which human actions, or inactions, are timely and sufficiently scaled to fulfil the UNFCCC objective. *Source: Author.*

Risk management: The plans, actions or policies to reduce the likelihood and/or consequences of risks or to respond to consequences. *Source: IPCC 2014b*.

Risk perception: The subjective judgment that people make about the characteristics and severity of a risk. *Source: IPCC 2014d.*

Risk response: Risk response is a reaction to the potential for climate change and related effects on physical, biological or human systems. A risk response can also be defined as actions, or inaction, where the potential for climate change and related effects on physical, biological or human systems are a factor in the decision to act or not. *Source: Author.*

Risk transfer: The practice of formally or informally shifting the risk of financial consequences for particular negative events from one party to another. *Source: IPCC 2014d.*

Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. In this report, the term risk is often used to refer to the potential, when the outcome is uncertain, for adverse consequences on lives, livelihoods, health, ecosystems and species, economic, social and cultural assets, services (including environmental services) and infrastructure. *Source: IPCC 2014b*.

Rule of law: Formal laws and working rules are closely aligned and that enforcers are held accountable to the rules as well as others. *Source: Ostrom 1990, p. 51.*

Scale: The relative size or extent of something. *Source: Oxford Dictionary*. Also see “at scale”.

Scenario: A possible set of conditions, situations or sequence of events. *Source: Modified from Oxford Dictionary and The Free Dictionary*. Also see baseline scenario, climate scenarios, emissions scenario, environmental scenario, mitigation scenario, and vulnerability scenario.

Science: The observation, knowledge and description of consistency. *Source: the author*.

Securitization: The process by which an issue comes to be represented as not only a political problem but as an existential threat to a valued reference object. *Source: Moncel and van Asselt 2012, p. 168.*

Serendipity: The occurrence and development of events by chance in a happy or beneficial way. *Source: Oxford Dictionary*. In the context of climate change, serendipity refers to the occurrence and development of events that by chance, rather than intent, contribute towards fulfilling the UNFCCC objective.

Shared Socio-Economic Pathways (SSPs): Reference pathways describing plausible alternative trends in the evolution of society and ecosystems over a century timescale, in the absence of climate change or climate policies. *Source: O'Neill et al. 2014.*

Shock: A sudden stressful event. *Source: Author.*

Signal: Information about a situation, system conditions or phenomena that influences decisions. *Source: Author*.

Sink: Any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. *Source: Article 1, UNFCCC 1992.*

Slow onset event: Hazardous conditions that evolve gradually from incremental changes occurring over many years or from an increased frequency or intensity of recurring events. Slow onset events include sea level rise, increasing temperatures, ocean acidification, glacial retreat and related impacts, salinization, land and forest degradation, loss of biodiversity and desertification. *Source: Adapted from UNFCCC 2012, Siegele 2012 and IPCC 2012.*

Social change and behaviour: The interests of people, as individuals, households and communities, and the actions, or inactions, these people might individually or collectively take. *Source: Author.*

Social change: Social change refers to a shift in common values, norms and expectations that influence behaviours of individuals, households, groups and communities, businesses and governments within a society. In short, it's a shift in the way individuals and groups live together and behave. *Source: Author.*

Social contract: An implicit agreement among the members of a society to cooperate for social benefits, for example by sacrificing some individual freedom for state protection. *Source: Oxford Dictionary.*

Solar radiation management: See solar radiation modification.

Solar radiation modification (SRM): The intentional modification of the Earth's shortwave radiative budget with the aim of reducing warming. Artificial injection of stratospheric aerosols, marine cloud brightening and land surface albedo modification are examples of proposed SRM methods. SRM does not fall within the definitions of mitigation and adaptation (IPCC, 2012b, p. 2). Note that in the literature SRM is also referred to as solar radiation management or albedo enhancement. *Source: IPCC 2018c.*

Source: Any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere. *Source: Article 1, UNFCCC 1992.*

Stranded assets: Stocks (i.e. things that hold value for periods greater than a year) that lose value or turn into liabilities before the end of their expected economic life. *Source: adapted from*

Paun et al. 2015. Carbon Tracker, which introduced the concept of stranded assets in the context of climate change, states “Stranded assets are now generally accepted to be fossil fuel supply and generation resources which, at some time prior to the end of their economic life (as assumed at the investment decision point), are no longer able to earn an economic return (i.e. meet the company’s internal rate of return), as a result of changes associated with the transition to a low-carbon economy” (Carbon Tracker 2017).

Strategy: A plan designed to achieve a specific goal or set of objectives under conditions of uncertainty. *Modified from Oxford Dictionary and Cambridge Dictionary.*

Stress test: An assessment with the purpose of understanding how something responds under difficult conditions, informing risk management and decision making. *Source: Author.*

Stress: Pressure or tension experienced by something. *Source: Author*

Stressors: Events and trends, often not climate-related, that have an important effect on the system exposed and can increase vulnerability to climate-related risk. *Source: Oppenheimer et al. 2014, p. 1048.*

Stringency: The formal tightness or substantive ambition of an agreement. Formal tightness means the agreement is legally binding, highly precise, with strong compliance mechanisms. Substantive ambition means the agreement is comprehensive in scope and has obligations sufficient to fulfil the goals, objectives, or purpose of the agreement. Note: Agreements with formal tightness or substantive ambition require participation and compliance to be effective. *Source: Modified from Hofmann 2019*.

Success scenario: A possible set of conditions or sequence of events that either result in fulfilling the UNFCCC objective or contribute towards fulfilling the UNFCCC objective. *Source: Author.*

Success: Fulfilling the UNFCCC objective which consists of limiting concentrations of greenhouse gases in the atmosphere to levels that allow ecosystem to adapt naturally, food production not to be threatened and economic development to proceed sustainably. *Source: Author.*

Technological response: Actors expect there are physical, chemical, or biological properties, related objects, knowledge and processes that can be used to solve the problem. *Source: Author.*

Technology: Methods used when attempting to achieve something, that rely on physical, chemical, or biological properties. This includes objects used for a particular purpose, the processes used, and information related to these things. *Source: Author.* Note: This is consistent with the Oxford Dictionary which defines technology as “the application of scientific knowledge for practical purposes”. Also see practices.

Technology and practices: Methods including objects, activities and rules, used when attempting to achieve something. *Source: Author.*

Theory of change: The description of a sequence of events that is expected to lead to a particular outcome. *Source: Davies 2012 in Vogel 2012.*

Tipping point: A level of change in system properties beyond which a system reorganizes, often abruptly, and does not return to the initial state even if the drivers of the change are abated. For the climate system, it refers to a critical threshold when global or regional climate changes from one stable state to another stable state. *Source: IPCC 2018c*.

Transformation: A change in the fundamental attributes of natural and human systems. *Source: IPCC 2018c.*

Transformation risk: Potential disruption due timely implementation of climate resilient low greenhouse gas emissions technologies and practices at a scale sufficient to limit climate change and related impacts. *Source: Author.*

Transition opportunity: See co-benefits.

Transition risk: Potential disruption due to adjustment towards a climate resilient low greenhouse gas emissions economy. *Source: Author adapted from Carney 2015.* Also see adverse side effects.

Transition stress test: An assessment with the purpose of understanding how something responds to adjustments towards climate resilient low greenhouse gas emissions development, informing risk mitigation and decision making. *Source: Author.*

Transnational: Something between sovereign states not involving governments. *Source: modified from Archer 2001.*

Treaty: A generic term embracing all instruments binding under international law, regardless of their formal designation, concluded between two or more international juridical persons. Thus, treaties may be concluded between: States; international organizations with treaty-making capacity and States; or international organizations with treaty-making capacity. *Source: UNTERM 2019b.*

Unique and threatened systems: Ecological and human systems that have restricted geographic ranges constrained by climate-related conditions and have high endemism or other distinctive properties. Examples include coral reefs, the Arctic and its indigenous people, mountain glaciers and biodiversity hotspots. *Source: IPCC 2018a*. Also see “reasons for concern”.

Viable: Ability to work successfully. *Source Oxford Dictionary*.

Vulnerability scenarios: Scenarios of factors affecting vulnerability, such as demographic, economic, policy, cultural and institutional characteristics are needed for different types of impact modelling and research. This information is crucial for evaluating the potential of humankind to be affected by changes in climate, as well as for examining how different types of economic growth and social change affect vulnerability and the capacity to adapt to potential impacts. Although some of these factors can be modelled and applied at regional or national scales, for the most part data at finer spatial resolution are required. *Source: Moss et al. 2010, p. 749.*

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. *Source: IPCC 2018c.*

Water security: The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability. *Source: UNWater 2019.*

Wicked problem: A problem related to many other problems that is perceived differently by various stakeholders and experts, and one for which no definition or solution can objectively be agreed or found. *Source: Author.*

Wildcards: Low probability, high impact opportunities and threats that would be disruptive should they occur, but for which there may not be any evidence today that they will eventually happen, e.g., an asteroid from space striking a large population centre on Earth. *Source: CSF and CSC 2012*.

Appendix B: Physical signals from IPCC assessments

Table B-1: Physical signals from IPCC assessments based on representative quotes.

Year	Climate science	Risks	Impacts
1992	"We are certain of the following: there is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be; Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases... These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it." (IPCC 1990, p. 52)	Potential future impacts identified in the areas of: 1. Agriculture and forestry; 2. Natural terrestrial ecosystems; 3. Hydrology and water resources; 4. Human settlements, energy, transport, and industrial sectors, human health and air quality; 5. Oceans and coastal zones; and, 6. Seasonal snow cover, ice and permafrost.	No impacts identified
1995	"Global mean surface temperature has increased by between about 0.3 and 0.6°C since the late 19th century, a change that is unlikely to be entirely natural in origin. The balance of evidence… …suggests a discernible human influence on global climate." (IPCC 1995, p. 5).	"Whereas many regions are likely to experience the adverse effects of climate change — some of which are potentially irreversible — some effects of climate change are likely to be beneficial. Hence, different segments of society can expect to confront a variety of changes and the need to adapt to them." (IPCC 1995, p. 6).	The Synthesis report does not identify any attributable impacts but stated "Unambiguous detection of climate-induced changes in most ecological and social systems will prove extremely difficult in the coming decades." (IPCC 1995, p. 6).
2001	"The Earth's climate system has demonstrably changed on both global and regional scales since the pre-industrial era, with some of these changes attributable to human activities." (IPCC 2001, p. 4).	5 reasons for concern were identified. "Projected climate change will have beneficial and adverse effects on both environmental and socioeconomic systems, but the larger the changes and the rate of change in climate, the more the adverse effects predominate" (IPCC 2001, p. 9)	"Observed changes in regional climate have affected many physical and biological systems, and there are preliminary indications that social and economic systems have been affected." (IPCC 2001, p. 6)
2007	"Warming of the climate system is unequivocal" (IPCC 2007, p. 2) "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations." (IPCC 2007, p. 5)	5 reasons for concern were updated. It was also noted that "Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change." (IPCC 2007, p. 13).	"There is medium confidence that other effects of regional climate change on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers." (IPCC 2007, p. 3)
2014	"Warming of the climate system is unequivocal" (IPCC 2014a, p. 2) Anthropogenic greenhouse gas emissions and other anthropogenic drivers "are extremely likely to have been the dominant cause of the observed warming since the mid-20th century." (IPCC 2014a, p. 4)	5 reasons for concern updated Risks to physical systems, biological systems and human systems identified 8 key risks identified "Climate change will amplify existing risks and create new risks for natural and human systems." (IPCC 2014a, p. 13)	"Evidence of observed climate change impacts is strongest and most comprehensive for natural systems." and "Some impacts on human systems have also been attributed to climate change, with a major or minor contribution of climate change distinguishable from other influences." (IPCC 2014a, p. 6).

Source: Compiled by author based on an assessment of physical signals in IPCC assessment report summaries for policy makers.

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Appendix C: Jellyfish model of the climate regime complex

Griffith University's Institute for Ethics, Governance and Law (IEGL) compiled a database cataloguing organizations formally linked to the UNFCCC in some way. Together with the Dutch IT company, LUST, this information was mapped graphically (Figure C-1) and organized into 9 interactive and hierarchical layers starting with the Convention at the top. Table C-1 highlights the layers of the climate regime that are within the institution of the UNFCCC and the parts of layers of the regime outside the institution of the UNFCCC but supporting its objective.

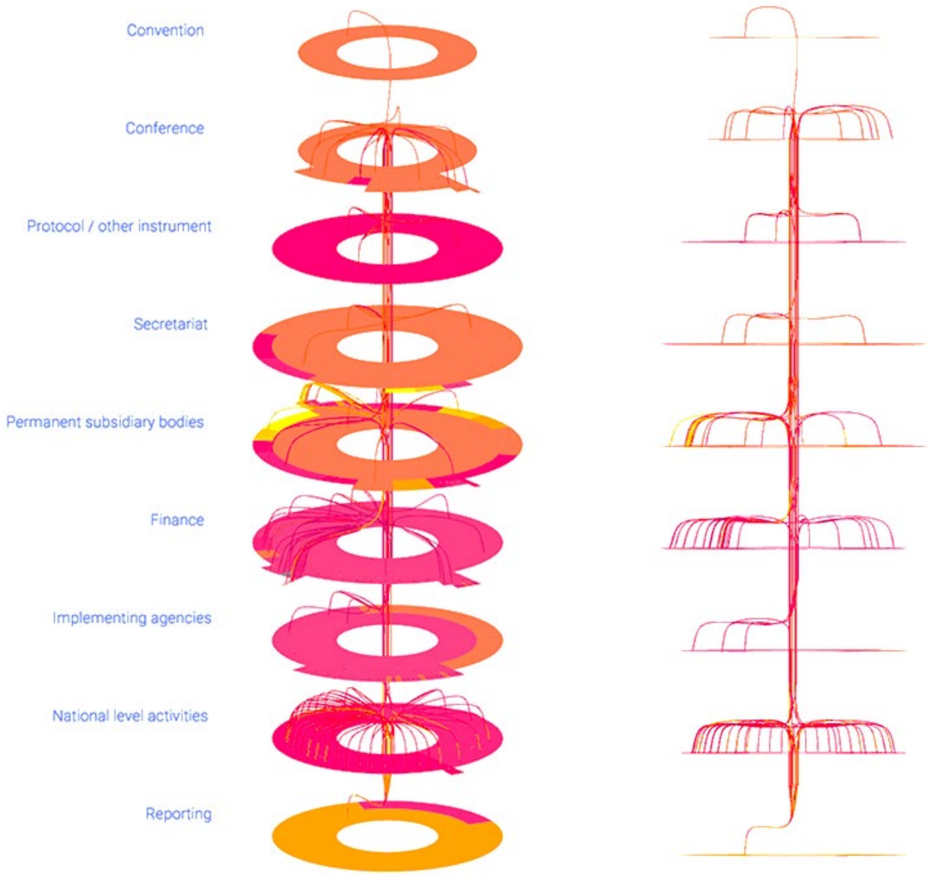

Figure C-1: Visualisation of the climate regime. Source: IEGL 2017.

The climate regime mapped by IEGL (2017) only consists of organisations formally linked to the UNFCCC and supporting the achievement of the UNFCCC objective. IEGL (2017) mapped over 300 such organisations. However, there are many more climate related organisations or initiatives that aren't included in the climate regime mapped by IEGL, for example there are thousands of organisations registered as observers to each COP (UNFCCC 2018b).

Table C-1: Levels used by IEGL to organise and map the climate regime. Source: Compiled from EIGL 2017.

Regime	Level	Description
Within UNFCCC	The Convention	The UNFCCC entered into force on 21 March 1994. Today it has near-universal membership. The 195 countries that have ratified the Convention are called Parties to the Convention. Preventing "dangerous" human interference with the climate system is the ultimate aim of the UNFCCC.
	Conference	The supreme body of the Convention. It currently meets once a year to review the Convention's progress.
	Protocol / other instrument	An international agreement linked to an existing convention, but as a separate and additional agreement which must be signed and ratified by Parties to the convention concerned. Protocols typically strengthen a convention by adding new, more detailed commitments.
	Permanent subsidiary bodies	Subsidiary body: A committee that assists the Conference of Parties. Two permanent subsidiary bodies are created by the Convention: the Subsidiary Body for Implementation (SBI) and the Subsidiary Body for Scientific and Technological Advice (SBSTA).
	Secretariat	The office staffed by international civil servants responsible for "servicing" the UNFCCC Convention and ensuring its smooth operation. The secretariat make arrangements for meeting, compiles and prepares reports and coordinates with other relevant international bodies and is based in Bonn, Germany.
Outside UNFCCC	Finance	Climate finance refers to local, national or transnational financing, which may be drawn from public, private and alternative sources of financing. Climate finance is critical to addressing climate change as significant financial resources are needed to allow countries to adapt to the adverse effect and mitigate the impacts of climate change.
	Implementation agencies	Agencies responsible for putting commitments into practice through programmes and projects. Usually used for UN agencies and bi-lateral and multilateral banks, but may refer to UNEP, non-governmental and governmental organisations.
	National level activities	Actions undertaken at the national level to address climate change usually through mitigation and adaptation activities.
	Reporting	Parties to the Convention must submit national reports on implementation of the Convention to the Conference of Parties (COP). The required contents of national reports and the timetable for their submission are different for Annex I and non-Annex I parties in accordance with the principle of "common but differentiated responsibilities".

IPCC Working Group III showed cooperation in support of the UNFCCC objective can happen between international, national, and sub-national actors (Stavins et al. 2014). Table C-2 lists the types of institutions related to climate change with relevant examples. This includes cooperation between international organisations, between state actors for example through environmental treaties and bilateral arrangements, as well as non-state actors for example city networks including transnational city networks.

Much of the IPCC's chapter on international cooperation regarded the climate regime although there are important sections on the overlap between the climate regime and trade, technology, intellectual property, investments and finance for example. Keohane and Victor's (2011) paper included an indicative map of institutions and initiatives inside and outside of the climate regime, that have a bearing on the global response to climate change (Figure C-2). Figure C-2 and related information (Table C-2) showed there are links between the UNFCCC and other institutions but did little to show how these institutions interact within the climate regime complex.

Table C-2: Types of institutions related to climate change. Source: Stavins et al. 2014.

Types of institutions related to climate change	Examples
UNFCCC	Kyoto Protocol, Clean Development Mechanism, International Emissions Trading
Other UN intergovernmental organizations	Intergovernmental Panel on Climate Change, UN Development Programme, UN Environment Programme, UN Global Compact, International Civil Aviation Organization, International Maritime Organization, UN Fund for International Partnerships
Non-UN international organisations	World Bank, World Trade Organization
Other environmental treaties	Montreal Protocol, UN Conference on the Law of the Sea, Environmental Modification Treaty, Convention on Biological Diversity
Other multilateral 'clubs'	Major Economies Forum on Energy and Climate, G20, REDD+ Partnerships
Bilateral arrangements	US-India, Norway-Indonesia
Partnerships	Global Methane Initiative, Renewable Energy and Energy Efficiency Partnership, Climate Group
Offset certification systems	Gold Standard, Voluntary Carbon Standard
Investor governance initiatives	Carbon Disclosure Project, Investor Network on Climate Risk
Regional governance	EU climate change policy
Subnational regional initiatives	Regional Greenhouse Gas Initiative, California emissions-trading system
City networks	US Mayors' Agreement, Transition Towns
Transnational city networks	C40, Cities for Climate Protection, Climate Alliance, Asian Cities Climate Change Resilience Network
NAMAs, NAPAs	Nationally Appropriate Mitigation Actions (NAMAs) of developing countries; National Adaptation Programmes of Action (NAPAs)

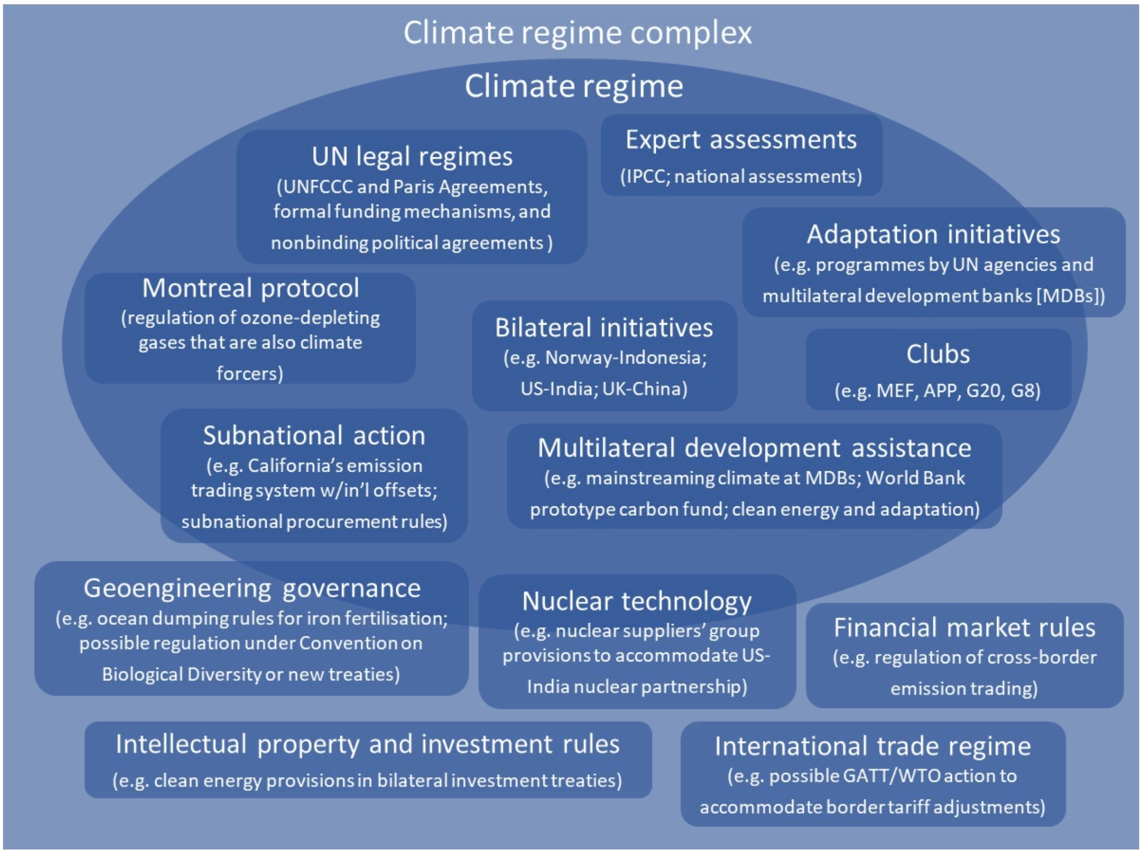

Figure C-2: The regime complex for managing climate change. Source: Adapted from Keohane and Victor 2011.

Jellyfish model of the climate regime complex

Drawing inspiration from IEGL's work representing the climate regime and fact that the UNFCCC has limited direct influence on the global response to climate change, the UNFCCC and climate regime can be represented as a jellyfish (Figure C-3). In this case the hood (also known as the bell) of the jellyfish covers the most coherent and easily identifiable parts of the UNFCCC, specifically the Convention, other agreements (e.g. Paris Agreement) and instruments under the UNFCCC, the COP, permanent subsidiary bodies and the UNFCCC Secretariat. Below the hood are tentacles representing the most difficult to map elements of the climate regime, that reach out from the international level, down to the national and sub-national levels where much of the global response to climate change happens. These tentacles consist of implementing agencies, finance, activities and actions that have a bearing on the global response to climate change for example by businesses, communities or households, and the reporting of progress which feeds back to the UNFCCC, for example to the Secretariat and the COP. The tentacles of the UNFCCC attempt to influence the national actors and non-state actors at the sub-national level.

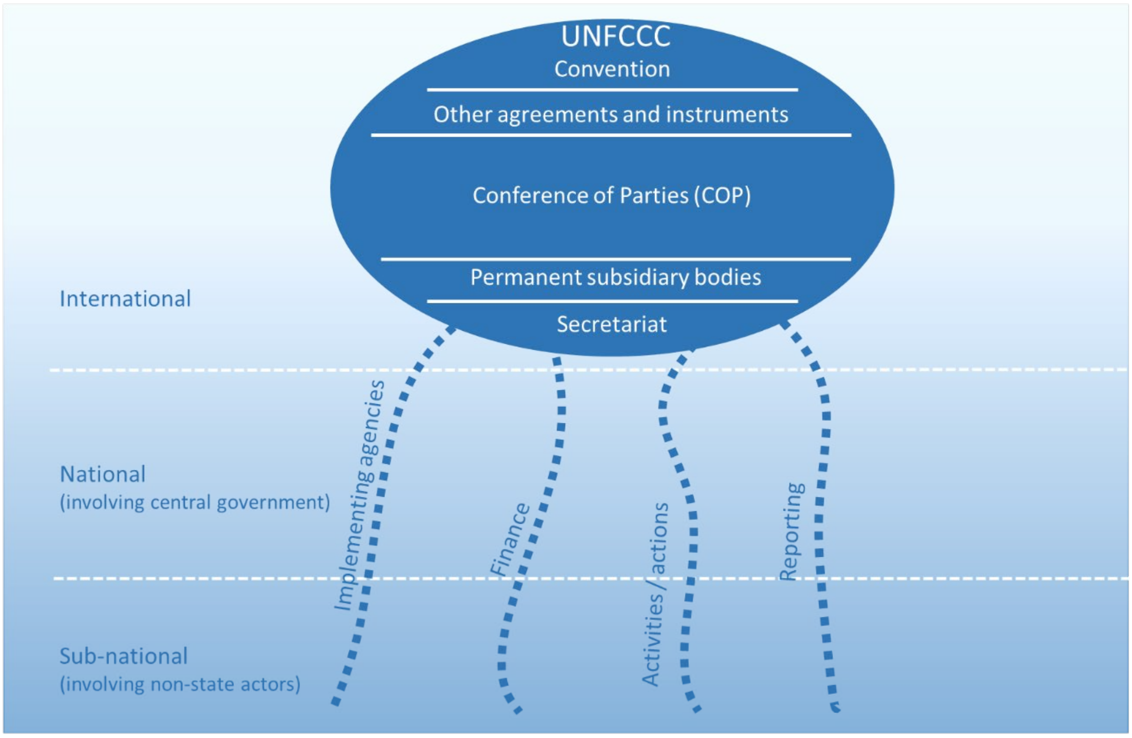

Figure C-3: Jellyfish model of the UNFCCC and global response to climate change.

The climate regime complex can also be represented using the jellyfish model expanded to include other international institutions and initiatives (Figure C-4). The UNFCCC (and climate regime) is represented as jellyfish with tentacles stretching down from the international level to the national and sub-national levels. However, there are other international institutions that include a hood consisting of international agreements, meetings of parties or members, a secretariat and other subsidiary bodies. These other international institutions also have tentacles that reach down from the international level to national governments and sub-national actors influencing their activities and actions. These influences can either help or hinder the global response to climate change.

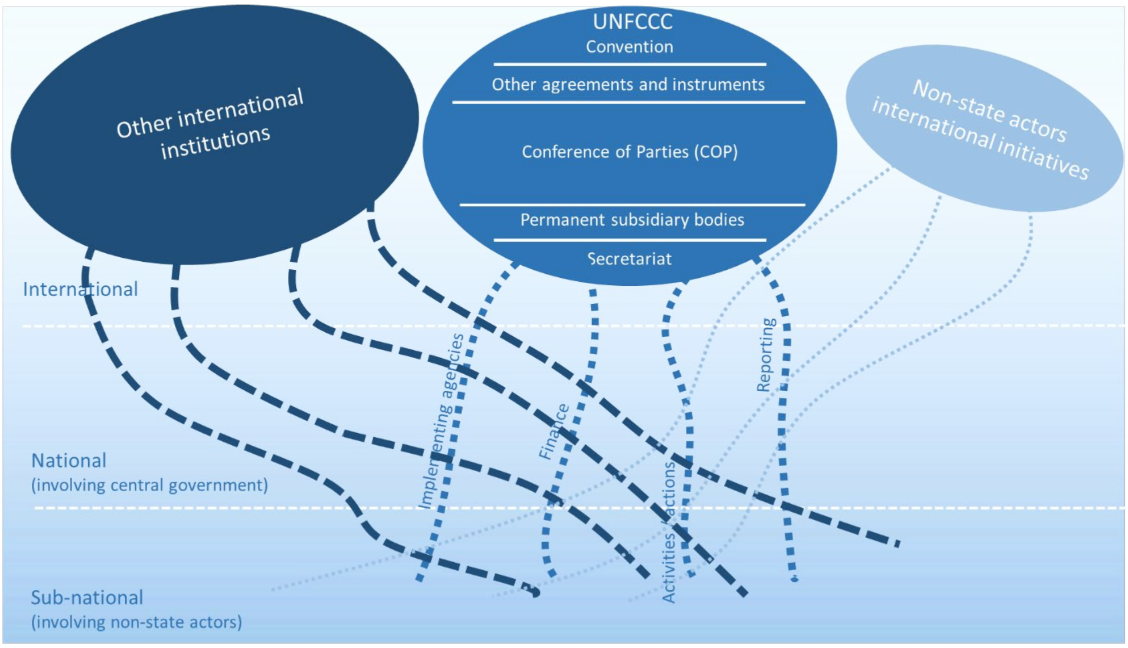

Figure C-4: Jellyfish model of the climate regime complex.

In addition to international institutions, which are established by sovereign states, there are international initiatives by non-state actors for example between cities, civil society and businesses from different countries. These international initiatives typically include some sort of agreement and may involve a secretariat for example. These initiatives also have mechanisms reaching down to the national and sub-national levels. The net result of applying the jellyfish model to the climate regime complex is that there are many competing influences affecting activities and actions at national and subnational levels, and the global response to climate change as a whole.

IEGL (2017), Stavins et al. (2014), Keohane and Victor (2011) and the Jellyfish model all focus on formal institutions. Formal institutions, in particular the spectacle of the COP with world leaders in attendance every year, generate signals indicating climate change is a problem that should be taken seriously. Figure C-5 indicates greater numbers of people are coming up with ideas to address the climate change problem because of this signal. This “informal influence” of the UNFCCC generates research and development activities that involve risk and cost to the individuals involved, akin to Hekkert et al.’s (2007) “entrepreneurial activities”. The people engaging in the generation of ideas and related activities are leaders and innovators, creating options for addressing climate change i.e. potential solutions. In some cases, other actors may engage in these ideas and activities for reasons other than climate change, for example when options appear commercially viable or politically attractive. While all activities contribute "collectively" to the global response and "cumulatively" to the effectiveness of the response, many activities might never be formally recognised or integrated into the climate regime. These actors and activities exist in the wide spaces between the tentacles of the Jellyfish Model (Figure C-4).

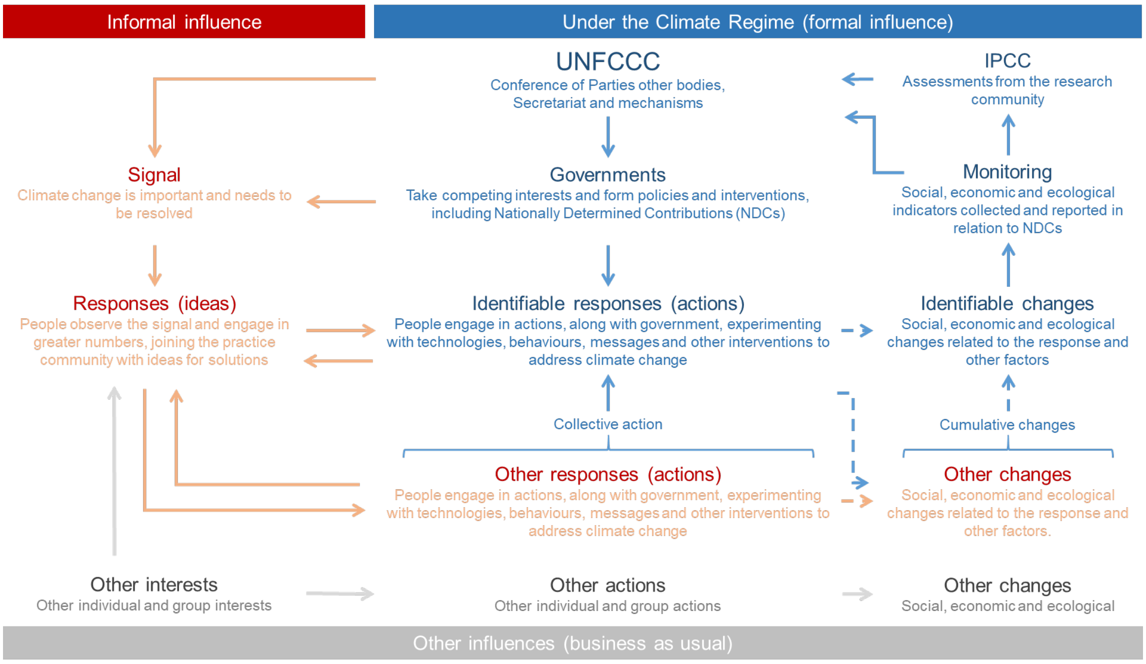

Figure C-5: The climate regime coupled with informal and other influences on the global response to climate change.

Note: There is scope for further investigation into Hekkert et al.'s (2007) functions of innovation systems and how these functions might influence the global response to climate change.

Appendix D: Environment and National Interests Model

The model presented in Figure 3-1 can be adapted to include more detail on climate, for example including forcing agents and feedbacks as discussed in Section 2.2.1. Socio-economic processes and physical risks can be framed in the context of national interests and the interests of various actors such as economic units, other legal entities including government actors. As such, the schematic model published by the IPCC (Figure 3-1) is adapted to include information from Section 2.2 and other literature to form an Environment and National Interests (ENI) model (Figure D-1).

Within the environment part of the ENI model, forcing agents, climate feedbacks, climate and other physical changes are highlighted (Figure D-1). Forcing agents include greenhouse gases as well as other forcing agents. Forcing agents are shown to influence climate directly as well as indirectly through feedbacks which as noted in Section 2.2.3 influence climate for long periods of time before reaching equilibrium. Climate includes natural variation as well as climate change. Linking climate to national interests are hazards that, coupled with vulnerability and exposure, create risks to actors and their interests. Climate hazards are linked to climate rather than climate change, reflecting the difficulty of attributing climate events and impacts to climate change (Allen 2003, Bindoff et al. 2013, National Academies of Sciences, Engineering, and Medicine 2016).

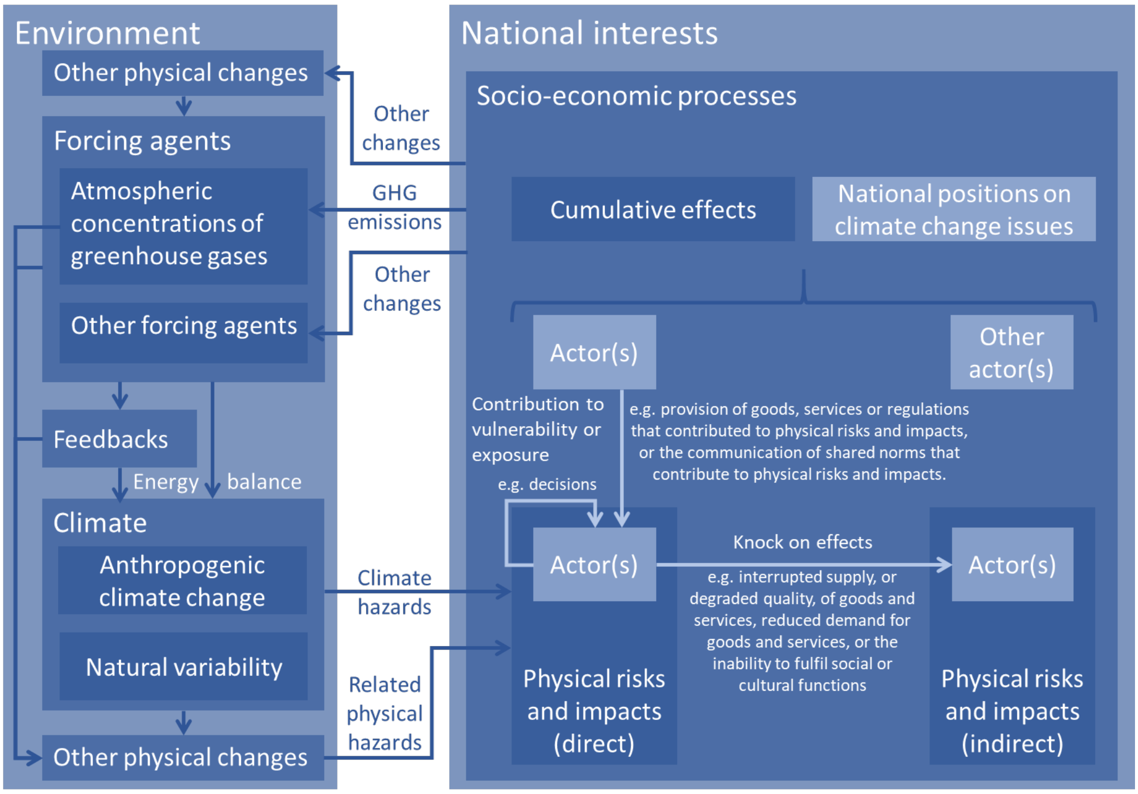

Figure D-1: Environment National Interests (ENI) Model showing the interactions linking climate related physical risks, national interests and greenhouse gas emissions.

In addition to climate hazards are other related physical hazards, such as sea level rise and ocean acidification, which are not climatic but are either related to climate change (e.g. sea level rise due to absorption of heat by seas), or are related to the accumulation of greenhouse gases (e.g. ocean acidification due to increased carbon dioxide absorption by the sea). Other related physical hazards may arise from other physical changes such as the impacts of climate change on physical systems and biological systems. An example might include changes in ecosystem services to remote communities (e.g. provisioning of fish) resulting from the impacts of climate change on marine ecosystems (Oppenheimer et al. 2014).

The national interests part of the ENI model focuses on actors. Contributions to vulnerability and exposure of actor(s) include actor(s) decisions as well as regulations including zoning, plans, and standards, the advice of other actors for example developers or designers, or the quality of goods such as building materials or heating and cooling systems. In addition to these things, there is the possibility of shared norms and practices to contributing to physical risks and impacts. Indirect physical risks and impacts are differentiated from direct physical risks and include interrupted supply, or degraded quality, of goods and services as well as the potential inability of impacted actors to provide social or cultural functions.

The combined actions of actors creates cumulative effects including GHG emissions as well as “other changes” to forcing agents and other physical systems. Furthermore, the interests of actors influence national positions on climate change issues (Marchiori et al. 2017).

Table D-1: Relationship between vulnerability and exposure and the provision of goods, services and regulations.

Contribution to:	Vulnerability	Exposure
Goods	Quality of materials used in construction Quality of heating and cooling systems	
Services	Design of buildings, infrastructure	Planning and location of buildings and infrastructure
Regulations	Building and infrastructure standards	Zoning and permitting

Note: The ENI model could be generalised to include possible benefits if hazards were substituted for “influences” good and bad.

Appendix E: Climate risk directionality

It is important to note that physical, transition and liability risks are each related. For example, Bowen and Dietz (2016) note that “As well as climate and carbon/transition risks, there is the possibility that parties who suffer losses due to climate change or to the transition to a low-carbon economy could successfully hold other parties legally liable” (Bowen and Dietz 2016, p. 33). Similarly, Hutley and Hartford-Davis (2016) note that physical and transitional risks “give rise to tertiary risks, stemming from litigation” (Hutley and Hartford-Davis 2016, p. 3). Figure E-1 illustrates the relationship between climate change risks.

Figure E-1 presents physical risks related to climate change, along with related transition and liability risks. Figure E-1 includes actors (i.e. economic units / legal entities) that trade goods and services with each other. Some of these actors might be exposed to the risk of physical impacts (i.e. physical risk). In a situation where an actor is impacted, they may not be able to deliver on their obligations to provide goods and services to other actors (see the horizontal arrow from left to right). The actors affected by the interrupted flow of goods and services could trigger clauses in business contracts to seek compensation or take legal action. As such, the liability runs in the opposite direction from physical and transition risks (see horizontal arrow running right to left).

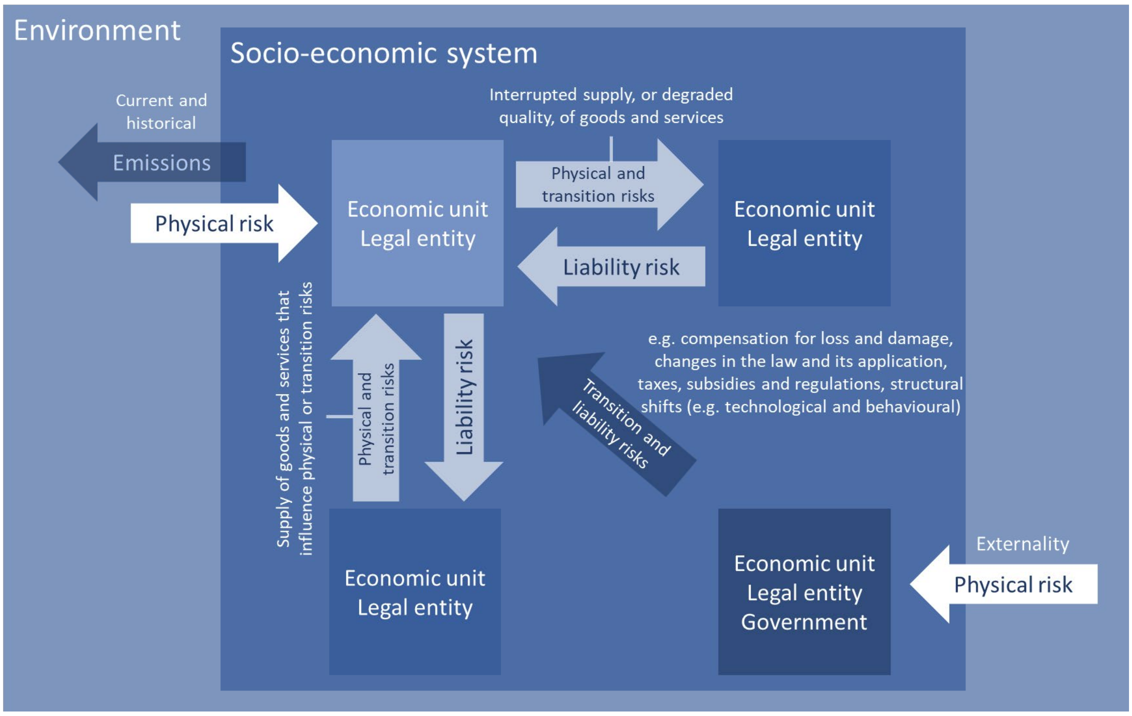

Figure E-1: Economic relationships between physical, transition and liability risks caused by physical climate change.

An actor affected by climate impacts might also seek compensation from other actors that provided goods or services that contributed to climate exposure or vulnerability (the flow of goods and services contributing to exposure or vulnerability run upwards, and liability runs downwards).

Another transition risk actors with technologies and practices that emit greenhouse gases face, is the risk of climate related regulations imposed by government (see arrow from bottom right to top left). Furthermore, there is the risk the other actors without commercial relations might take legal action related to greenhouse gas emissions (see arrow from bottom right to top left).

Appendix F: Stress test principles

In addition to the information already reviewed (see sections above), Oura and Schumacher (2012), Comes et al. (2013), and Nadim (2017) provided guidance that could be used as principles to help in the design of stress tests.

Based on IMF experiences and research, Oura and Schumacher (2012) identified 7 principles for macroprudential stress tests, consisting of (Oura and Schumacher 2012, p. 20):

1. Define appropriately the institutional perimeter for the tests
2. Identify all relevant channels of risk propagation
3. Include all material risks and buffers
4. Make use of the investors' viewpoint in the design of stress tests
5. Focus on tail risks
6. When communicating stress test results, speak smarter, not just louder
7. Beware of the "black swan"

Comes et al. (2013) provided guidance for stress tests with the purpose of supporting decisions on the design of critical infrastructure. This guidance stated that a stress test should (Comes et al. 2013, pp. 308-309):

1. Focus on the vulnerabilities inherent in the system, not on particular external triggering events;
2. Recognise the interconnectedness of critical infrastructure, address and evaluate cascading failures;
3. Be a continuous process that iteratively recognises and adjusts to new information;
4. Be adaptable to multiple geopolitical scales, socio-economic sectors or groups, time scales and critical infrastructures;
5. Integrate technical, social, economic, environmental, behavioural and organisational perspectives; and
6. Prioritise strategies to design more resilient critical infrastructure and economic networks.

Nadim (2017) provided guidance for physical stress tests based on practices from traffic, financial and nuclear stress tests. The guidance consisted of (Nadim 2017, p. 208):

1. Consider extreme event scenarios;
2. Identify the "cliff edge" possibilities in the system;
3. Identify the conditions that could produce an external factor shock;
4. Identify the tipping points of the system;
5. Provide measures to improve the robust/resilience of the system; and,
6. Consider further stress testing after taking measures.

While it is useful having guidance, the list of points above is long and unwieldy. Furthermore, many of these points of could be combined, refined or generalised. As such, the guidance from Oura and Schumacher (2012), Comes et al. (2013), and Nadim (2017) are discussed below and a concise list of stress test principles are derived (see Table 4-1).

The first principle from Oura and Schumacher (2012) regards inclusions and exclusions from the stress test, through the definition of an institutional perimeter. Comes et al. (2013) advises that stress tests should be adaptable at different scales and applications. It is debatable how adaptable any one stress test method can be, but at a minimum it is useful to consider what should be included and excluded from a stress test including issues of geographic coverage, social groups, economic sectors and time periods. In the case of the stress testing the UNFCCC, this should include the Parties to the UNFCCC.

The second principle from Oura and Schumacher was identify all channels of risk propagation. This is difficult in practice. Propagation channels could include climate impacts propagating between countries through trade, security alliances or migration for example. Comes et al. (2013) advises that stress tests should recognise the interconnectedness of systems. Understanding interconnectedness is important as this can help with the identification of cascade effects (i.e. changes that propagate other changes through the system and beyond) including cascading failures.

The third principle from Oura and Schumacher, include all material risks and buffers, could include climate change loss and damage as well as climate resilience and climate adaptation options emerging from international cooperation (including from international institutions and non-state actors). Comes et al. (2013) advised that stress tests should be focused on vulnerabilities ahead of identifying specific stresses that trigger wider problems (i.e. triggering events). Comes et al. (2013) were focused on understanding vulnerabilities and building resilience rather than identifying specific scenarios or extreme events that could result in failure.

Nadim (2017) noted the need to identify cliff edge possibilities and tipping points of systems. Cascade effects, cliff edges and tipping points are similar as they each regard changes that can not easily be undone. According to the Oxford Dictionary, a tipping point is “The point at which a series of small changes or incidents becomes significant enough to cause a larger, more important change”. Meanwhile, according to the Cambridge Dictionary, a cliff edge is “A point where a situation changes very suddenly and completely in a damaging way, or where something suddenly becomes much worse”.

The fourth principle from Oura and Schumacher (2012) was to make use of the investor’s viewpoint, and focused on the market value of assets during periods of stress. It was noted that investor perceptions and confidence are very important in this regards. Comes et al. (2013) advises that stress tests should take into account different perspectives for example social, economic and environmental perspectives. This is especially important when dealing with complex systems or problems that affect many groups.

The fifth principle from Oura and Schumacher (2012) was to focus on tail risks. Tail risks are low probability risks that technically occur on the extremes of a normal distribution. Fat tail risks refer to the tails having greater risk than might typically expected. Oura and Schumacher (2012) note that “The rule of thumb for stress tests has traditionally been to apply “extreme but plausible” shocks, but there is no systematic way to determine these.” (Oura and Schumacher 2012, p. 37). The authors note that it was normal to calibrate scenarios using historical experience, but as BCBS (2009) noted, historical experience may be inadequate for addressing possible future stresses especially when new circumstances exist. In the case of climate change, and given the scenarios reported in successive IPCC assessment reports, the future promises to include greater manifestation of climate risks as impacts. Furthermore, the emergence of technological and other options makes historical experience an even poorer guide to climate change and the options available to sovereign states.

Identifying conditions that could produce an external shock (Nadim 2017) could be expanded to include all other possible stresses on the system that could influence outcomes. For example, there is no apparent reason why fast onset events and influences would have precedence over slow onset events and influences. Stern et al's (2017) model serves as an example, as it included climatic conditions as well as other environmental, socio-economic and political conditions.

With regards to extreme event scenarios, Nadim (2017) focused on low probability high impact events (i.e. shocks) and Zhang et al. (2017) focused on rainfall events (i.e. fast onset events). Stern et al's (2013) system model included fast onset and slow onset events. As such, it is important to consider all types of extreme events (e.g. a year of continuous drizzle included).

The seventh principle from Oura and Schumacher (2012) was to beware of "the black swan", a reference to Nassim Taleb's book by the same name. Taleb (2007) noted that European explorers, prior to travelling to Australia, would never have believed that black swans could exist based on their European experience. However, black swans did exist. Taleb (2007) then uses the black swan to epitomise the concept that just because something has not been seen before, does not mean it won't be seen in the future. Thus, Oura and Schumacher (2012) note that "Regardless of how extensive the coverage of risk factors, how refined the analytical models, how severe the shocks incorporated in the stress tests, and how careful the communications strategy, there is always the risk that the "unthinkable" will materialize." (Oura and Schumacher 2012, p. 44). Importantly, Taleb (2007) notes that the unexpected can be orders of magnitude more consequential than the things that can be anticipated or are considered plausible.

Oura and Schumacher (2012) suggest "[o]ne approach is to supplement the traditional ways used to identify possible shocks with expert judgment and new information, where available, rather than simply be guided by history." (Oura and Schumacher 2012, p. 44). Interestingly, Taleb (2007) was sceptical about expert judgement and claims that such judgement is typically too conservative. Another possibility is to run multiple adverse scenarios rather than just one.

Oura and Schumacher (2012) also suggest the possibility of reverse stress testing, as did Borio et al. (2014). Instead of asking what happens given a particular scenario, experts are asked something to the effect of, what would it take to break the institution? Various scenarios can be elicited and explored and thus "help extend the frontier of tail risks" (Oura and Schumacher 2012, p. 44). This is consistent with Principle 9 from BCBS (2009) which included "A stress testing programme should also determine what scenarios could challenge the viability of the bank (reverse stress tests) and thereby uncover hidden risks and interactions among risks." (BCBS (2009, p. 14).

Stress test principles

Nadim's (2017) guidance reflects the practical nature of stress tests, and states stress tests should "provide measures to improve the robust/resilience of the system" (Nadim 2017, p. 208). Similarly Comes et al. (2013) states that stress tests should "Prioritise strategies to design more resilient critical infrastructure and economic networks" (Comes et al. 2013, p. 309). Stress tests should inform options and decisions and, as such, should include risk management options, interventions and strategies.

Nadim (2017) also indicates that there should be further stress testing after taking measures. This apparently refers to the possibility of conducting periodic stress tests as part of risk monitoring system. Similarly, Comes et al. (2013) suggested that stress tests should be "a continuous process that iteratively recognises and adjusts to new information" (Comes et al. 2013, p. 308). In addition, it is also useful to stress test options before implementing them to get a sense of how much they might change risk, for example as proposed by Zhang et al. (2017) in Nadim (2017).

Table F-1: Stress test principles derived from Oura and Schumacher 2012, Comes et al. 2013 and Nadim 2017.

Stress test principles	Source
1. Clearly define the scope and boundaries of the stress test	
• Define appropriately the institutional perimeter for the tests	OS 2012 (1)
• Be adaptable to multiple geopolitical scales, socio-economic sectors or groups, time scales and critical infrastructures	Cet 2013 (4)
2. Identify all channels of risk propagation especially interconnections that create the possibility of cascading failures	
• Identify all relevant channels of risk propagation	OS 2012 (2)
• Recognise the interconnectedness of critical infrastructure, address and evaluate cascading failures	Cet 2013 (2)
3. Include all material risks and buffers in the model and analysis	
• Include all material risks and buffers	OS 2012 (3)
4. Identify vulnerabilities especially those that could result in fundamental shifts in state	
• Focus on the vulnerabilities inherent in the system, not on particular external triggering events	Cet 2013 (1)
• Identify the "cliff edge" possibilities in the system	N 2017 (2)
• Identify the tipping points of the system	N 2017 (4)
5. Seek multiple perspectives and use experts from different disciplines and backgrounds when conducting a stress test	
• Make use of the investors' viewpoint in the design of stress tests	OS 2012 (4)
• Integrate technical, social, economic, environmental, behavioural and organisational perspectives	Cet 2013 (5)
6. Address all possible risks (including implausible but possible risks)	
• Focus on tail risks	OS 2012 (5)
• Identify the conditions that could produce an external factor shock	N 2017 (3)
• Consider extreme event scenarios	N 2017 (1)
• Beware of the "black swan"	OS 2012 (7)
7. Make recommendations on risk minimisation and resilience	
• Prioritise strategies to design more resilient critical infrastructure and economic networks	Cet 2013 (6)
• Provide measures to improve the robust/resilience of the system	N 2017 (5)
8. Communicate the results of the stress test in meaningful and smart ways	
• When communicating stress test results, speak smarter, not just louder	OS 2012 (6)
9. Consider follow up activities	
• Consider further stress testing after taking measures	N 2017 (6)
• Be a continuous process that iteratively recognises and adjusts to new information	Cet 2013 (3)

Sources: Author, Oura and Schumacher 2012 (OS 2012), Comes et al. 2013 (Cet 2013), and Nadim 2017 (N 2017)

Based on the review of physical stress tests and the guidance from Comes et al. (2013) and Nadim (2017), stress principles have been identified in Table 4-1.

Appendix G: Stress test definition

Table G-1 brings together stress test definitions from the fields of engineering, finance and economics, information technology, medicine and security as well as general definitions. From these definitions, common elements were identified and used as a basis for the definition used in this study.

Table G-1: Stress test definitions.

Source	Field	Definition
General definitions		
Collins Dictionary	General	A simulation designed to show how a person or thing functions when affected by adverse circumstances
Oxford Dictionary	General	A test designed to assess how well a system functions when subjected to greater than normal amounts of stress or pressure.
Application specific definitions		
Business Dictionary	Engineering	A test conducted on some equipment to determine how much of a load the system can handle before it breaks or reaches its limit.
Cambridge Dictionary	Engineering	A process intended to test whether a building, product, material, etc. is damaged by particular forces
Basel Committee on Banking Supervision (BCBS 2012)	Finance and economics	The evaluation of a bank's financial position under a severe but plausible scenario to assist in decision making within the bank.
Cambridge Dictionary	Finance and economics	A process intended to test whether a bank or similar organization can deal successfully with a financial crisis
Canada's Office of the Superintendent of Financial Institutions (OSFI 2009)	Finance and economics	A risk management technique used to evaluate the potential effects on an institution's financial condition, of a set of specified changes in risk factors, corresponding to exceptional but plausible events
Financial Times (FT 2019)	Finance and economics	Attempts to gauge the health of banks by running disaster scenarios and seeing if they survive
MacMillan Dictionary	Finance and economics	A test used to find out if a bank or other financial institution is likely to fail or have serious problems in a difficult economic situation.
Techpedia	Information technology	Testing of software or hardware to determine whether its performance is satisfactory under any extreme and unfavourable conditions, which may occur as a result of heavy network traffic, process loading, underclocking, overclocking and maximum requests for resource utilization.
Cambridge Dictionary	Medical	A test designed to show whether someone's heart works well when exercising hard
MacMillan Dictionary	Medical	A test that is used to find out if a person has a particular health problem
Merriam-Webster	Medical	An electrocardiographic test of heart function before, during, and after a controlled period of increasingly strenuous exercise
Oxford Dictionary	Medical	A test of cardiovascular capacity made by monitoring the heart rate during a period of increasingly strenuous exercise.
Climate change related		
National Research Council (Steinbruner et al. 2013)	Security	An exercise to assess the likely effects on particular countries, populations, or systems of potentially disruptive climate events.
Clarke and Obrien (2016)	Engineering	The process of determining the ability of a network to maintain a certain level of effectiveness under unfavourable conditions

Table G-1 shows that there is no single widely accepted definition of what a stress test is. However, a stress tests can be said to:

- regard someone or something;
- regard failure, breakage, limits, performance, functioning, wellness or success;
- involve stress, pressure, load, forces, strain, adverse circumstances, or exceptional events;
- involve a test, controlled experiment, assessment, simulation, scenario or process; and,
- assist decision making, risk management and the design of interventions

Based on the common elements identified above, a stress test can be defined as:

An assessment with the purpose of understanding how something responds under difficult conditions, informing risk management and decision making.

This definition highlights what stress testing involves i.e. “An assessment… of… how something responds under difficult conditions”, what stress testing regards i.e. “something” and “difficult conditions”, and the reasons for conducting a stress test “with the purpose of understanding… informing risk management and decision making”.

Appendix H: Semi-structured interview guidance

Reverse Stress Testing the UNFCCC and the Global Response to Climate Change
Semi-structured interview questionnaire

Start of survey

1. **Please indicate how much you agree or disagree with the following statements:**

	Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree
The world is worse place to live today than it was in the past	○	○	○	○	○
The world will be a better place to live in the future	○	○	○	○	○
The UNFCCC should be abandoned	○	○	○	○	○
The UNFCCC is essential for an effective global response to climate change	○	○	○	○	○

2. **Have you attended the Conference of Parties to the UNFCCC? Y / N**

Current conditions

3. **How would you describe the current climate change situation?**
    - For example, in relation to:
        - the ability of ecosystems to adapt naturally?
        - food production?
        - economic development?

        - *the global response?*
        - *the threat of climate change?*
        - *poverty reduction and sustainable development?*
        - *limiting global warming?*
        - *climate resilience?*
        - *financial flows being consistent with low GHG emissions?*
        - *financial flows being consistent with climate resilience?*

    - Who are the main actors and how are they contributing to the global response to climate change?
        - Countries?
        - Groups of countries?
        - Businesses and business groups?
        - Civil society and civil society groups?
        - The UNFCCC and other international organisations?
        - Individuals and households?

    - How would you describe the UNFCCC's role in addressing climate change to date?

    - Outside of climate change processes, what are the key things driving the climate change situation?

    - So, would you say we are on path towards achieving the UNFCCC objective or not?

Failure scenarios

4. **Please describe a scenario where global response has failed to achieve the UNFCCC objective.**
   i.e. atmospheric concentrations of greenhouse gases are increasing meanwhile food production and economic development are adversely impacted and ecosystems have failed to adapt naturally.

   - Who are the key actors in this scenario?

   - How do they influence the situation and for what reasons?

   - How would you describe the situation?
     For example, in relation to:
     - the ability of ecosystems to adapt naturally?
     - food production?
     - economic development?
     - society, politics and other things?

5. **Please describe a scenario where the UNFCCC objective (Article 2) is amended by the Conference of Parties to the UNFCCC.**

   - Under what circumstances would the international community agree to amend the UNFCCC objective?

   - Which actors would drive this and for what reasons?

6. **Please describe a scenario where Parties withdraw from the UNFCCC.**

   - Under what circumstances would Parties withdraw?

   - Which actors might withdraw and for what reasons?

Success scenarios

7. **Please describe a scenario where the global response to climate change succeeds in achieving the UNFCCC objective.**
   i.e. atmospheric concentrations of greenhouse gases are stabilised meanwhile food production and economic development are fine and ecosystems are adapting naturally to climate change.

   - Who are the key actors in this scenario?

   - How do they influence the situation and for what reasons?

   - How would you describe the situation?
     For example, in relation to:
     - the ability of ecosystems to adapt naturally?
     - food production?
     - economic development?
     - society, politics and other things?

8. **Please describe a scenario where a stringent international climate change agreement is enforced.**

   - Under what circumstances would the international community agree to a stringent agreement?

   - Which actors would drive this and for what reasons?

   - How would the agreement be enforced?

9. **Please describe a scenario where greenhouse gas removals successfully stabilise atmospheric concentrations of greenhouse gases at safe levels.**

   - Which actors would drive this and for what reasons?

Other scenarios

10. What other unusual things might happen?

- Megatrends or black swan (low probability high impact) events…

- How would these events affect the scenarios described?

11. What other scenarios can you imagine for the UNFCCC?

Reflective questions

12. What role do you and the organisation you are with have in relation to climate change?

- How would you describe your organisations contribution towards the global response to climate change?

- Which scenario would you say your organisation contributing towards?

Other possible survey participants

13. Is there anyone else that you think I should interview?

Appendix I: Intermediate and ultimate outcomes

Paris Agreement supports the UNFCCC objectives (Figure I-1). For example, finance for climate resilient low GHG emissions development supports the achievement of climate resilient low GHG emissions development (as specified in the Paris Agreement purpose), which in turn helps stabilise atmospheric greenhouse gas concentrations at safe levels (as specified in the UNFCCC objective). Similarly, limiting global warming to well below 2°C (as specified in the Paris Agreement purpose) is expected to help allow ecosystems to adapt naturally to climate change (as specified in the UNFCCC objective) which along with improved adaptive capacity (as specified in the Paris Agreement purpose) helps avoid disruption to food production systems, while at the same time helping economic development to proceed in a sustainable manner (as specified in the UNFCCC objective).

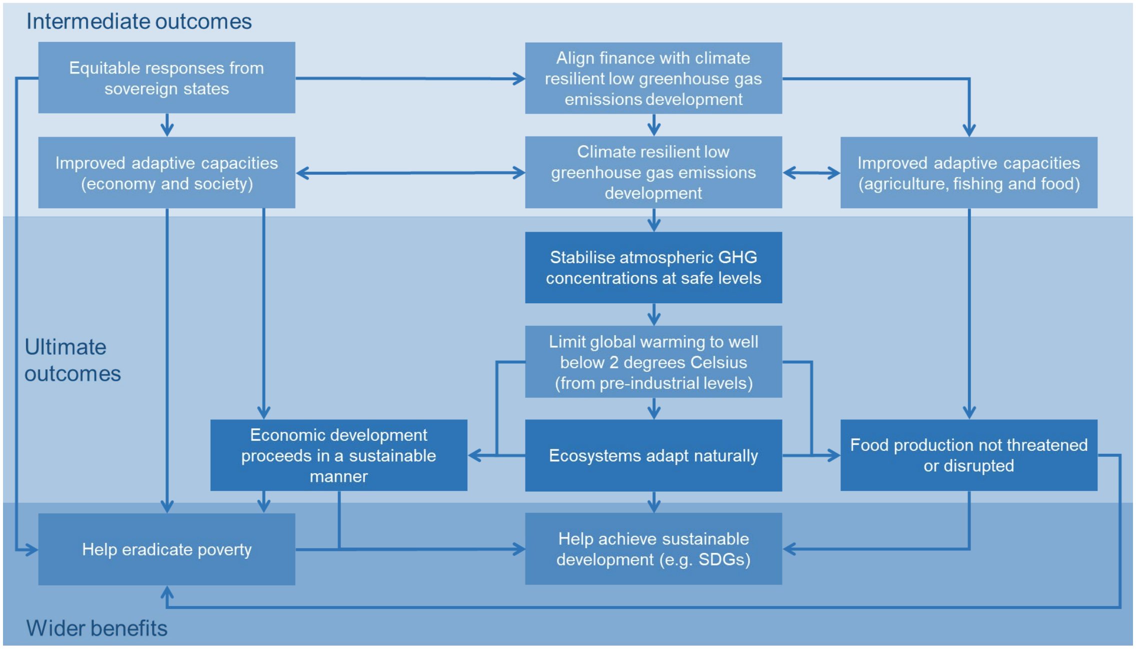

Figure I-1: Intermediate and ultimate outcomes from the Paris Agreement and UNFCCC, including indicative relationships between each outcome.

Appendix J: UNFCCC negotiations options

Within the UNFCCC there are options for change as well. Figure J-1 illustrates climate negotiations options. Decision paths were identified with the status quo flowing straight down, meanwhile changes in agreements, or new agreements and policies, step sideways. Importantly, it is possible for Parties to the UNFCCC to agree to a protocol under the Paris Agreement. A protocol is “An additional legal instrument that complements and add to a treaty. A protocol is ‘optional’ because it is not automatically binding on States that have already ratified the original treaty; States must independently ratify or accede to a protocol.” (UNICEF 2017, p. 2). Alternatively, it is possible that some or all sovereign states might choose the option of abandoning the UNFCCC objective or Paris Agreement aims. The United States has already indicated that it will abandon the Paris Agreement. Note: leaving the Paris Agreement in Figure J-1 is the same as having interventions mainly outside the UNFCCC.

Leaving the UNFCCC, changing the UNFCCC or Paris Agreement, creating a protocol, or raising ambition are all options related to the UNFCCC and climate change negotiations. However, the global response to climate change depends on domestic policy options related to energy, agriculture, finance, women and girls for example, as each of these things have an influence on greenhouse gas emissions as well as climate resilience. Adaptation and mitigation options related to these issues have been discussed above, but it is important to note other options include greenhouse gas lock in as well as the locking in of climate vulnerability (i.e. maladaptation).

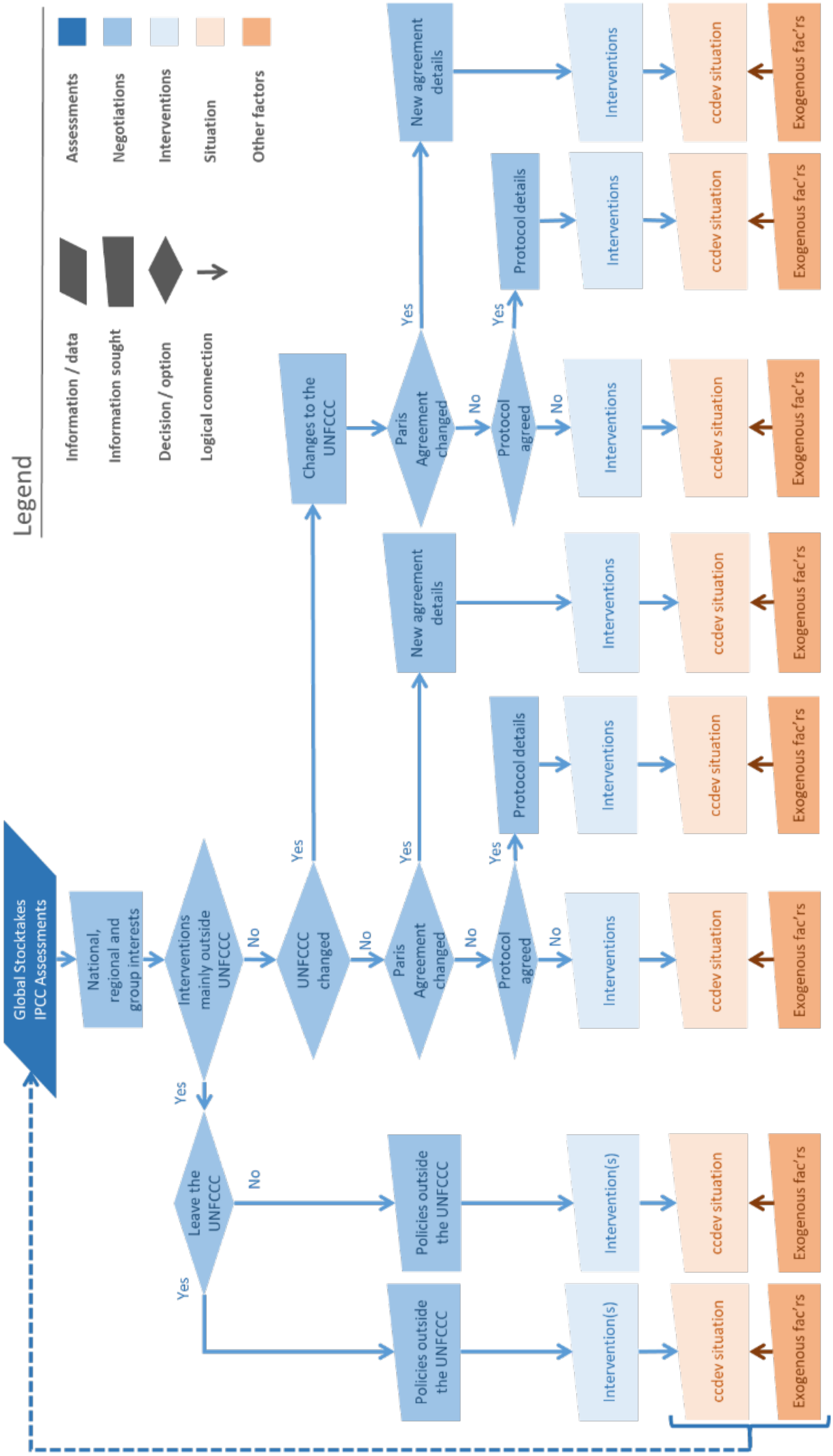

Figure J-1: Negotiations options inside and outside of the UNFCCC including exogenous factors.

Appendix K: Invitation letter

DEPARTMENT OF SCIENCE, TECHNOLOGY, ENGINEERING AND PUBLIC POLICY (UCL STEaPP)

UCL

Dear [Name],

My name is Jeremy Webb and I am a doctoral research student at University College London's Department of Science, Technology, Engineering and Public Policy (STEaPP). My research is looking at climate negotiations and the global response to climate change.

I am writing to invite you to participate in a survey on scenarios under the United Nations Framework Convention on Climate Change. The survey is being conducted as part of my doctoral research.

Before deciding whether to participate in the survey, please read the Survey Participant Information Sheet (attached) that provides more information on the study and the survey. If you agree to take the survey, please respond and we can organise a time to hold an interview.

Please note: All data will be collected and stored in accordance with the Data Protection Act 1998.

If you have any questions regarding the survey or my research, please feel free to contact me by email at any time.

Best regards,

Jeremy

Doctoral Research Student

Department of Science, Technology, Engineering and Public Policy (STEaPP)

University College London (UCL)

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Appendix L: Participant information sheet

DEPARTMENT OF SCIENCE, TECHNOLOGY, ENGINEERING
AND PUBLIC POLICY (UCL STEaPP)

UCL

Survey Participant Information Sheet

Research project title: Stress testing the UNFCCC and the global response to climate change

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 9333/002

Invitation

You are being invited to take part in a survey of scenarios under the United Nations Framework Convention on Climate Change for addressing climate change. The survey is part of a wider doctoral research project stress testing climate change negotiations and the global response to climate change.

Before you decide whether to participate, it is important for you to understand why the research is being done and what participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Please take time to decide whether or not you wish to take part. Thank you for reading this.

What is the project's purpose?

The objective of this survey is to collect information on possible international cooperation scenarios related to the United Nations Framework Convention on Climate Change.

The survey results will help understand how climate change, and other factors, might influence international cooperation on climate change – which is the purpose of the doctoral research project.

Why have I been chosen?

The survey is targeting people involved in climate related policy. This includes climate change negotiators, people involved in the preparation of climate change assessment reports, as well as people involved in climate change related initiatives and research.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep (and be asked to sign a consent form – if applicable). You can withdraw at any time without giving a reason.

What do I have to do?

Participate in a survey interview last between 30 and 60 minutes.

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What are the possible disadvantages and risks of taking part?

There are no anticipated disadvantages or risks associated with taking part in this survey, except for the time used to respond to the survey.

What are the possible benefits of taking part?

There are no anticipated benefits associated with taking part except for the chance to contribute to the study.

What if something goes wrong?

If something goes wrong as part of the survey, and you want to raise a complaint (e.g. regarding treatment by the interviewer or the content of the survey), please contact the interviewer's Primary Supervisor, Professor Yacob Mulugetta [redacted] If a complaint is made, and you feel it has not been addressed adequately by my Primary Supervisor, please contact the Chair of the UCL Research Ethics Committee (http://ethics.grad.ucl.ac.uk/members.php).

Note: If something goes wrong but not as part of the survey (e.g. a serious event on the way to, during or after the interview) please contact the relevant authorities or required emergency services.

Will my taking part in this project be kept confidential?

All the information that we collect from you as part of this survey, will be kept strictly confidential. You won't be identifiable in any ensuing reports or publications.

What will happen to the results of the research project?

The results of this research will be included in a doctoral thesis, papers published in peer reviewed journals and other media.

Who is organising and funding the research?

The research is being organised by Jeremy Webb as part of University College London's (UCL's) Department of Science, Technology, Engineering and Public Policy's (STEaPP's) doctoral training programme. This research is being funded by the United Kingdom's Engineering and Physical Sciences Research Council (EPSRC).

Contact for further information

For more information, please contact: Jeremy Webb

E: [redacted] M: [redacted]

Note: All data will be collected and stored in accordance with the Data Protection Act 1998.

Thank you for reading this information sheet and for considering take part in this research.

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Appendix M: Consent form

DEPARTMENT OF SCIENCE, TECHNOLOGY, ENGINEERING
AND PUBLIC POLICY (UCL STEaPP)

UCL

Informed Consent Form for Use of Information Provided in Research Studies

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Project: Stress Testing the UNFCCC and the Global Response to Climate Change

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 9333/002

Thank you for your interest in taking part in this research. Before you agree to take part, the person organising the research must explain the project to you.

If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you to decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

Participant's Statement

I [Participants Name]:

- have read the notes written above and the Information Sheet, and understand what the study involves.
- understand that if I decide at any time that I no longer wish to take part in this project, I can notify the researchers involved and withdraw immediately.
- consent to the processing of my personal information for the purposes of this research study.
- understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.
- agree that the research project named above has been explained to me to my satisfaction and I agree to take part in this study.
- Agree that my data, after it has been fully anonymised, can be shared with other researchers [to satisfy Research Council funded projects as Research Councils have changed their guidance regarding data sharing]

Signed:

Date:

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Appendix N: Summary of scenario notes

Table N-1: Summary of branching success or failure scenario notes.

Response	Actors and interests	Issues and options
Climate sensitivity Cooperative or defensive Impact response Infrastructure International regime Over-consumption Policy Political will Social change Technology Timing	Defence or cooperation Government and their research and development budgets Youth concerned with climate change and will take action themselves	Climate change event and food security How to respond to catastrophic climate change Timing of the response

Table N-2: Summary of general failure scenario response notes.

Response	Actors and interests	Issues and options
Adaptation Conflict Defence Economic impact Ecosystem impacts Failure of international cooperation on climate change Fossil fuel push Fragmentation GHG removals Health Impacts Insecurity International cooperation Limited impact of behavioural change Migration Negative impacts of climate action Over-consumption Paris Agreement amended Policy Political will Social unrest SRM Stringent enforced agreement	Africa Australia Businesses profit from increased consumption Canada China Consumption not a political priority Cost avoidance Europeans Food security Fossil fuel resource states defend their interests and make these interests central to foreign policy GHG removals Governments focused on immediate political priorities individuals looking after their property Japan Land rights Migrants National interests National security National self interest New Zealand North Africans Responsibility moves from civilian government to military Russia Saudi Arabia Small landholders Social concern Some states have an interest in the use of fossil fuels States States looking for a grand political solution States non-state actors want their own forums UNFCCC Urban versus rural interests USA	1.5 degrees of global warming happened CO2 continuing to increase Consumerism Continuing climate change Development paths Food insecurity Food production Food security GHG removals and land Grand political solutions Hunger Injustice Insecurity Lack of social security and social welfare in developing countries Loss of trust Many people to look after Moral concern Moral duty More than 2 degrees of global warming Overconsumption Resources Security Security and insecurity Systemic risk Technology and consumption Trade agreements Trade and economic issues distract Trust between states Trust between states and citizens Undermine efficiency efforts

Summary of scenario notes

Table N-3: Summary of withdrawal scenario notes.

Response	Actors and interests	Issues and options
Amendment Cascading withdrawal coalitions of the willing Defence Fragmented responses Poor domestic progress bad press Populist driven, Regional cooperation, Regional emissions trading blocks Stringency Stringent enforced agreement, penalties and sanctions UNFCCC defunded Weakening of objective What failure looks like Withdrawal	China Dictatorial politics Distrust EU Latin America Limited interest in international cooperation MENA Middle East Nationalism Other parties have left Politically feasible to withdraw from UNFCCC Populists blame the process and highlight that it has not worked Protectionism Rejection of international cooperation Shift in domestic politics to the right Small party frustration States with irreconcilable interests Symbolism for domestic audience USA Vulnerable countries	A lack of progress A large party has already withdrawn from the Paris Agreement Ignorance on climate change Inability to meet the objective of the agreement Increased climate change impacts

Table N-4: Summary of amended international agreement scenario notes.

Response	Actors and interests	Issues and options
Activism and leadership Ambition Amendment Amend UNFCCC to allow solar radiation management Cascading withdrawal Failure Impact response Paris Agreement amended Social change (social movement) Success Weakening of objective Withdrawal and amendment	Leaders Other parties have left Youth	1.5 degrees of global warming happened A lack of progress Inability to meet the objective of the agreement Locked in climate change above safe limits Solar radiation management

Table N-5: Summary of general success scenario notes.

Response	Actors and interests	Issues and options
Activism	Affected groups	Agriculture and forestry
Ambition	Africa	Behaviour change is ineffective, need policy
Amendment	ASEAN	Carbon tax
Behaviour	Big business	Climate change impacts
Business	Brazil	Climate change one of many issues
Carbon tax	Business	Climate finance
Coupled business and local government	Business leaders	Climate resilience plans
Domestic responses	Business realise that profits can not come at the cost of the environment	Climate risk
Economy	Central governments	Communication like with cigarettes
Enlightenment	China	Fairness
Geopolitical power	Cities	Finance
GHG removals	Civil society	Governance and the roles of local government and business in society
Impact response	Communities	How to organise the international regime supporting the global response to climate change
Information	Consumers want CRLC products	Impacts affecting society
International cooperation (US-EU)	Courts	Inputs to production
International cooperation	Developed countries	International cooperation as well as energy sources and capital, including early retirement of coal fired power plants
International regime	Developing countries	Law and which parties are favoured
International standards	Developing countries and condition NDCs	Low carbon development plans
Leadership	Developing countries and regulation of business	Policies and technology
Leadership (political and regional)	Europe	Production methods
Leadership (political)	FAO	Renewable energy
Localisation	Farmers	Social unrest
Policy	G7	Something really bad happens
Policy response	Geopolitical powers want an agreement	Support for NDCs
Political will	Government leaders	Taxes and subsidies
Regional responses	Governments	Technology and energy efficiency, renewable energy
Re-industrial revolution	Humanity	Technology creates now opportunities and coalitions between politicians and business interests
Risk response	Humanity recognises need for change in lifestyles as well as the need for redistribution	There could be a technological tipping point
Security	IMF	Very cheap clean energy solves a large part of the problem, but if there are technical issues or costs then developing countries will be at a disadvantage.
Social change	India	War or some other calamity affecting humanity
Social change (movement)	Individuals	Waste management
Subsidies	Individuals and households	
Technology	Jacinda	
	Large geopolitical powers and influencers	
	Large geopolitical powers want to limit unrest and climate change Impacts	
	Leaders	
	Local government	
	Major geopolitical powers looking after wider security interests	
	MDBs	
	NGO leaders	
	Other states want to trade with geopolitical Powers	
	Political leaders are interested in supporting technology	
	Political leaders want to meet societies demands	
	Politicians	
	Society want climate change to be addressed	
	Society want to see climate change addressed	
	South Africa	
	States	
	States have a learning moment	
	UK	
	UN subsidiary body	
	UNFCCC	
	UNGA	
	UNSC	
	USA	
	USA and EU want to address the issue	
	World Bank	
	WTO	
	Youth	

Summary of scenario notes

Table N-6: Summary stringent enforced agreement scenario notes.

Response	Actors and interests	Issues and options
Budgets	Australia	Governance
Coalitions	BRICS	International agreements
Economy	Business	International cooperation
Geopolitical coalition	China	
Geopolitical power	India	
Impact response	Large powers	
Information	States	
International cooperation	UNSC	
Penalties and sanctions		
Risk response		
Stringent enforced agreement		

Table N-7: Summary of GHG removal scenario notes.

Response	Actors and interests	Issues and options
Adaptation	Business	Agriculture and forestry
Behaviour	Business, local government	Backup (in case of higher climate sensitivity)
Business	Society	Climate action
Cheap energy		Climate change challenge
Economy		Contingencies
Geoengineering		Cost of energy for removals versus other adaptation options
GHG removals		Ecosystems
Governance		Geo-engineering
Impact response		GHG removals
impacts response,		Health
International cooperation,		Information and monitoring
Natural removals		Innovation
Policy		Losses inevitable
Political will		Mix
Security		Prosperity
Society change		Renewable energy
Socio-political response,		Scale
Solar radiation management		Scale and methods
Technology		Technology research
		Tipping points still possible
		Trade-offs
		Unintended consequences
		Waste management
		Wellbeing

Table N-8: Summary of other scenario notes. Source: Author.

Response	Actors and interests	Issues and options
Adaptation Behaviour Business and economy Carbon capture and storage Conflict Defence Disruption Enlightenment Failure of international cooperation Fragmentation of international cooperation Geoengineering Geo-political power Geo-political power (coalition) Impact response Inequality Insurance retreat International cooperation International regime International regime Leadership Legal response Other impact response, Policy Political will Public service retreat Social change Solar radiation management Space colonisation Surpassing NDCs Technology Withdrawal	Big developing countries China Business Cities City authority maintenance services and budget costs Civil society Coastal communities, Consumers Courts Developing countries Governments Governments attention completely taken up by the war Hopelessness Humans India Individuals, Insurance industry, Large states, Loss of societal trust Macho political leaders Nationalist leaders Poor people Powerful states will decide and impact other countries Realisation Rich people Security sector see climate change as a security issue (military industrial complex) Shareholders Small states, Society Society may become hopeless Some states may be fine regardless of having passed a tipping point. Other states may not be fine. States States and others realise international cooperation can be effective States interested in regional cooperation rather than global cooperation States not interested in the UNFCCC, States, local government, industry Sub-national actors are interested in continuation of the Paris Agreement Subnational administrative units could adopt targets and goals from the Paris Agreement and NDCs. UNFCCC a negotiations mechanism, politically driven UNFCCC could be marginalised United Nations Wealthy and poor Youth shaping the future they want	A large volcanic eruption block sunlight and cools the world, then when aerosols fall out, temperatures go back up. The event serves as a natural experiment that may either encourage or discourage adoption. A period of volcanic eruptions with aerosols slowing down global warming for a time, followed by a big jump in global warming. Affordability of housing Biotechnological advance and application to people Border taxes, Carbon capture and storage. What if it leaks? Change in North Atlantic ocean current Climate is a public good issue, but has been politicised Climate sensitivity lower than expected, more time to organise, respond, learn and adapt. Collapse of human population Contact with another sentient species Ease of uptake and scale of uptake. Environmental feedback or tipping point. Fast feedback Flooding Food insecurity, nationalism, conflict Fraudulent carbon markets GHGs from the environment, Global issues not related to climate change might distract from the global response to climate change. Global pandemic and international cooperation Hot war in various places Impacts of climate change and related physical changes. Technological fixes. Investment signals Legal cases in different jurisdictions. Legal options, public interest litigation, Limited nuclear war Linking carbon markets, Low ambition Market forces Massive melting of ice sheets Massive volcanic eruption affecting climate Meteor strike Methane Methane or carbon dioxide release from permafrost Methane release tipping point (Arctic) Nationalism NDCs Oceans releasing heat Option of solar radiation management Other change, crisis or catastrophe. Other global issues that are related to climate change may encourage a global response climate change. Participation and compliance with international climate change agreements. Private sector law Quality of the legal system. Rapid and massive methane release. How to monitor it? How to stop it? Regional versus global cooperation Risk Sea level rise Sea level rise lower than expected Severe climate change impacts Social stratification Technological innovation Technologies meeting the needs of different actors and groups. Tipping point Transfer payments Volcanic eruption, War at different scales Why privilege climate change ahead of other environmental issues, why not focus on planetary boundaries in all areas.

Appendix O: Failure of international cooperation scenarios

O.1 Fragmentation of international regime

Respondent 7 addressed “fractionalizing” of international cooperation and put forward a scenario, “precipitated by some other global event “that evolves into a situation where “the coherence amongst the parties is breaking down”. In this scenario, you end up with “some parties within it [i.e. a climate agreement] say, "It's not enough, fast enough, deep enough. We're going to take it in our own”. Meanwhile, “others will take a Trump type dystopian view. It isn't worth the talks.”

Respondent 6 put forward a scenario where “trade wars”, “regional conflicts” and “resource conflicts” results in “regionalization and very frictional relationship between the major powers.” Then, “They try and cooperate on a few things” but there is “much less trust between countries. Basically, people stop believing that international agreements is what gives security and prosperity.” Likewise, Respondent 17 noted that if “we don't have enough faith as a collective, in the collective, we don't work together.”

Respondent 27 noted a possible scenario could be a situation where “bilateral” and other “little groupings” form around “common interests over trade, over land use over security”. These groupings could also address climate change making the UNFCCC process redundant.

Respondent 7 had a scenario where “coherence amongst the parties is breaking down” and parties go their “own way”. Respondent 7 noted this could be precipitated by “some other global event”. This could include some Parties taking “a Trump type dystopian view. It isn't worth the talks.”

O.2 Amendment of international climate agreement

The semi-structured interview included a specific follow up question asking for a scenario where the UNFCCC objective is amended. Many respondents said they could not think of such a scenario often stating that the difficulty of getting consensus on such a change would make an amendment to the UNFCCC very unlikely. In other cases, respondents suggested amendments to the other parts of the UNFCCC or Paris Agreement.

Respondent 21 suggested the UNFCCC objective could be amended because “reality is catching up with ambition” and hence, “some of the targets… …are now impossible.” The respondent noted “if we get to 2030 and things have just got progressively worse” then, “I could see then some sort of switch from mitigation to adaptation… in terms of the focus of the agreement.”

In another scenario, Respondent 9 suggested powerful and influential parties might withdraw from the UNFCCC and remaining parties could “amend the object[ive] to better suit their abilities.” Alternatively, Respondent 21 suggested that despite other parties withdrawing from the UNFCCC, there could be “demand from people to respond… trying to stop stuff happening now.” for example through adaptation.

Respondent 24 noted that if “we continue on the business as usual and we are heading toward three to five degrees and… maybe in a decade or two, we will have locked in that temperature change, right?” and then “the only option is to use solar radiation modification to relatively quickly bring the temperature down while the world still tries to do something about the fundamental cause. Now, for that scenario, it would be actually quite helpful to change the UNFCCC article two.” The reason this might need an amendment is “Because right now the Article 2 is about avoiding a negative anthropogenic interference in the climate system. Now for some, solar radiation modification, and I'm not making a judgment of that, I'm just saying for some that's a positive anthropogenic interference. Okay. Which is very different. So as small adjustment in that article two would actually allow the UNFCCC process to consider solar radiation modification. Which it cannot really do easily now.”

O.3 Failure scenarios

O.3.1 Top down failure

Respondent 1 noted that there the global response to date had relied on a top down approach, and an attitude of “Just wait for us, we're going to cut the grand political “ The respondent noted that this is “hugely inhibiting… it prevents innovation, encourages a kind of a slow gradual emissions decrease rather than thinking more creatively.” Meanwhile, Respondent 23 stated “The forces of "let's play safe" are dominating.” the UNFCCC and “as a result, we get stuck with what feels safe in the short-term, but that will lead to very unsafe future, absence of progress.”

O.3.2 Lack of ambition among Parties

Respondent 7 noted adaptation “can't be achieved by small incremental change” but at the same time, “there really is no appetite for bigger change.” Respondent 23 also noted “the state, as a central element of UNFCCC, I fear is… losing ambition. And in the climate context that we have now, it's not just about enforcing rules… It's also about coming up with new stuff. And states are not particularly, at present, good in that.”

Respondent 27 provided a failure scenario where “in the early 2020s, ambition is just very low and people… the countries… are just preoccupied with maybe a failing global economy or you know, trade wars or, struggling with low productivity, as a result of climate change ironically in some places” Then, “there’s [no] ambition to make tough decisions which may have financial costs and burdens on already stressed governments, treasuries.”

O.3.3 Zombie convention

Respondent 23 stated they could see scenario where the UNFCCC is on “a slow transition towards irrelevance” This could be a situation “where the process continues to exist in paper… and COP 47 takes place in some country… but it will become more and more like a vestige of the past.” Respondent 6 noted that in a worst case scenario “we end up with a zombie.”

Respondent 10 put forward a scenario where the UNFCCC “are under pressure of reducing this, the number of meetings they are having, people are criticizing them that they are just talk shows, and, so maybe they, maybe the cost will continue but not all these… pre-COP meetings." Respondent 25 noted a scenario where the UNFCCC "slips into the same obscurity as many other international conventions, meets once a year and nobody cares and nobody pays any attention."

O.4 Withdrawal scenarios

In one of the specific follow up questions related to failure, respondents were asked to provide scenarios where parties withdraw from the UNFCCC. In some cases, clarification had to be given that the President Trump, of the United States, had only announced that the United States would withdraw from the Paris Agreement rather than the UNFCCC as a whole. In some cases, respondents gave scenarios where parties withdrew only from the Paris Agreement.

Respondent 26 stated it is possible that there could be a breakdown in confidence the institution, "states start to walk away" and "the UNFCCC itself will come to an end." Respondent 6 also noted "the only people who would pull it down would be the vulnerables if they thought it was covering up." The respondent stated, "the key issue is that the debate moves to security council". Then it is possible that "and you would get the non-permanent members of security council… maybe even a permanent member trying to block action in the security council… just generally making a nuisance of themselves..."

It was noted that populist, nationalist or personality driven politicians might withdraw from the UNFCCC or Paris Agreement. Respondent 23 noted there may be a "Proliferation of personality-centric government administrations that do not care about being part of a harmonious global governance system." and Respondent 11 noted the UNFCCC "is one of the sort of symbolic things that they could step away from." Respondent 9 noted some nationalist governments might "deny the existence of climate change as a problem." It was noted by Respondent 26 that "it's very easy for sort of populists to turn around and go, "Oh, look at these processes, they cost loads of money and yet they don't really work... So, you can easily blame processes..." Furthermore, Respondent 3 suggested populist leaders could say "actually this was agreed to under my predecessor and it's putting too heavy a burden on my economy to deliver it."

It was noted by Respondent 2 that "You'll always find some people who would argue... that actually we should relax [what the] UNFCCC is doing... you know, it's trying to do too much" especially people that are reliant of fossil fuels for income. In some cases, parties to the UNFCCC withdraw, including "those who would say that UNFCCC is preventing them from enjoying the benefits that developed countries… have had in the past. Or the policy that UNFCCC is advocating will severely damage their economy"

In another scenario from Respondent 23, "countries that form the multilateral system that holds institutions together will begin to not have enough money to comfortably commit to stuff". As things get economically uncomfortable, "there is an increasing propensity to judge all input versus output, cost benefit, is it worth flying 10,000 people for an annual meeting where insufficient is accomplished." If parties stop paying their dues, the UNFCCC could essentially become "bankrupt" due to an "absence of money". It was noted that "Running the machinery is expensive." In such a scenario, the UNFCCC would effectively fail as an institution and cease to function.

Respondent 21 noted that if "one party is leaving, they are sort of making rogue decisions" and "it's much easier to follow than it is to be the first mover… once one has moved, it's a lot easier for more to move". The respondent provided a scenario where someone comes into power in a country, "Then it's also easier for them to leave [the UNFCCC] if they then point to other countries that have left". Respondent 8 noted, "it looses it's power I suppose, or it's unifying ability if half of states are pulling out."

Respondent 9 put forward a cascading scenario where successive influential parties withdraw. It was noted by the respondent that the "We already had one large emitter withdraw from the Paris Agreement". Then, "We can also see China, the number one emitter, pull out..." And if China "continue to produce more emissions then we can see a situation where the EU is uncomfortable leading and providing finance for the rest of the world" and "if they pull out, that's the top three emitters gone." And then "we really have a system… [that] really breaks down." Similarly, it was noted by Respondent 10 that if climate change negotiations under the UNFCCC fails to create results then major parties may withdraw and the process could collapse. Respondent 9 also noted in a withdrawal scenario where ecosystems are unable to adapt naturally and agricultural systems are impacted, that there would be "no collective forum where we can internationally work on a response to dealing with those changes" and "it would be every country for themselves in terms of what to do".

With regards to the order in which parties might withdraw from the UNFCCC, Respondent 10 stated "I can't see the G77 and China withdrawing without seeing… key players withdrawing first, because… they are feeling the impact and they're expecting the worst to come. So, they're very keen that they see this problem solved." Respondent 12 put forward a scenario "the US still want to withdraw and China would like to deliver on its promise of being… better." Other respondents put forward scenarios where the vulnerable parties withdraw before large influential parties.

Respondent 6 noted that if "[the] major economies [are] failing to act." then "I think the most likely group, you know, whether it's the UNFCCC or just from Paris is the vulnerables. I mean Africa Group pulling out and the LDC group pulling out". The respondent noted "Whether that means they withdraw from the UNFCCC or just from Paris… would be a question of tactics". The respondent also noted that "the scenario in which the vulnerable countries withdraw is when they get… a clear feel that the Paris... process is just giving cover for countries to be aiming at somewhere between two and a half and three and a bit degrees… and they decide it's better to pull that edifice down… than to give cover to countries who have decided not to make decisions… needed for their survival." Importantly, the respondent noted "the Security Council remains an option for them." However, in another scenario where there was a stringent enforced agreement, Respondent 18 noted "some will take objection to that." and as such, these parties could withdraw.

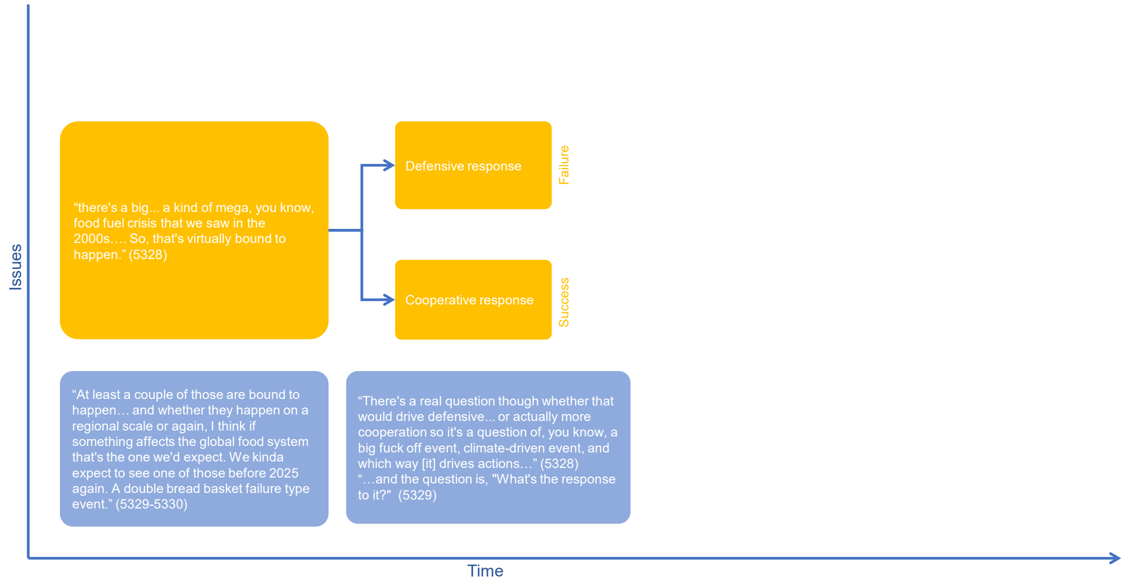
Failure of international cooperation scenarios

Respondent 1 noted that if parties withdraw from the UNFCCC, then “you are looking at a growth or a continued growth [in emissions]. The issue is the speed of growth [in emissions] and the pace of growth and the worst-case scenario is that business as usual or worse... takes us into the world of four degrees plus against pre-industrial... Why is that our worst-case scenario? Because we don't actually know what will happen.”

Parties withdrawing from the UNFCCC also has “a serious implication [for] the world's ability to even monitor how climate change is progressing” because “under the UNFCCC nations report on their emissions… and this allows science, other scientific bodies and other research bodies to measure and project scenarios for how much the climate is changing.” The respondent noted that it would really hinder the global response to climate change if you “can't figure how much you need to do.”

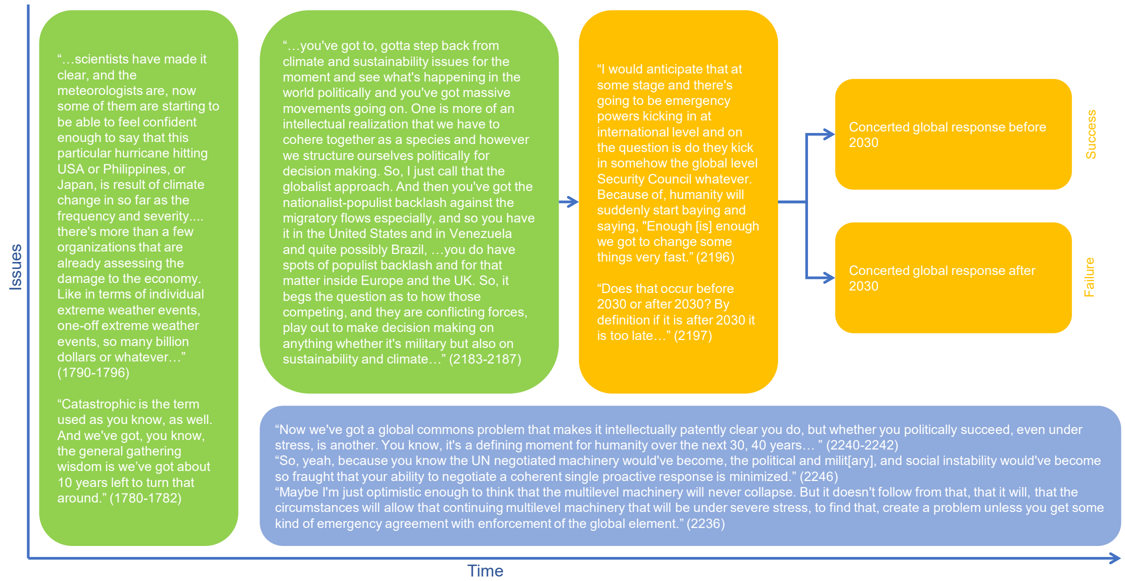
Appendix P: Branching scenarios

Respondent 6 – Branching success or failure scenario



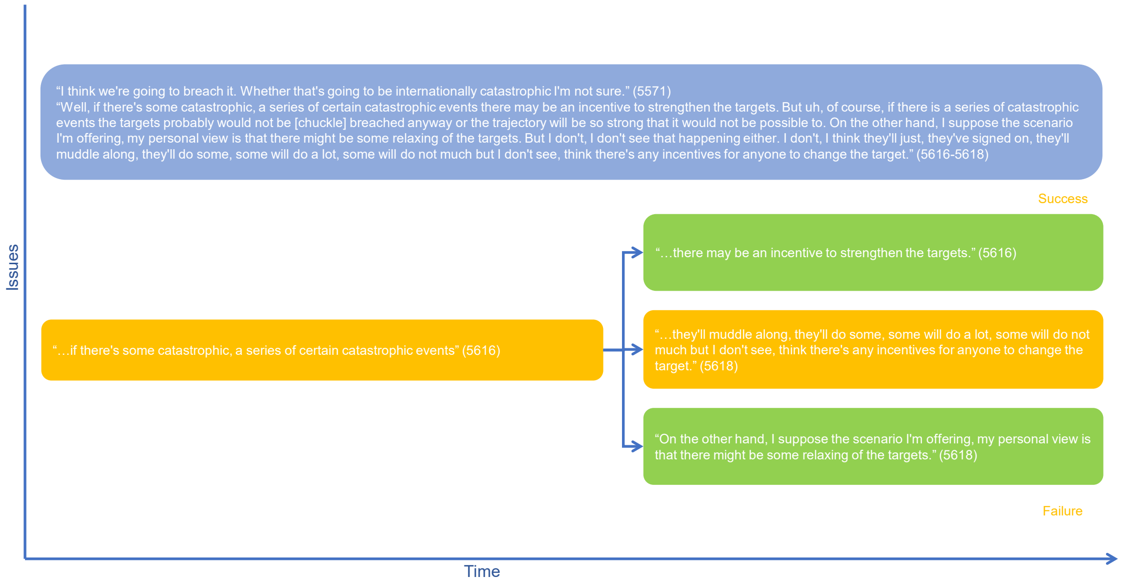
Complexity: Two steps, branching, three layers including assumptions
Assumptions:
Issues and options: Climate change event and food security
Actors and interests: Defence or cooperation
Response: Cooperative or defensive
Outcome: Branching success or failure,
Notes:
Code: Branching success or failure, cooperation, defence

Respondent 13 – Branching success or failure scenario



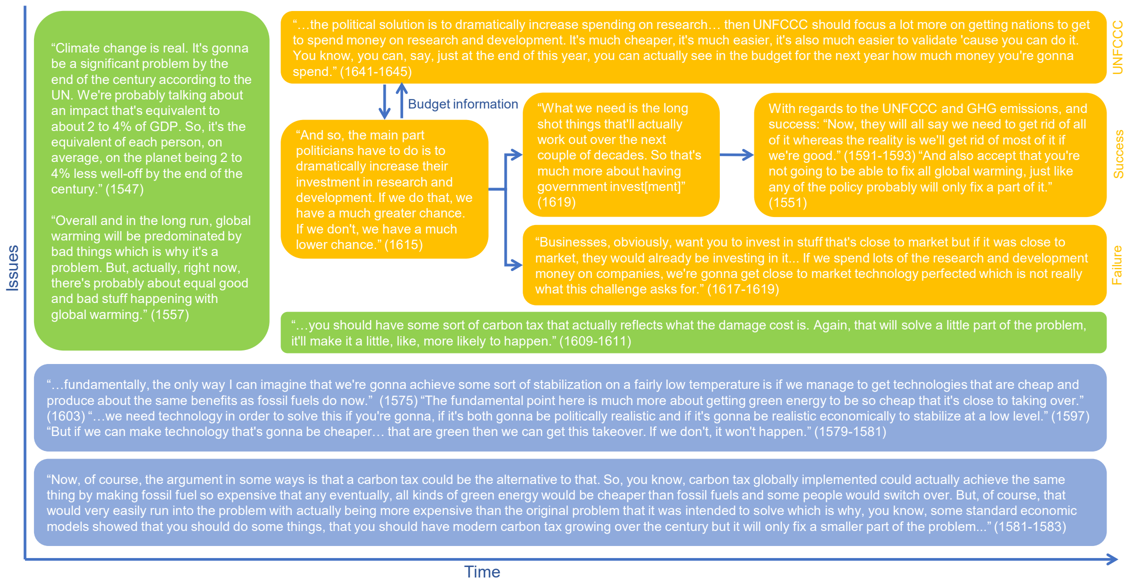
Complexity: Three steps, branching, three layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Timing, international regime
Outcome: Branched success or failure, timing
Notes: Concerted global response before or after 2030
Code: Branching success or failure, timing, ambition

Respondent 14 – Branching success or failure scenario



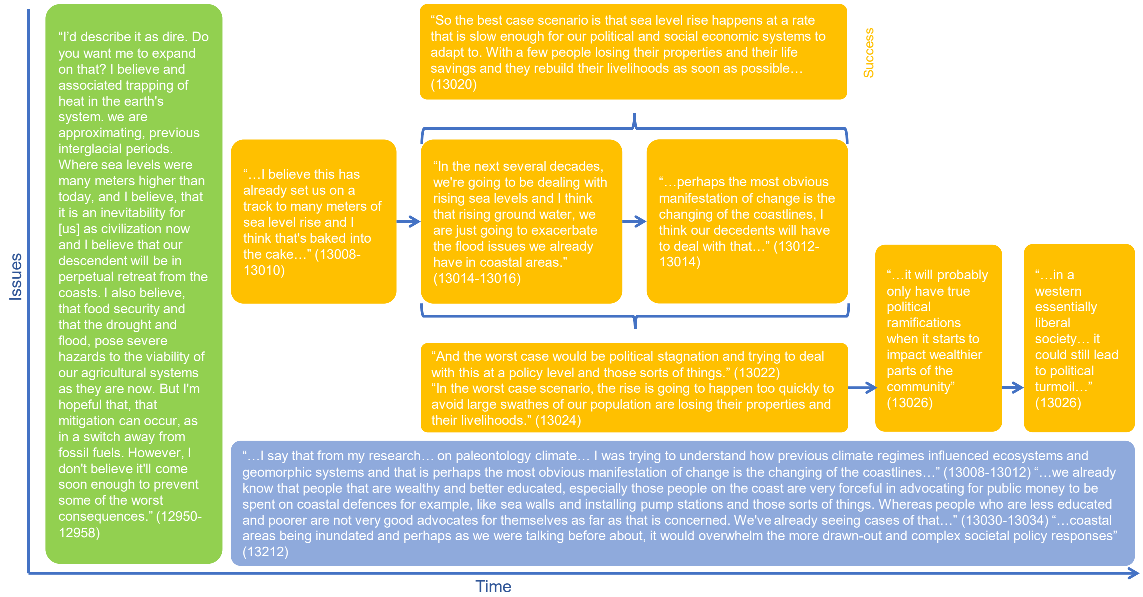
Complexity: Two steps, branching, four layers including assumptions
Assumptions:
Issues and options: How to respond to catastrophic climate change
Actors and interests:
Response: Impact response, political will and policy
Outcome: Success or failure
Notes:
Code: Branching success or failure, impact response, political will and policy

Respondent 15 – Branching success or failure scenario



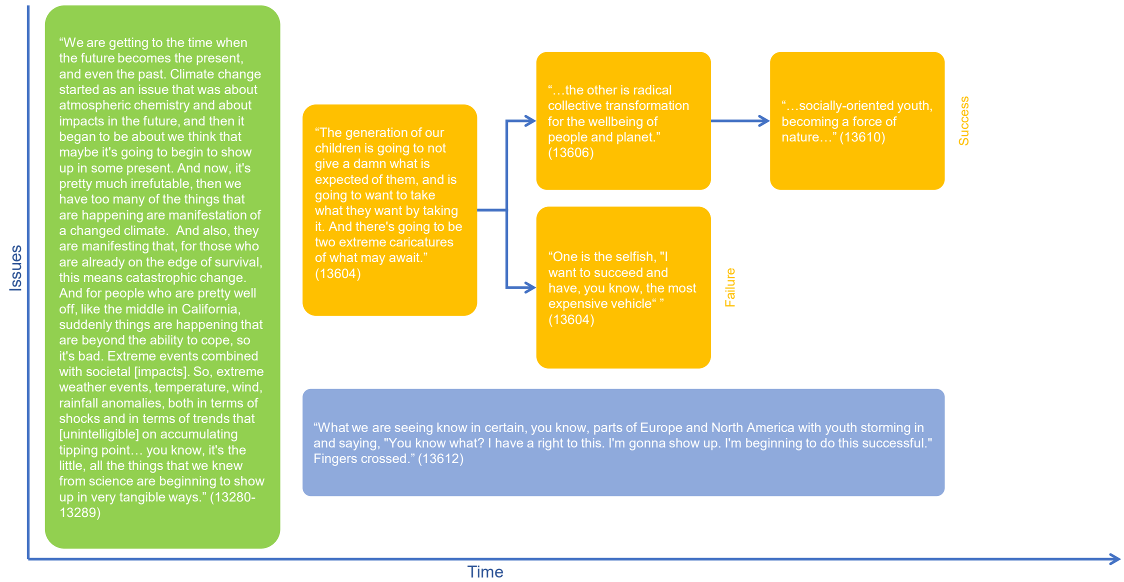
Complexity: Three steps, branching, six layers with interrelations, parallel conditions and assumptions
Assumptions:
Issues and options:
Actors and interests: Government and their research and development budgets
Response: Technology, political will and policy,
Outcome: Branched success or failure,
Notes: Investment in long shot or close to market technology
Code: Branching success or failure, technology, political will and policy, research and development

Respondent 20 – Branching success or failure scenario



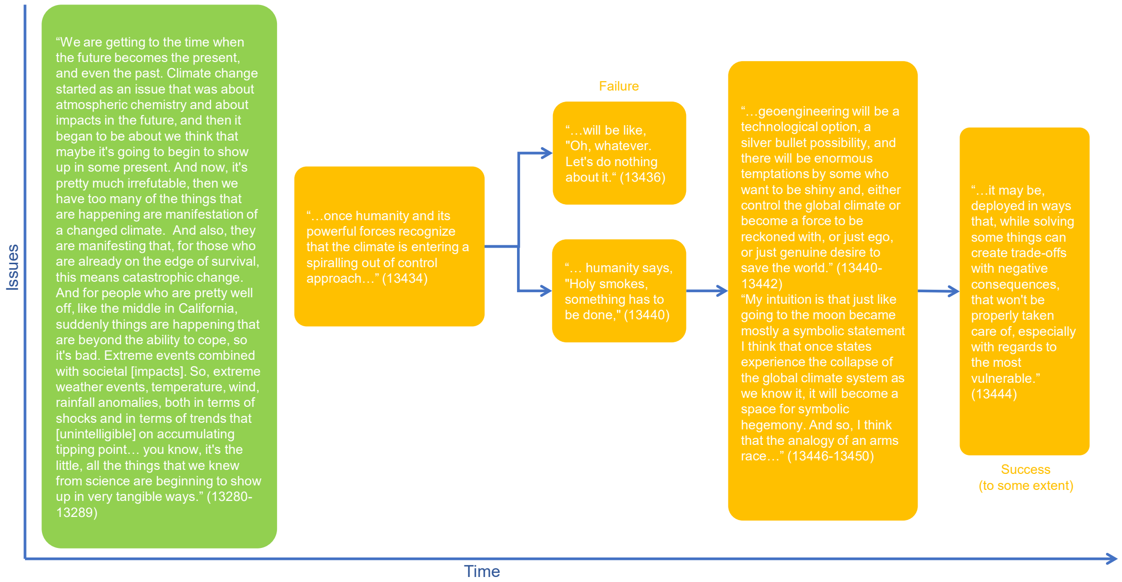
Complexity: Five steps, branching, four layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Impact response, climate sensitivity, political will and policy
Outcome: Branched success or failure
Notes:
Code: Branching success or failure, impact response, climate sensitivity, political will and policy

Respondent 23 – Branching success or failure scenario



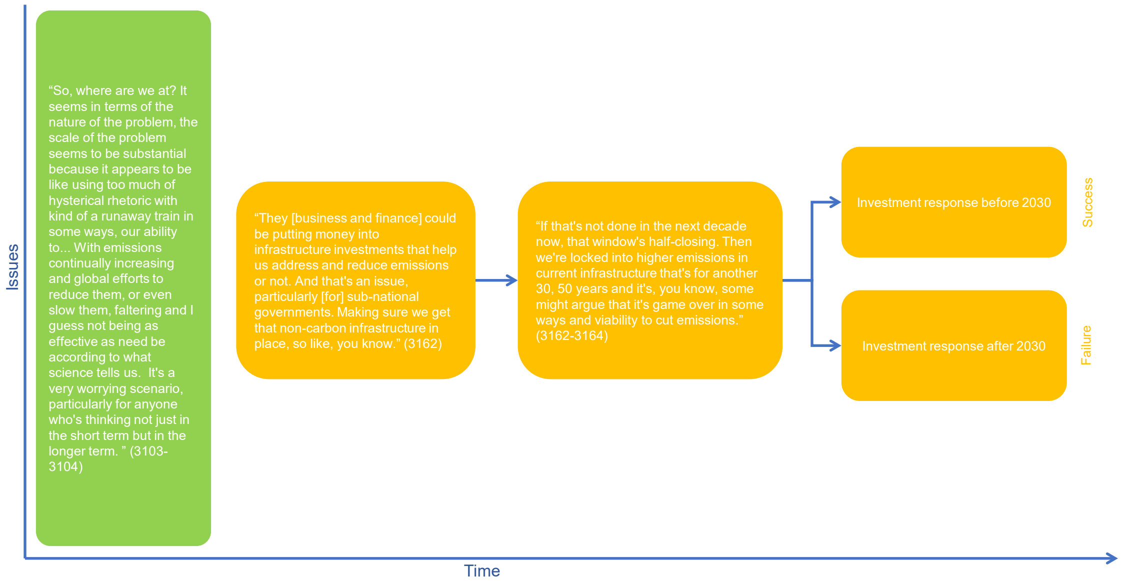
Complexity: Three steps, branching, three layers with assumptions
Assumptions:
Issues and options:
Actors and interests: Youth concerned with climate change and will take action themselves
Response: Social change, over-consumption
Outcome: Branched success or failure
Notes:
Code: Branching success or failure, enlightenment, over-consumption

Respondent 23 – Branching success or failure scenario



Complexity: Four steps, two layers branching
Assumptions:
Issues and options: Unintended consequences
Actors and interests:
Response: Impact response, socio-political response, GHG removals, technology,
Outcome: Success
Notes:
Code: Branching success or failure, impact response, apathy, removals

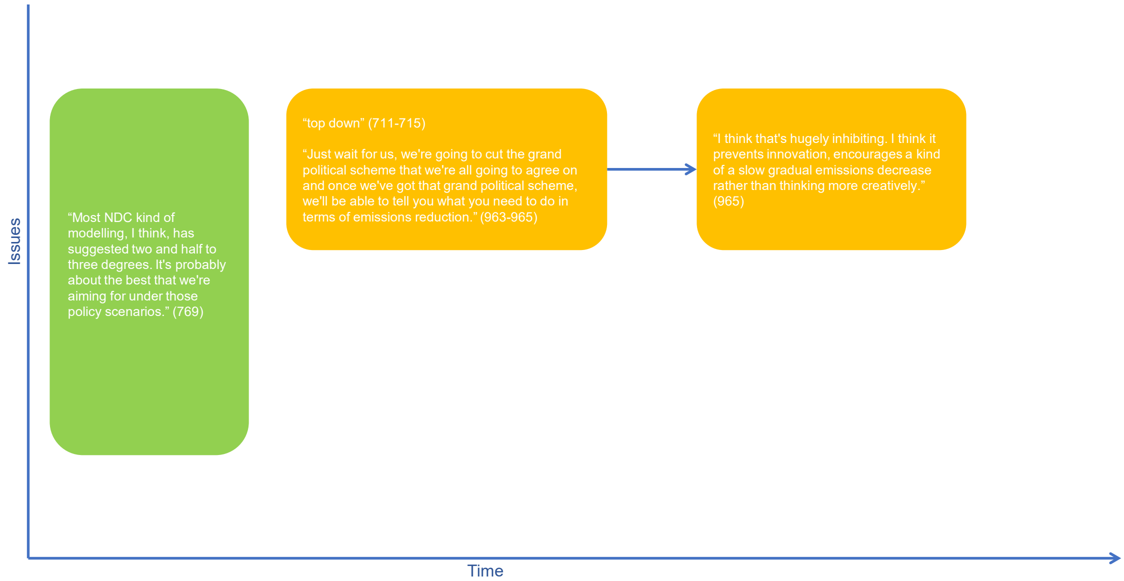
Respondent 27 – Branching success or failure scenario



Complexity: Three steps, branching, two layers
Assumptions:
Issues and options:
Actors and interests:
Response: Technology, timing, infrastructure
Outcome: Branched success or failure,
Coding: Branching

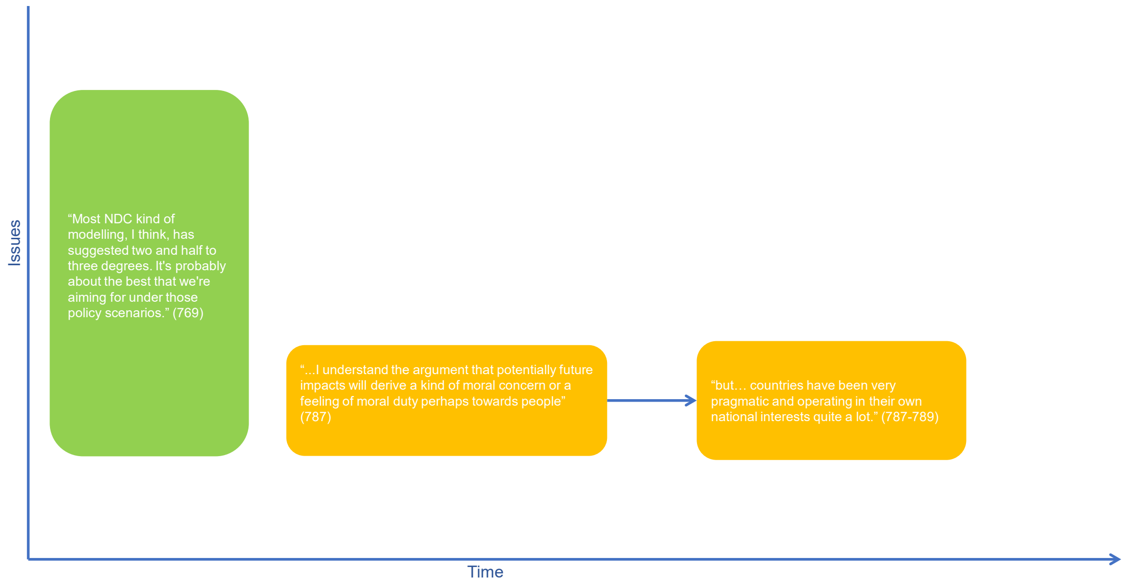
Appendix Q: Failure scenarios

Respondent 1 – Failure scenario



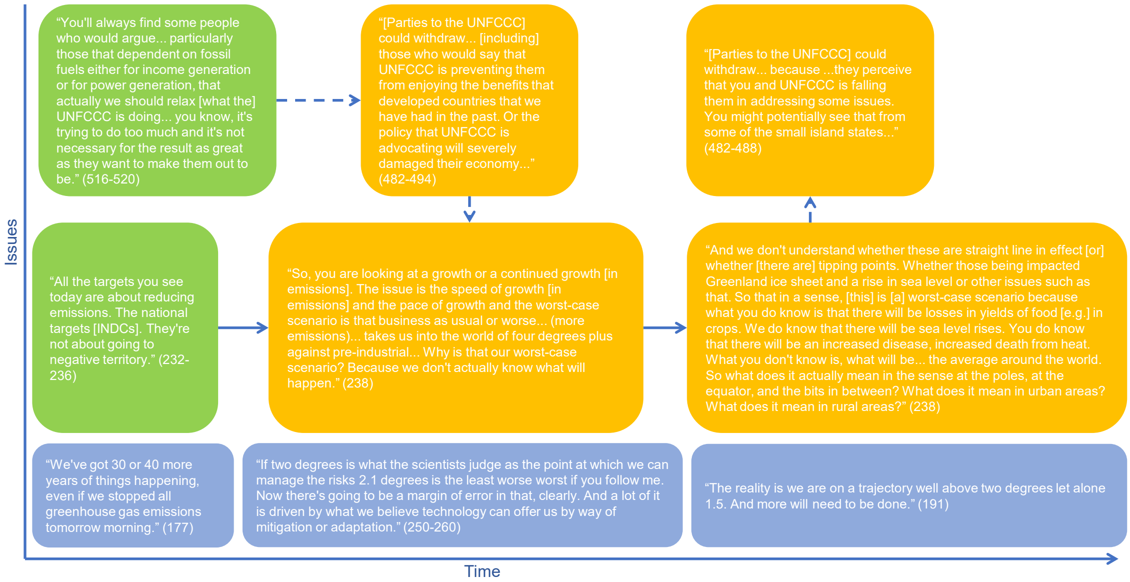
Complexity: Two steps, linear, one layer
Assumptions:
Issues and options: Grand political solutions
Actors and interests: Looking for a grand political solution
Response: Failure of international cooperation on climate change
Outcome: Failure
Notes: Waiting for a negotiated agreement, a lack of innovation, gradual changes
Code: Failure, international cooperation

Respondent 1 – Failure scenario



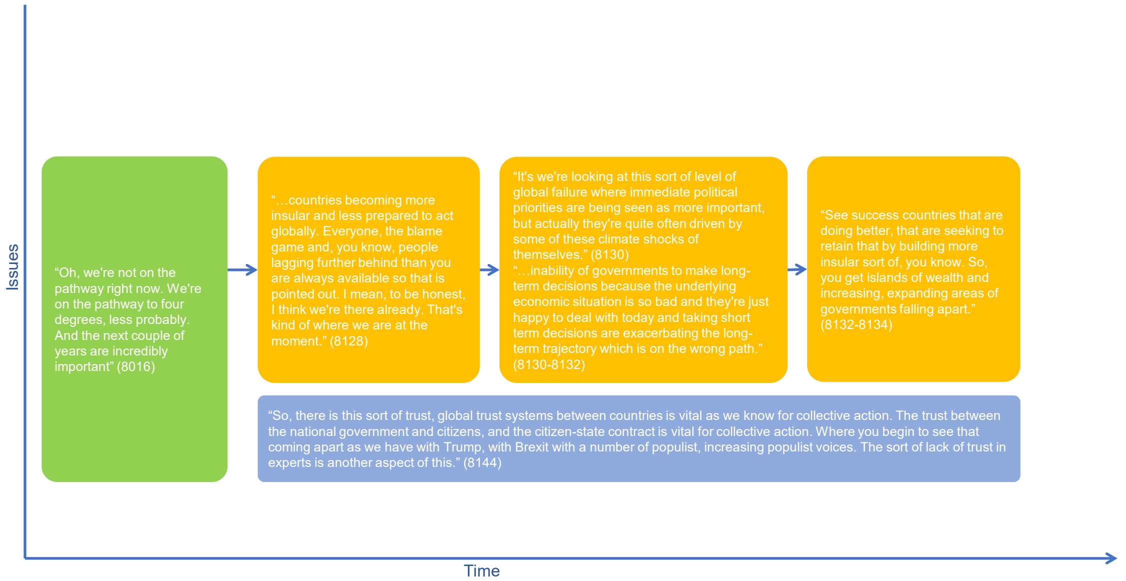
Complexity: Two steps, linear, one layer
Assumptions:
Issues and options: Moral concern, moral duty
Actors and interests: National interests
Response:
Outcome: Failure
Notes:
Code: Failure, non-response

Respondent 2 – Failure scenario



Complexity: Three steps, linear, three layers with interconnections and assumptions
Assumptions:
Issues and options: A lack of progress
Actors and interests: Small party frustration
Response: Withdrawal
Outcome: Failure
Notes: Withdrawal due to a lack of progress
Code: Failure, withdrawal

Respondent 3 – Failure scenario

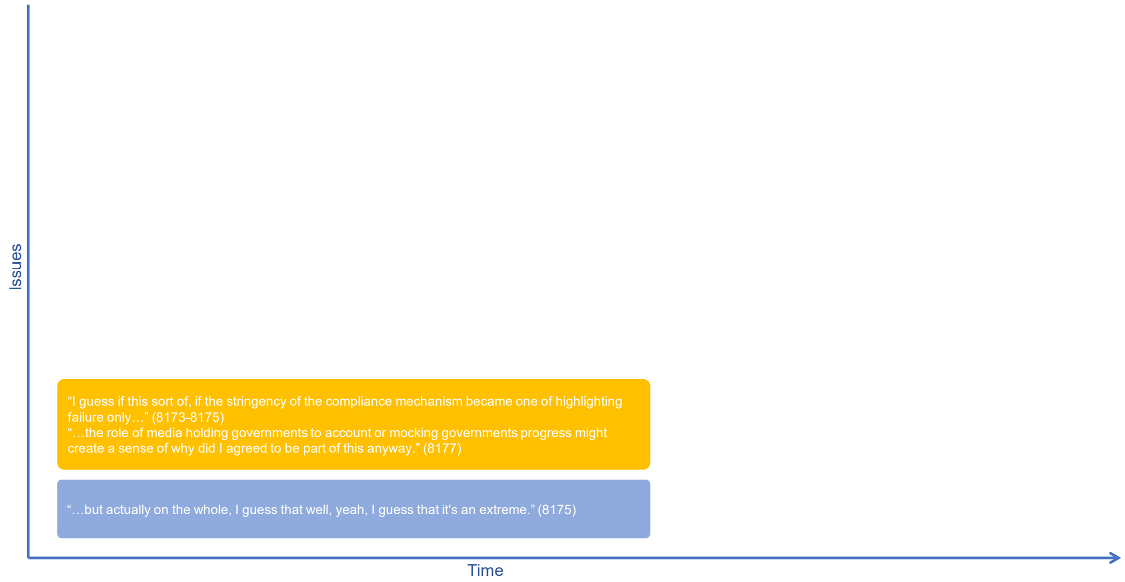


Complexity: Four steps, linear, two layers with assumptions
Assumptions: Breakdown of trust in institutions
Issues and options: Loss of trust, trust between states, trust between states and citizens
Actors and interests: Governments focused on immediate political priorities
Response: Defence
Outcome: Failure
Notes: Islands of wealth while more areas fall apart
Code: Failure, fragmentation

Respondent 3 – Failure scenario

Complexity: One step, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Withdrawal, populist driven
Outcome: Failure
Notes:
Code: Failure, withdrawal

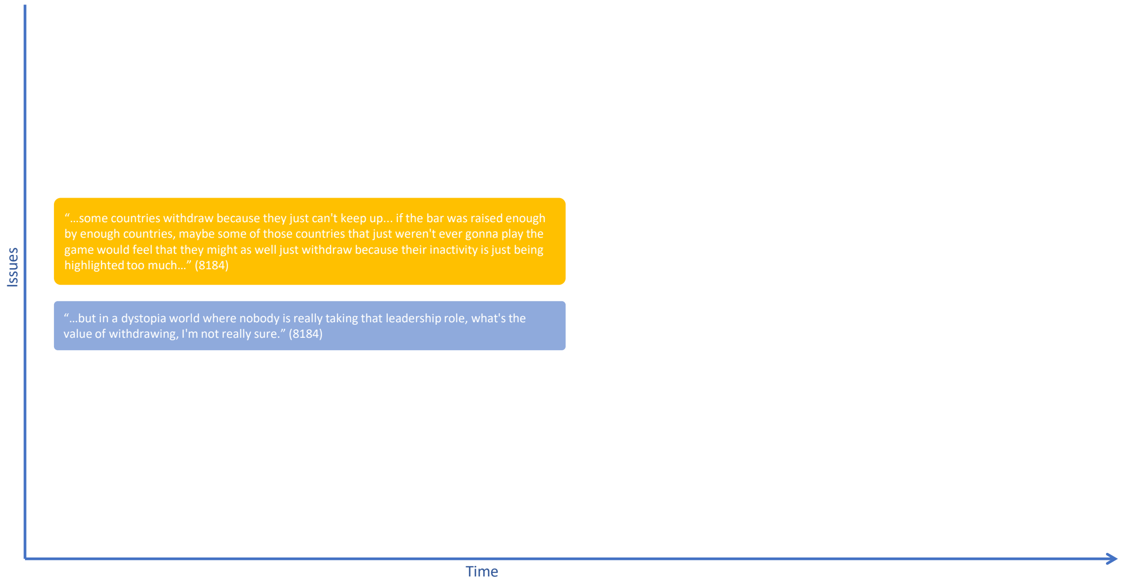
Respondent 3 – Failure scenario



Complexity: One step, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Withdrawal, stringency
Outcome: Failure
Notes:
Code: Failure, withdrawal

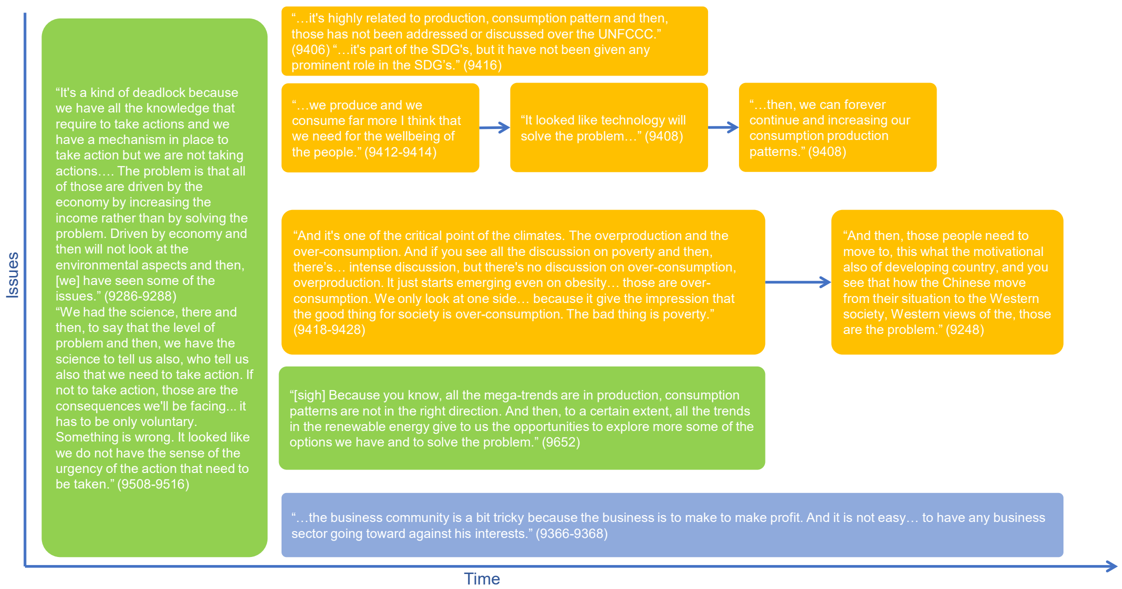
Failure scenarios

Respondent 3 – Failure scenario

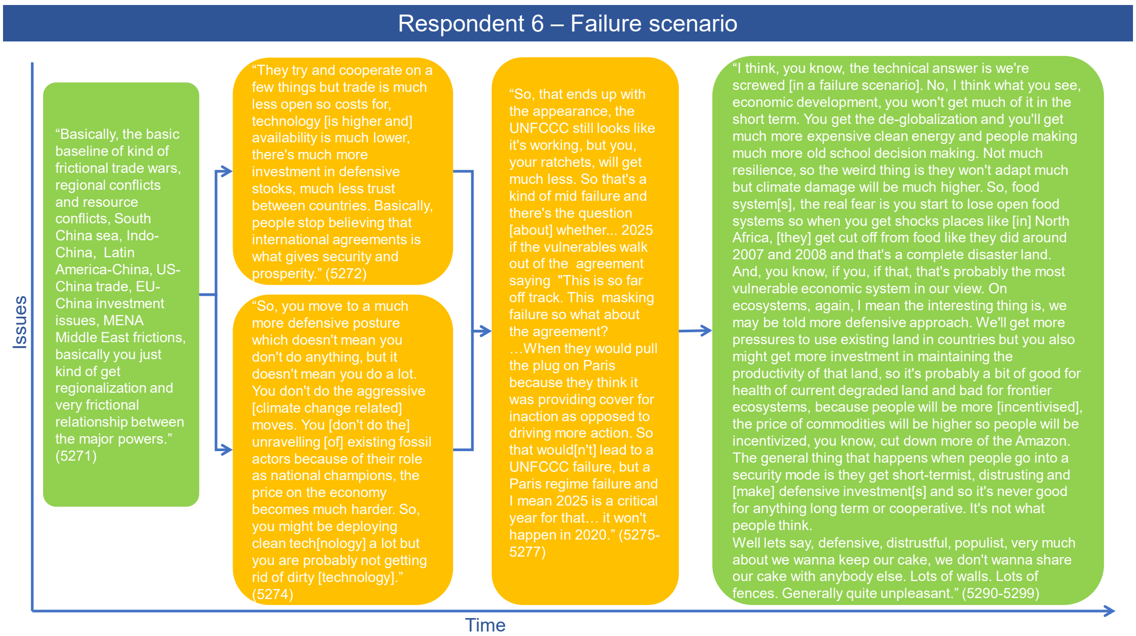


Complexity: One step, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Withdrawal, poor domestic progress bad press
Outcome: Failure
Notes:
Code: Failure, withdrawal

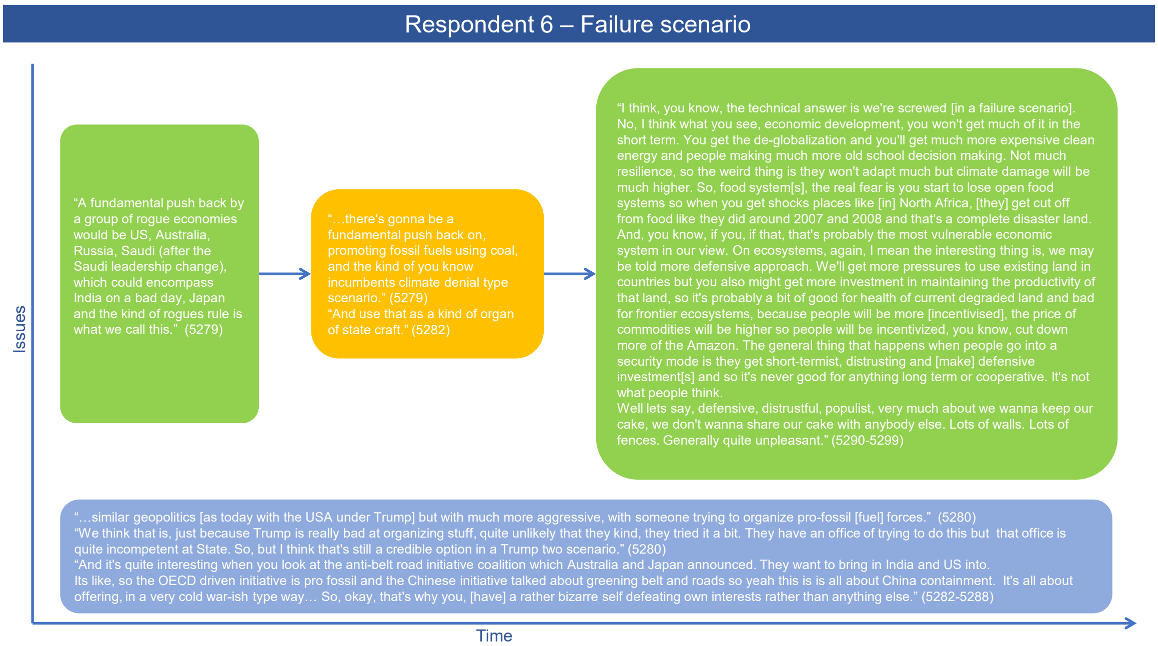
Respondent 5 – Failure scenario



Complexity: Three steps linear, five layers, including parallel conditions and assumptions
Assumptions:
Issues and options: Overconsumption
Actors and interests: Businesses profit from increased consumption, consumption no a political priority
Response: Over-consumption
Outcome: Failure
Notes:
Code: Failure, over-consumption

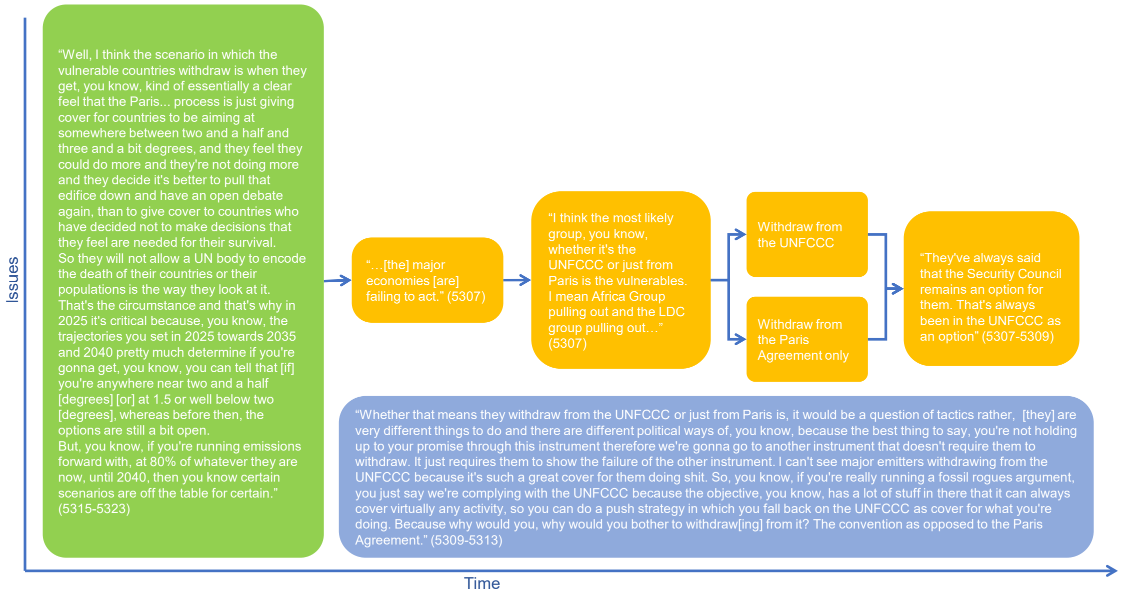


Complexity: Four steps, branching merging, two layers
Assumptions:
Issues and options:
Actors and interests: US, China, EU, Latin America, MENA, Middle East, protectionism, limited interest in international cooperation, distrust. Vulnerable countries
Response: Defence, withdrawal, what failure looks like
Outcome: Failure, de-globalisation, expensive clean energy, closed food systems (hunger during shocks)
Notes:
Code: Failure, defence



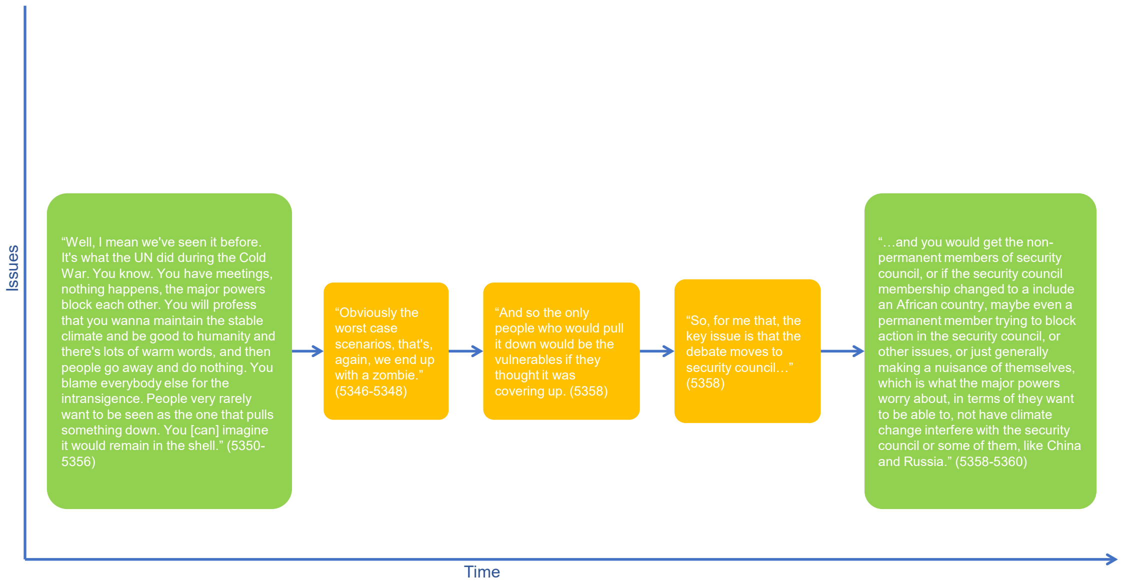
Complexity: Three steps linear, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests: Fossil fuel resource states defend their interests and make these interests central to foreign policy. US, Austalia, Russia, Saudi Arabia, Japan
Response: International cooperation (Fossil fuel push), political will and policy
Outcome: Failure
Notes: Climate denial, fossil fuel promotion, food insecurity. Description of what failure looks like. Closed food systems, migration, expensive energy
Code: Failure, fossil fuel push

Respondent 6 – Failure scenario



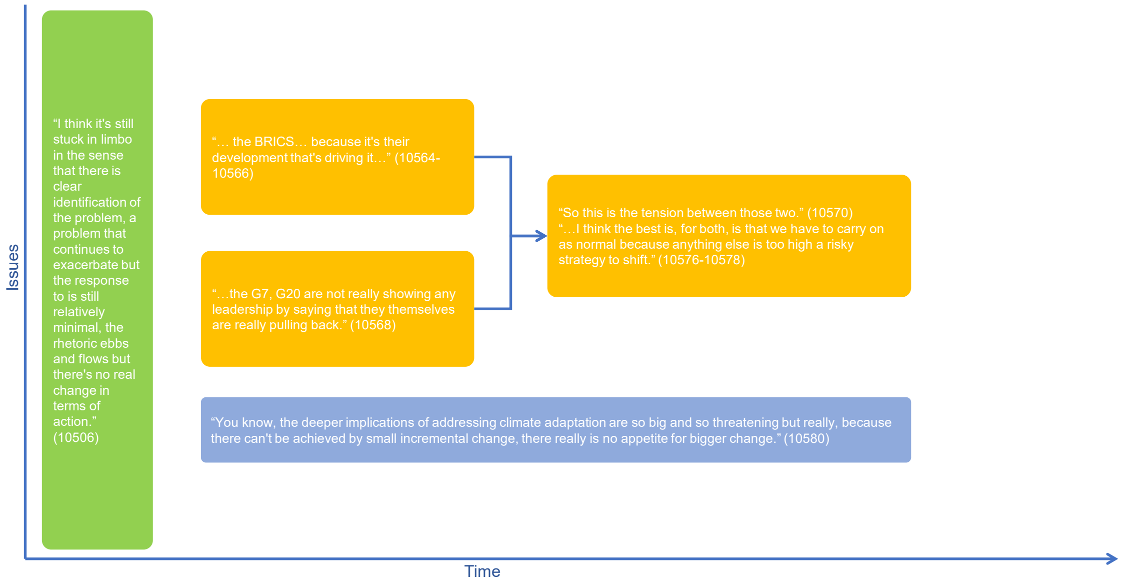
Complexity: Five steps, branching, merging, three layers with assumptions
Assumptions:
Issues and options: A lack of progress
Actors and interests: Small party frustration
Response: Withdrawal,
Outcome: Failure
Notes:
Code: Failure, withdrawal

Respondent 6 – Failure scenario



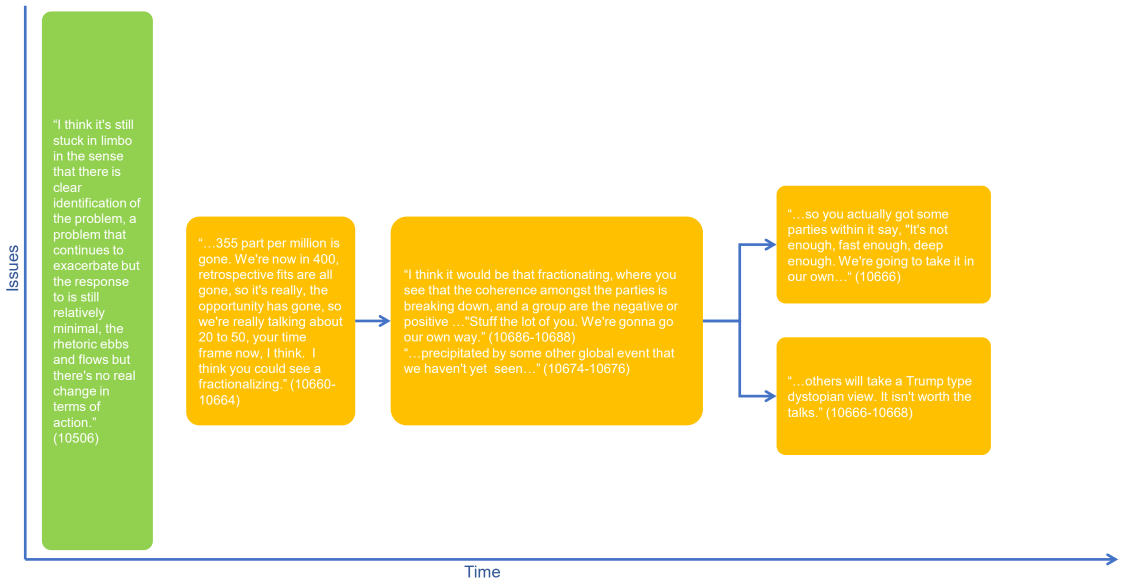
Complexity: Five steps linear, one layer
Assumptions:
Issues and options: More than 2 degrees of global warming, security
Actors and interests: National security, United Nations Security Council (UNSC)
Response: Failure of international cooperation on climate change
Outcome: Failure
Notes: escalate CC to UNSC, defence, international non-cooperation
Code: Failure, defence, non-cooperation, UNSC

Respondent 7 – Failure scenario



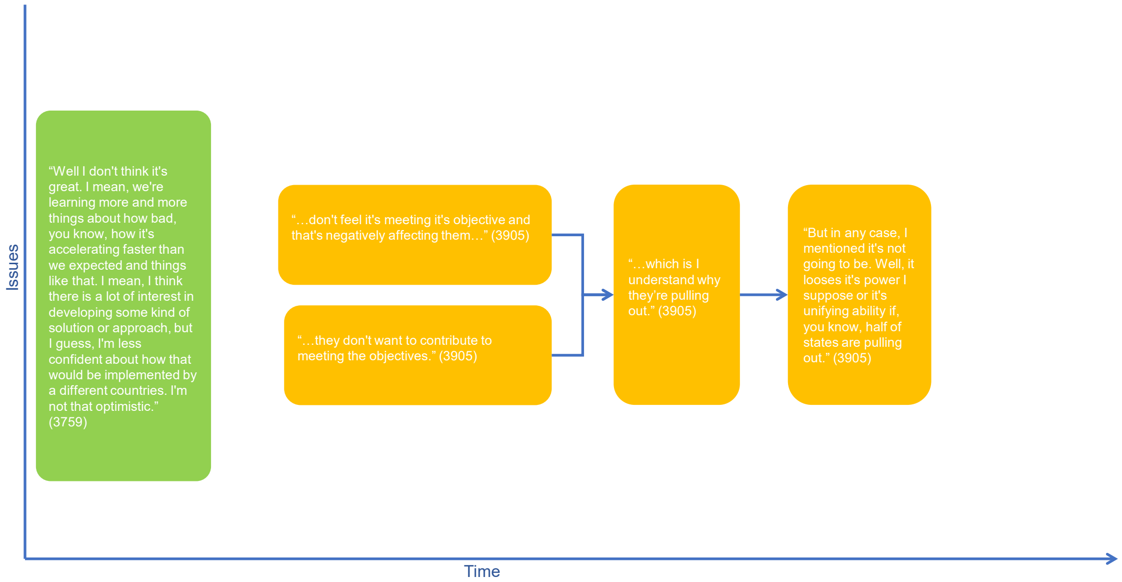
Complexity: Two steps merging, three layers including assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Failure of international cooperation on climate change
Outcome: Failure
Notes: No leadership
Code: Failure, business as usual

Respondent 7 – Failure scenario



Complexity: Three steps, branching, two layers.
Assumptions:
Issues and options:
Actors and interests:
Response: Fragmentation
Outcome: Failure
Notes: Blocks, non-participation
Code: Failure, fragmentation

Respondent 8 – Failure scenario

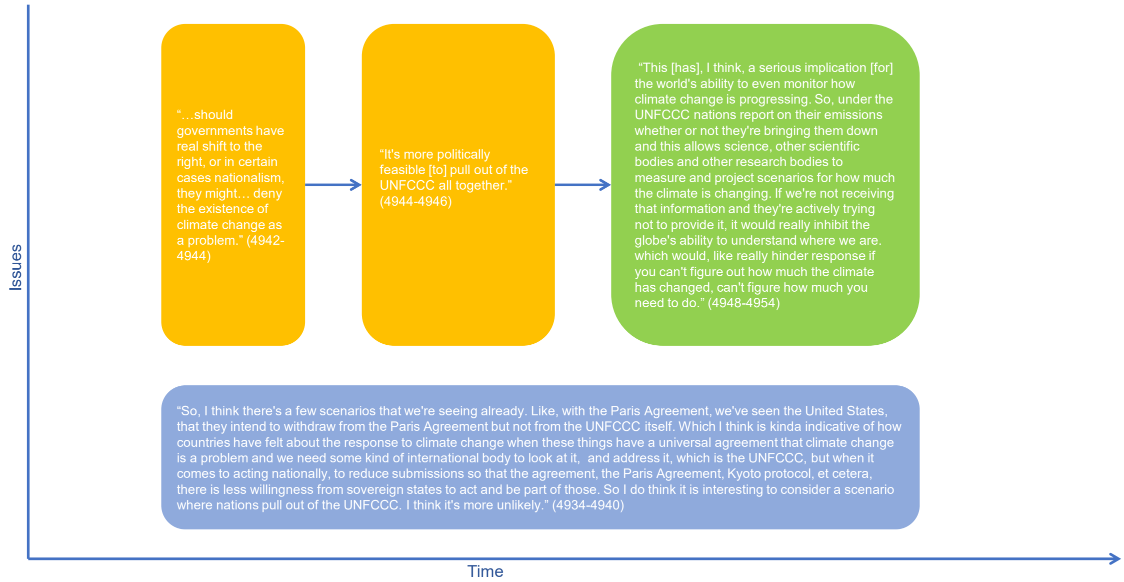


Complexity: Three steps, two layers merging.
Assumptions:
Issues and options:
Actors and interests:
Response: Cascading withdrawal
Outcome: Failure
Notes:
Code: Failure, withdrawal

Respondent 9 – Failure scenario

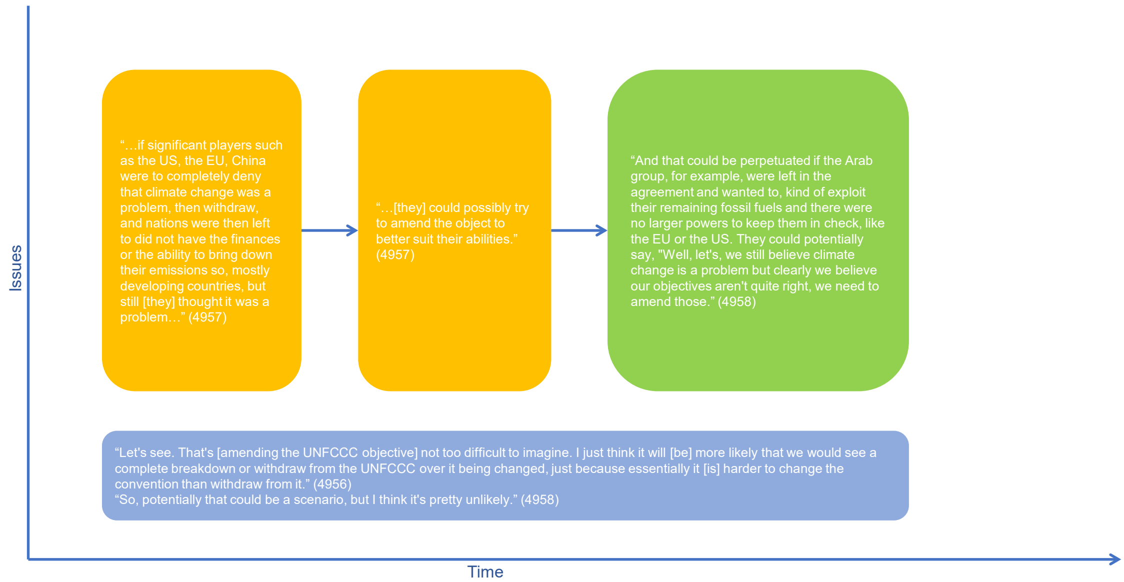
Complexity: Seven steps, five layers, successive parallel conditions, parallel conditions with assumptions
Assumptions:
Issues and options: A large party has already withdrawn from the Paris Agreement
Actors and interests:
Response: Cascading withdrawal
Outcome: Failure, increasing climate change impacts
Notes:
Code: Failure, withdrawal

Respondent 9 – Failure scenario



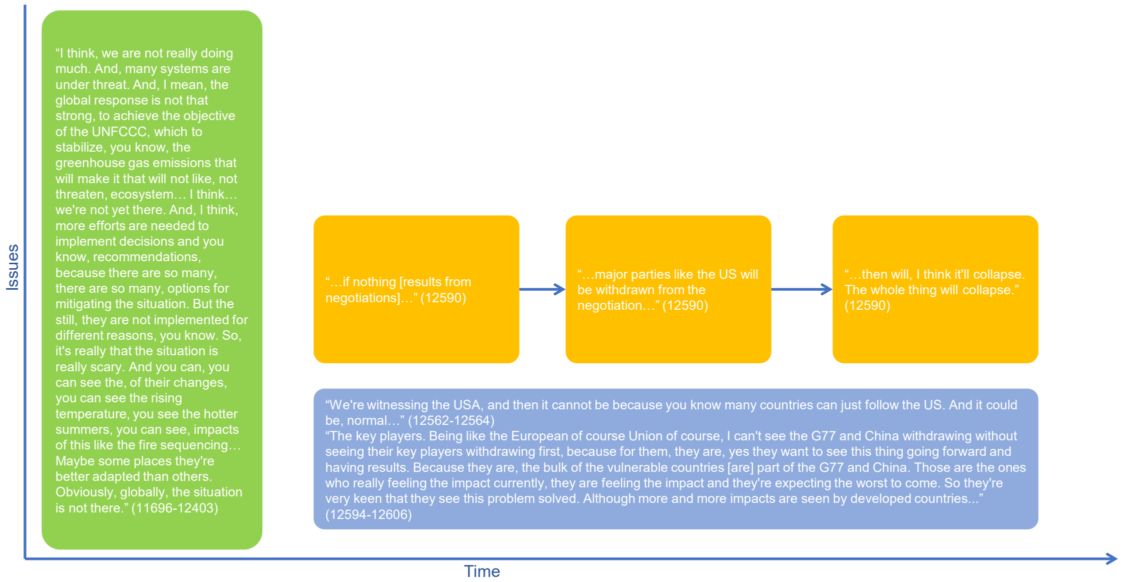
Complexity: Three steps, two layers with assumptions.
Assumptions:
Issues and options:
Actors and interests: Shift in domestic politics to the right, nationalism, politically feasible to withdraw from UNFCCC
Response: Withdrawal
Outcome: Failure
Notes: Knock on effect of limiting reporting and ability to monitor GHG emissions and have a complete set of inventories
Code: Failure, withdrawal

Respondent 9 – Failure scenario



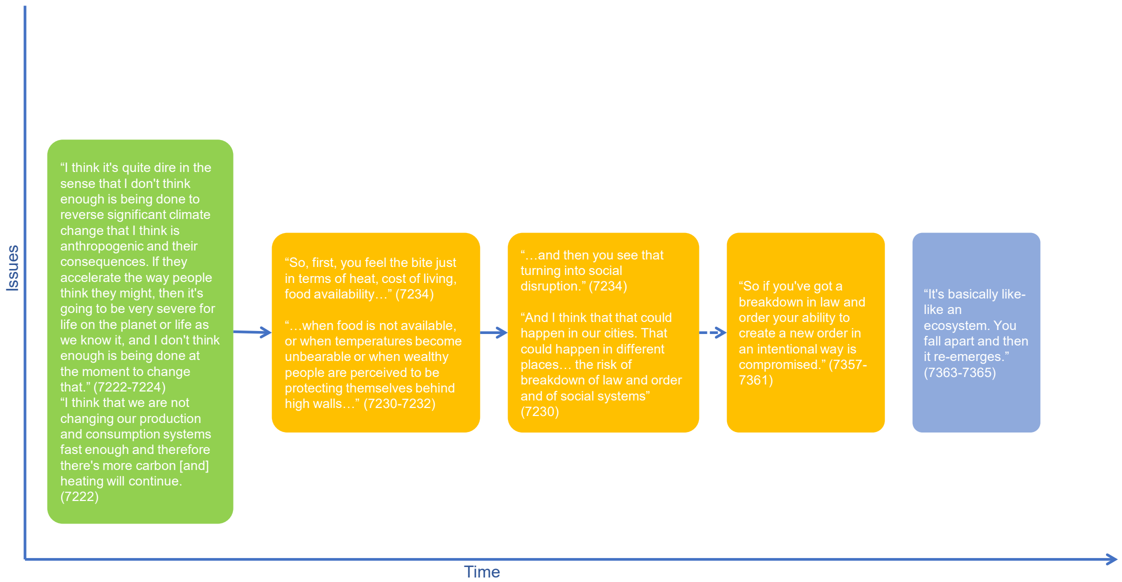
Complexity: Three steps, two layers, including assumptions
Assumptions:
Issues and options: Inability to meet the objective of the agreement
Actors and interests:
Response: Withdrawal and amendment, weakening of objective
Outcome: Failure
Notes:
Code: Failure, withdrawal

Respondent 10 – Failure scenario



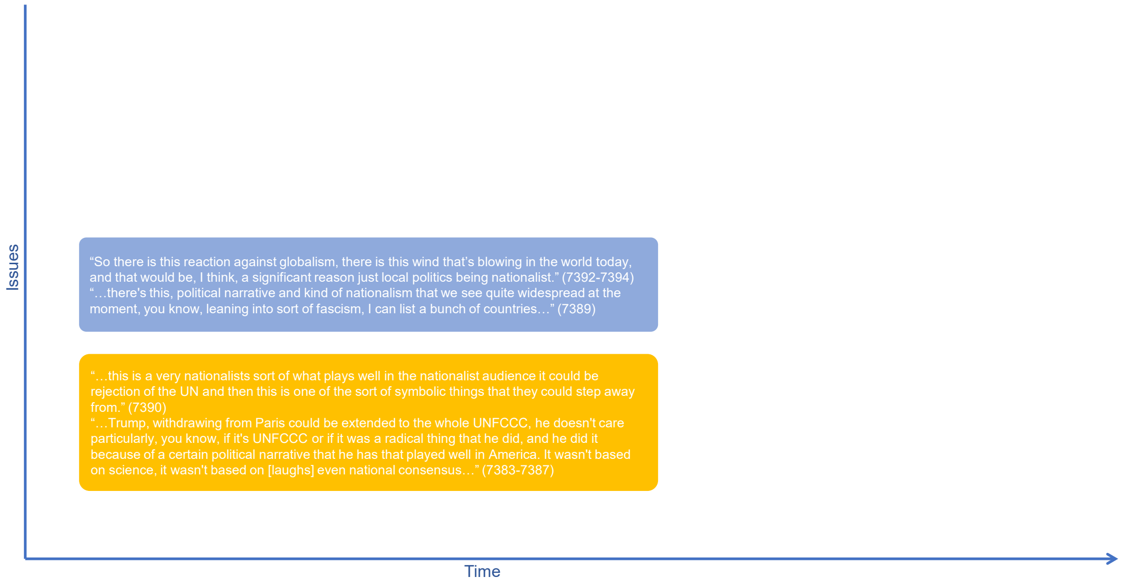
Complexity: Three steps, two layers with assumptions.
Assumptions:
Issues and options:
Actors and interests: States with irreconcilable interests
Response: Cascading withdrawal
Outcome: Failure
Notes:
Code: Failure, withdrawal

Respondent 11 – Failure scenario



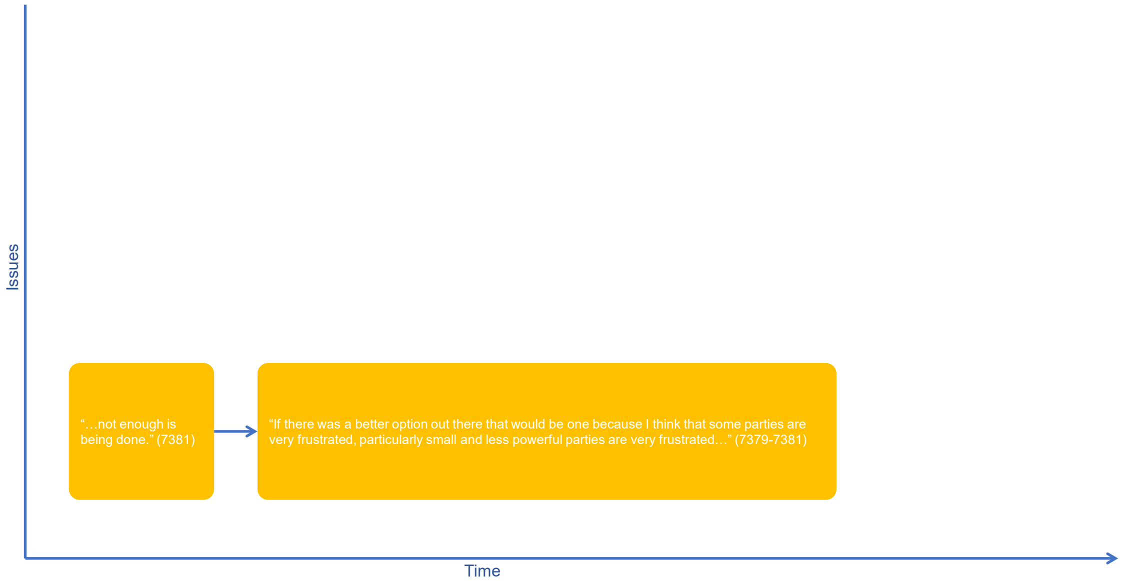
Complexity: Four steps, linear, one layer including assumptions
Assumptions:
Issues and options: Continuing climate change, security and insecurity
Actors and interests:
Response: Insecurity, defence, social unrest, fragmentation
Outcome: Failure
Notes: Food scarcity, breakdown of law and order, institutional breakdown, new world
Code: Failure, defence, self interest

Respondent 11 – Failure scenario



Complexity: One step, two layers with assumptions.
Assumptions:
Issues and options:
Actors and interests: Nationalism, rejection of international cooperation, symbolism for domestic audience
Response: Withdrawal
Outcome: Failure
Notes:
Code: Failure, withdrawal

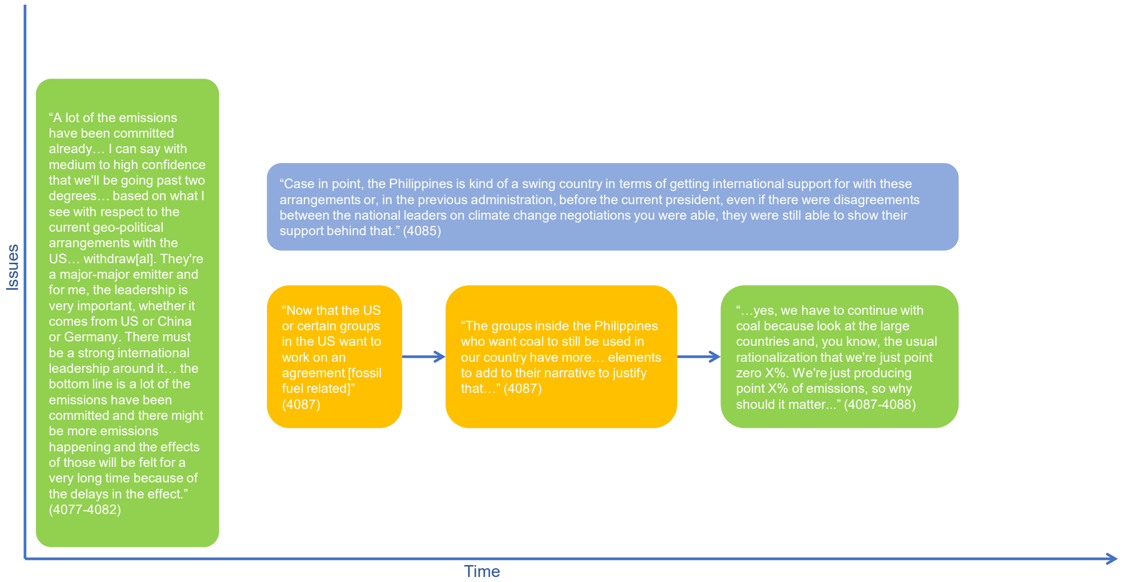
Respondent 11 – Failure scenario



Complexity: Two steps, one layer
Assumptions:
Issues and options: A lack of progress
Actors and interests: Small party frustration
Response: Withdrawal
Outcome: Failure
Notes:
Code: Failure, withdrawal

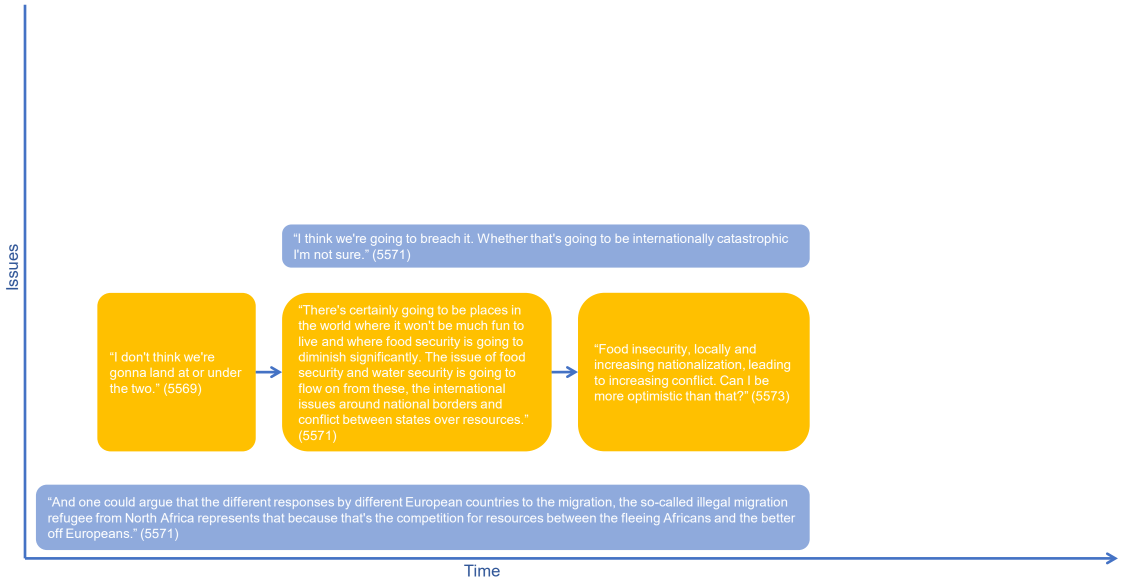
Failure scenarios

Respondent 12 – Failure scenario



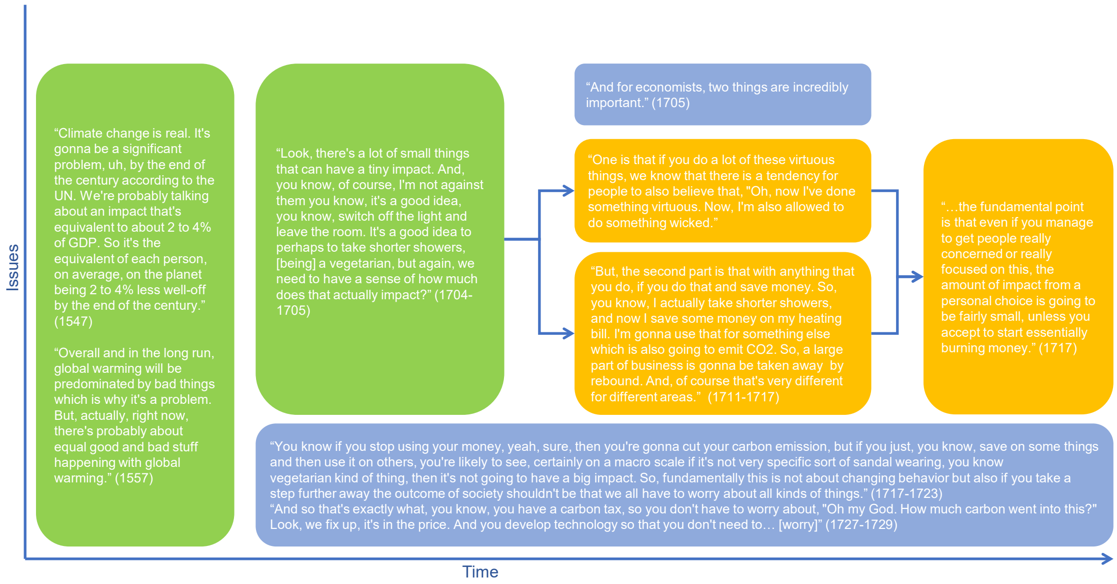
Complexity: Three steps, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests: Some states have an interest in the use of fossil fuels
Response: Fossil fuel push
Outcome: Failure
Notes:
Code: Failure, fossil fuel push

Respondent 14 – Failure scenario



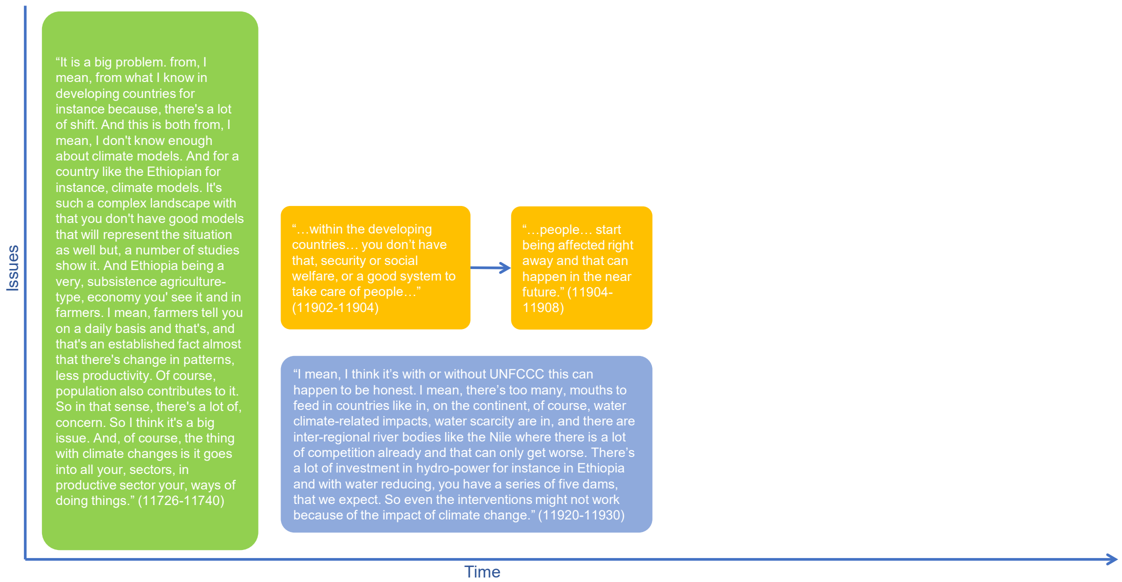
Complexity: Three steps linear, three layers including assumptions
Assumptions:
Issues and options: More than 2 degrees of global warming, food security
Actors and interests: North Africans, Europeans, migrants and food security
Response: Defence, conflict
Outcome: Failure, food insecurity, nationalism
Notes:
Code: Failure, defence, extreme politics, conflict

Respondent 15 – Failure scenario



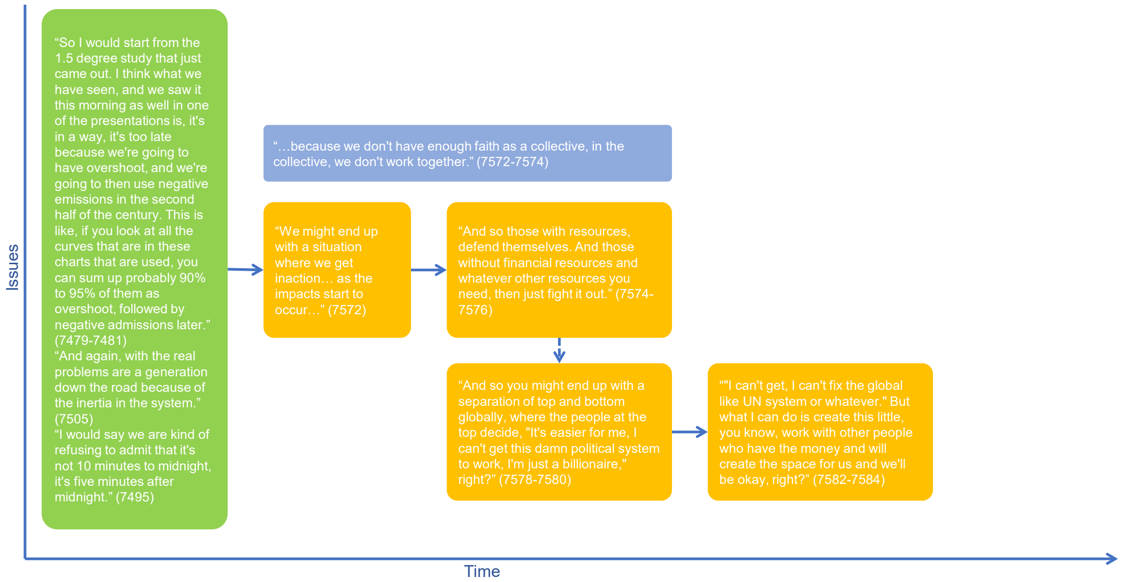
Complexity: Four steps branching and merging, four layers with interrelations and assumptions
Assumptions:
Issues and options:
Actors and interests: Social concern
Response: Limited impact of behavioural change,
Outcome: Failure
Notes:
Code: Failure, behaviour (insufficient change)

Respondent 16 – Failure scenario



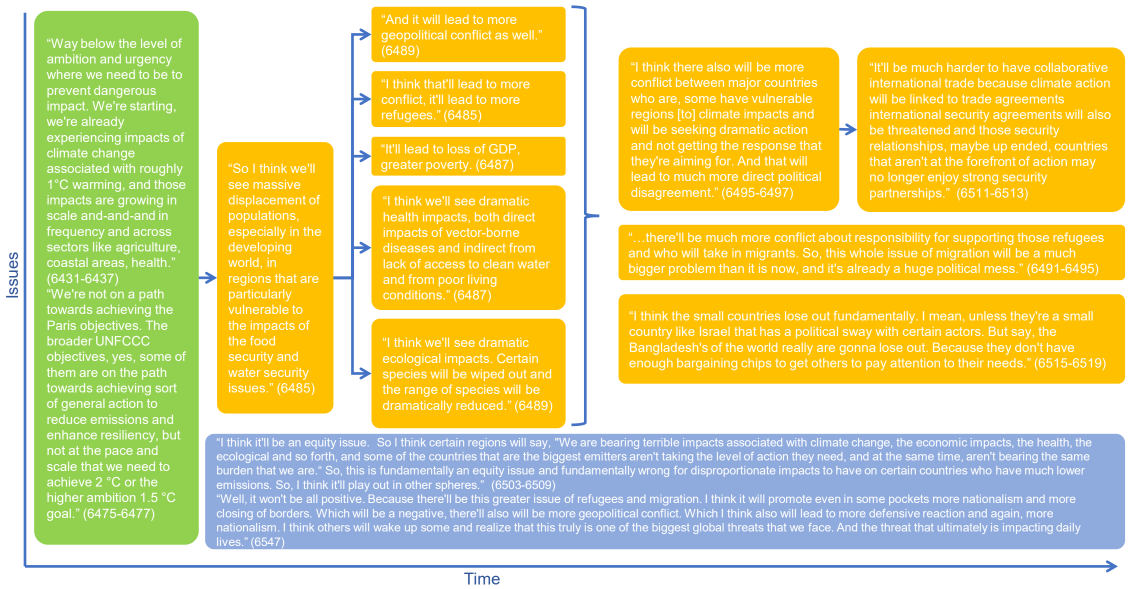
Complexity: Two steps linear, two layers including assumptions
Assumptions:
Issues and options: Lack of social security and social welfare in developing countries, many people to look after
Actors and interests:
Response: Failure of international cooperation on climate change
Outcome: Failure
Notes:
Code: Failure, failure of international cooperation on climate change

Respondent 17 – Failure scenario



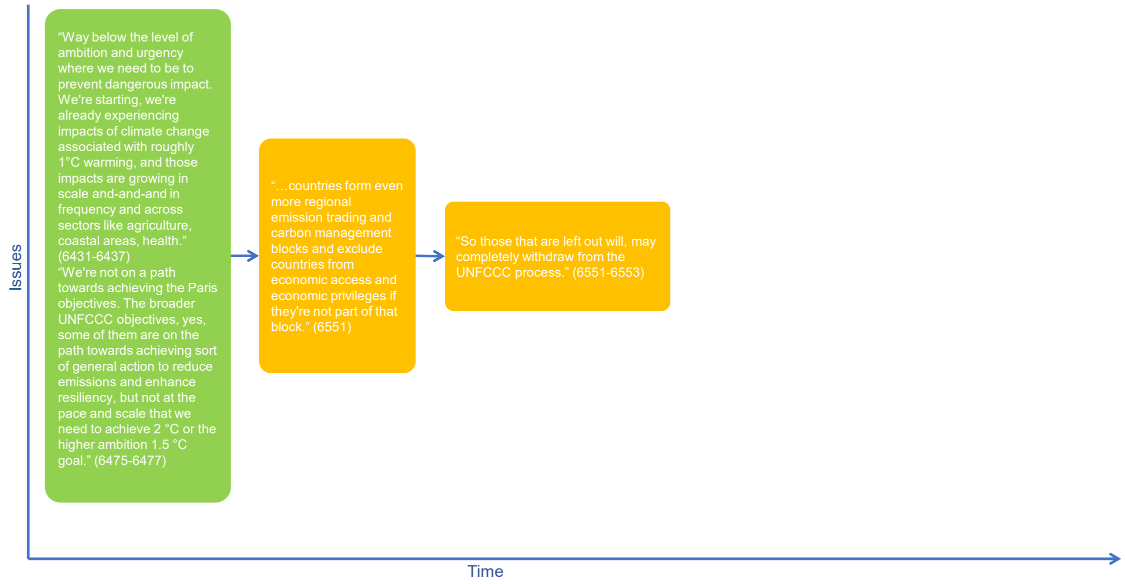
Complexity: Three steps, three layers with interrelations and assumptions
Assumptions:
Issues and options:
Actors and interests: Individuals looking after their property
Response: Defence
Outcome: Failure
Notes: Fragmentation, individual self interest
Code: Failure, defence, individual self interest

Respondent 18 – Failure scenario



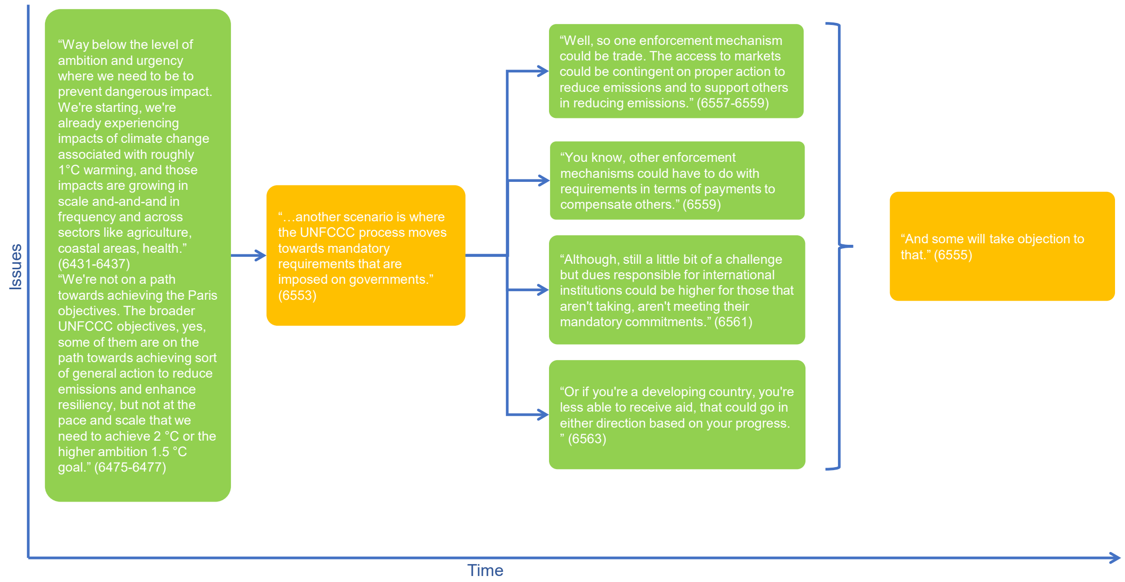
Complexity: Five steps, branching and merging, six layers with parallel conditions and assumptions.
Assumptions:
Issues and options: Insecurity
Actors and interests:
Response: Migration, conflict, fragmentation, migration, health, ecosystem impacts, insecurity, conflict, economic impact
Outcome: Failure, geopolitical conflict, refugees, poverty, impacts on health, impacts on ecosystems, small countries impacted
Notes: Low ambition, inadequate response
Code: Failure, failure of international cooperation on climate change

Respondent 18 – Failure scenario



Complexity: Three steps linear, one layer.
Assumptions:
Issues and options:
Actors and interests:
Response: Withdrawal, regional cooperation, regional emissions trading blocks
Outcome: Failure
Notes:
Code: Failure, withdrawal

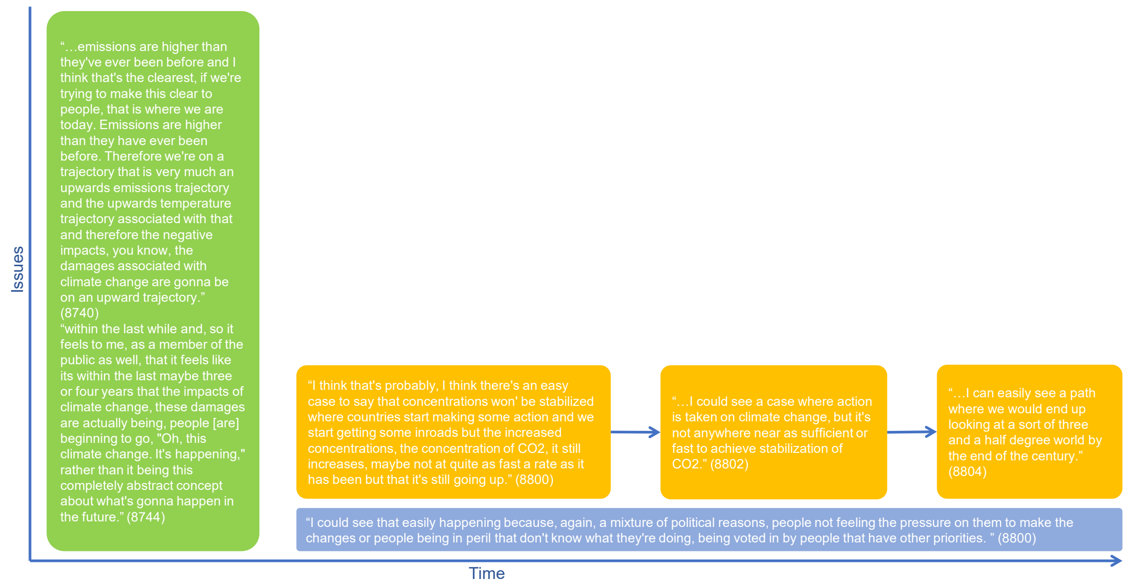
Respondent 18 – Failure scenario



Complexity: Four steps, branching and merging, four layers including options
Assumptions:
Issues and options:
Actors and interests:
Response: Withdrawal, stringent enforced agreement, penalties and sanctions
Outcome: Failure
Notes:
Code: Failure, withdrawal

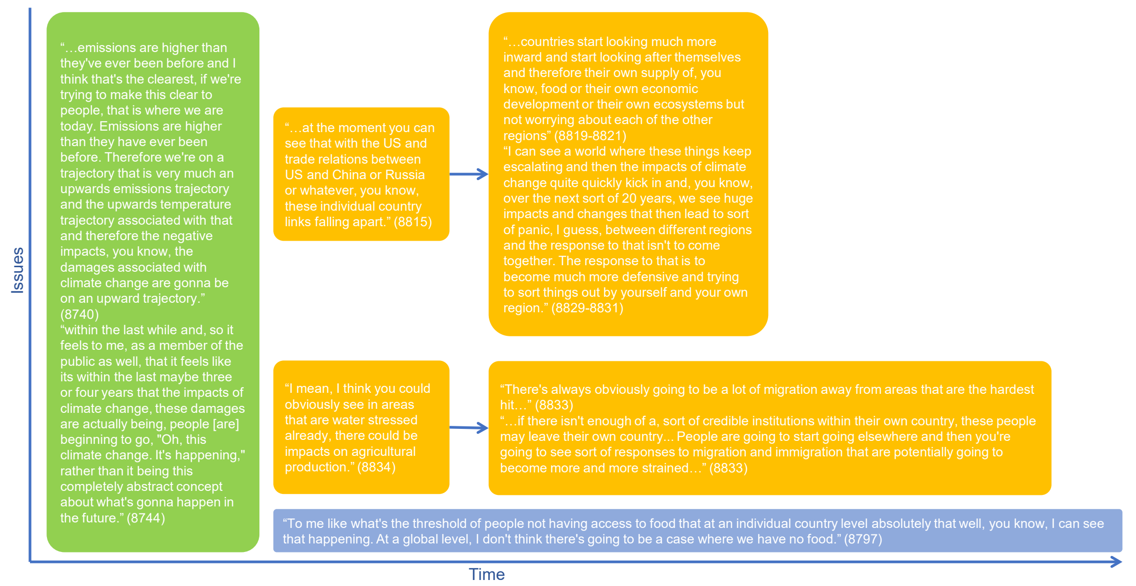
Failure scenarios

Respondent 21 – Failure scenario



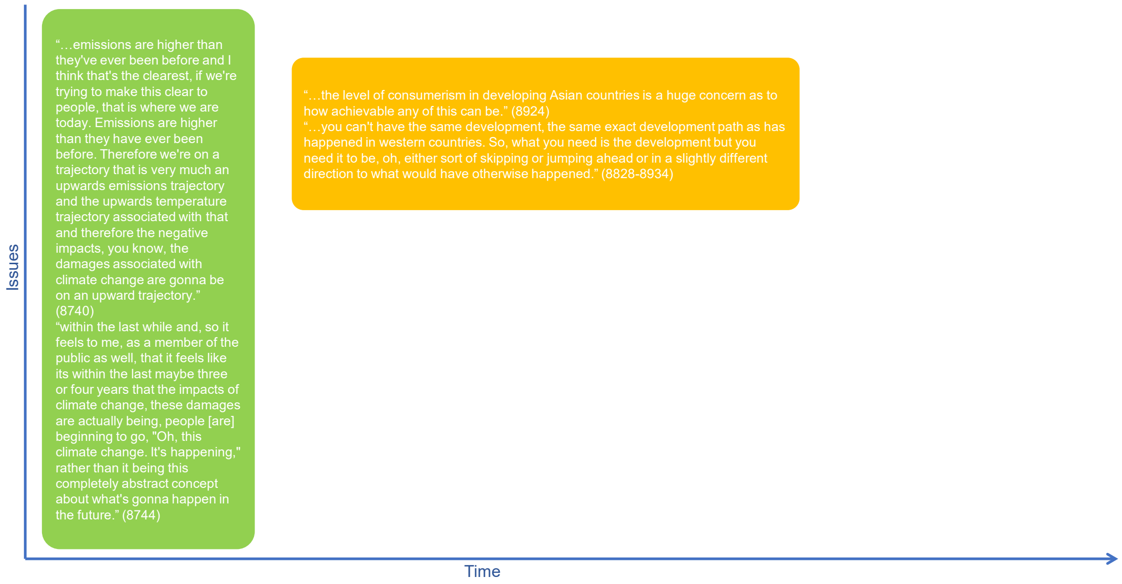
Complexity: Thee steps linear, two layers including assumptions
Assumptions:
Issues and options: CO2 continuing to increase
Actors and interests:
Response: Failure of international cooperation on climate change, political will and policy
Outcome: Failure
Notes: 3.5 degrees of global warming
Code: Failure, failure of international cooperation on climate change

Respondent 21 – Failure scenario



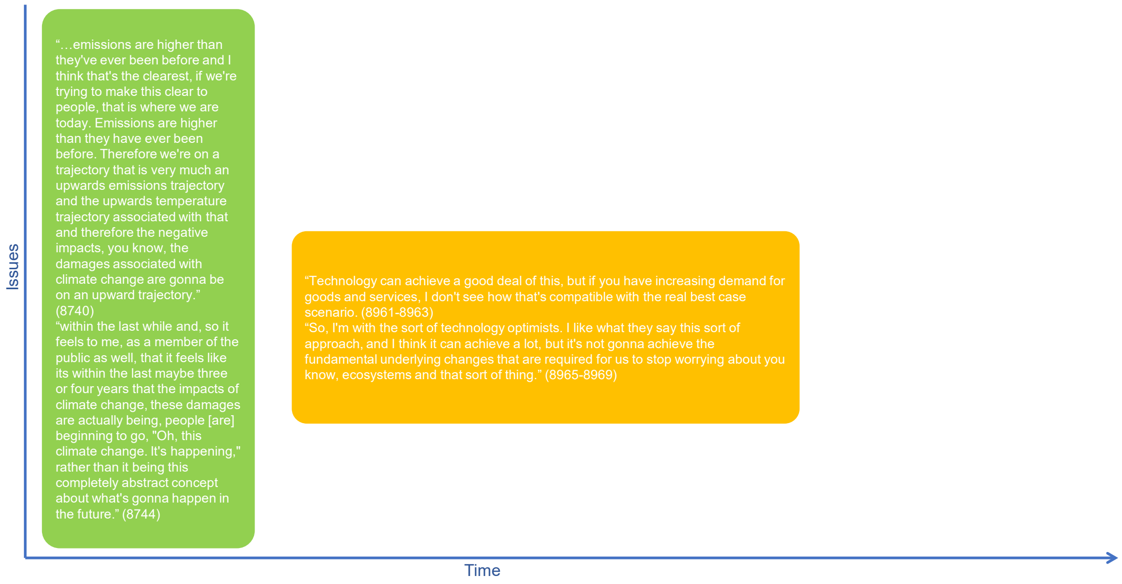
Complexity: two steps linear, three layers including assumptions
Assumptions:
Issues and options: Food production,
Actors and interests: National self interest
Response: defence, migration, fragmentation,
Outcome: Failure, migration from areas without food
Notes:
Code: Failure, defence, migration

Respondent 21 – Failure scenario



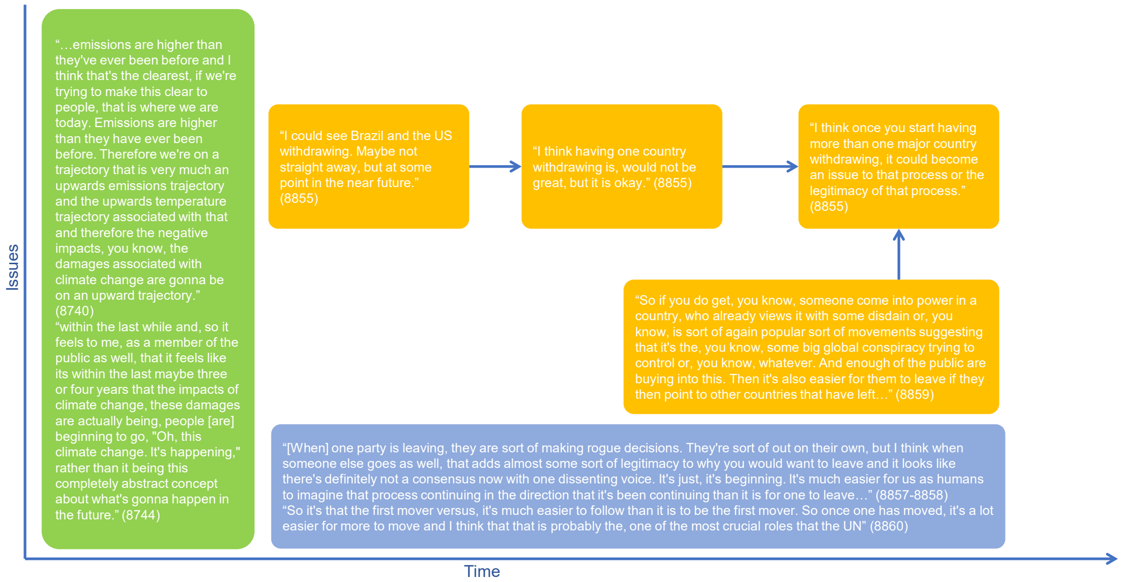
Complexity: One step, one layer
Assumptions:
Issues and options: Consumerism, development paths
Actors and interests:
Response: Over-consumption
Outcome: Failure,
Notes: Western development in the east
Code: Failure, over-consumption

Respondent 21 – Failure scenario



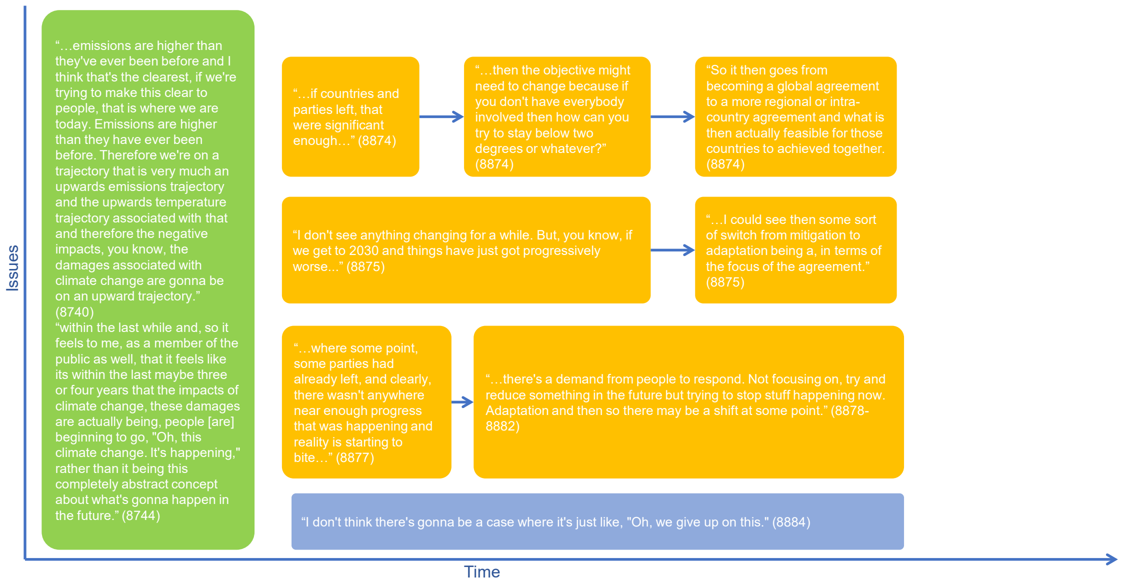
Complexity: One step, one layer
Assumptions:
Issues and options: Technology and consumption
Actors and interests:
Response: Over-consumption
Outcome: Failure
Notes:
Code: Over-consumption

Respondent 21 – Failure scenario



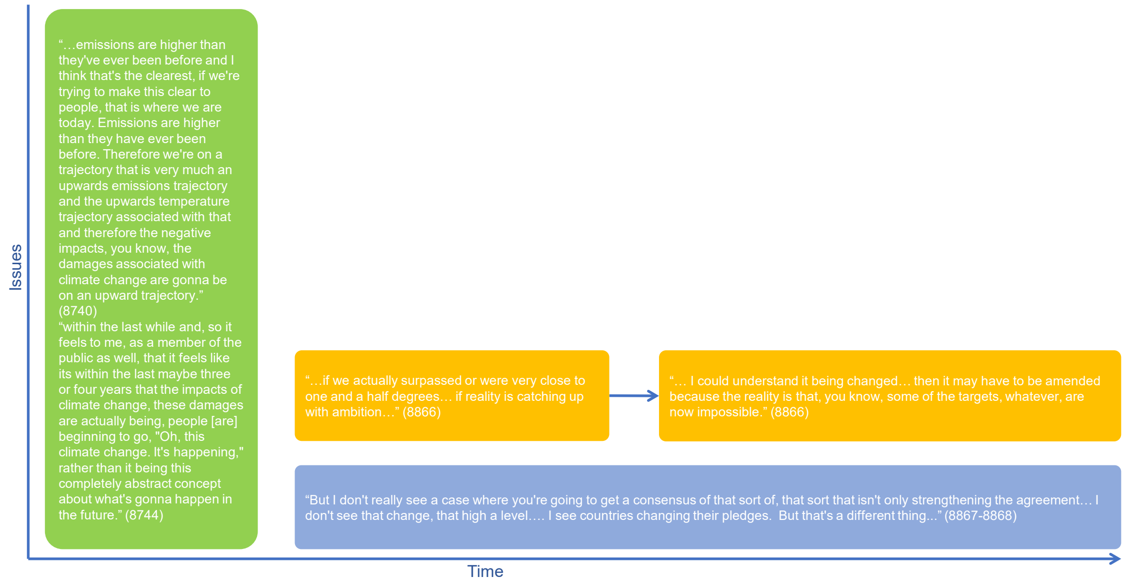
Complexity: three steps merging, three layers with assumptions.
Assumptions:
Issues and options:
Actors and interests:
Response: Withdrawal, populist driven, cascading withdrawals,
Outcome: Failure
Notes:
Code: Failure, withdrawal

Respondent 21 – Failure scenario



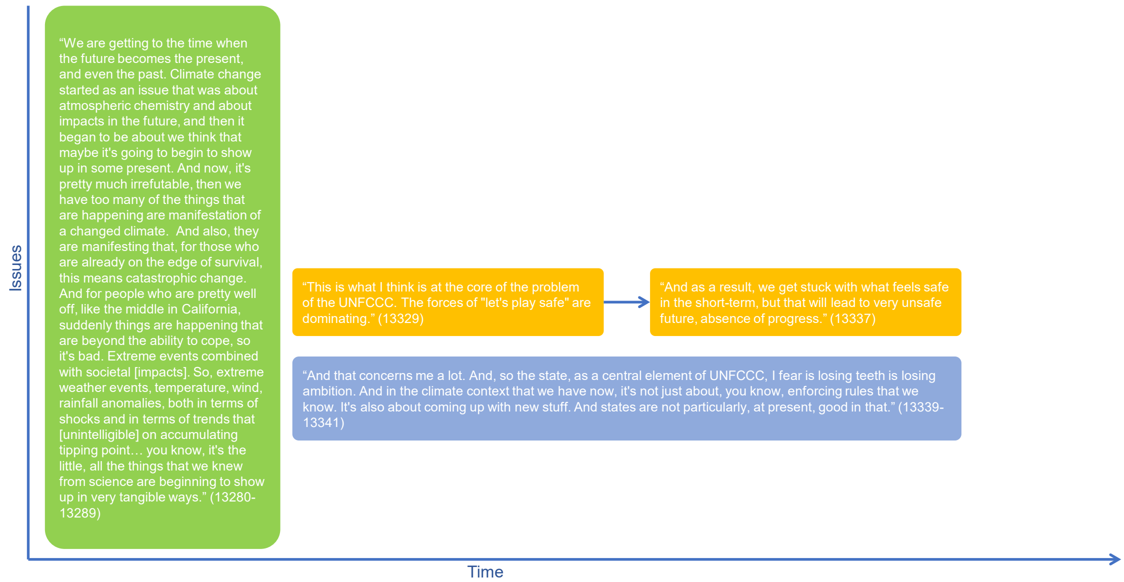
Complexity: Three steps, four layers, including assumptions
Assumptions:
Issues and options: A lack of progress
Actors and interests: Other parties have left,
Response: Cascading withdrawal
Outcome: Failure
Notes:
Codes: Failure, withdrawal

Respondent 21 – Failure scenario



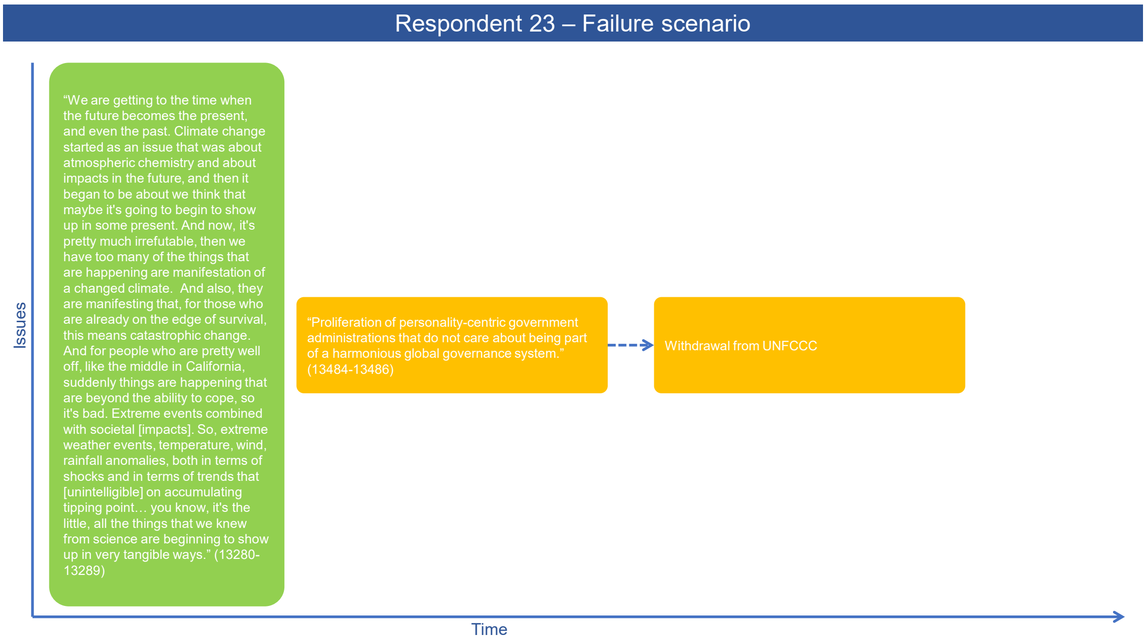
Complexity: Two steps, two layers including assumptions
Assumptions:
Issues and options: 1.5 degrees of global warming happened
Actors and interests:
Response: Paris Agreement amended
Outcome: Failure
Notes:
Code: Failure, amend

Respondent 23 – Failure scenario

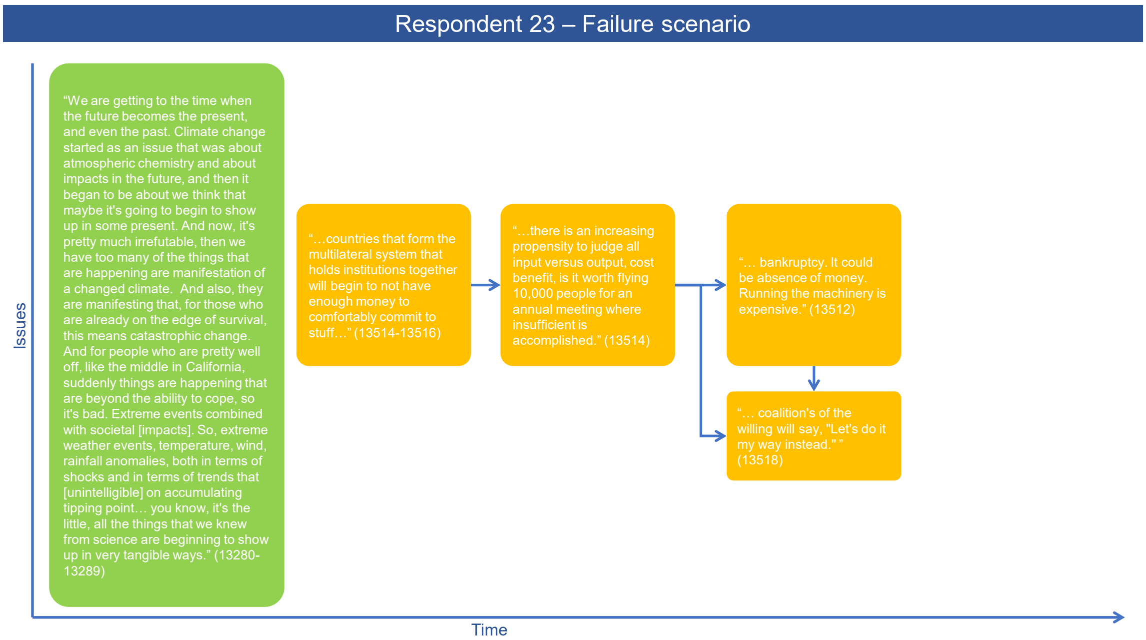


Complexity: Two steps linear, two layers with assumptions.
Assumptions:
Issues and options:
Actors and interests:
Response: Failure of international cooperation on climate change
Outcome: Failure
Notes:
Code: Failure, failure of international cooperation on climate change

Failure scenarios

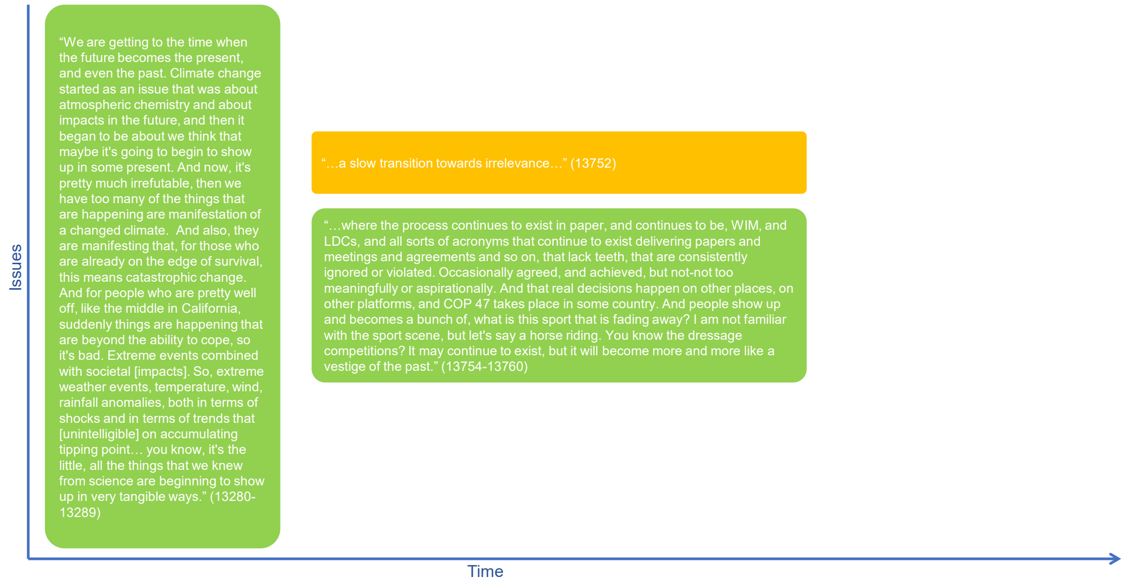


Complexity: Two steps linear, one layer
Assumptions:
Issues and options:
Actors and interests: Dictatorial politics
Response: Withdrawal
Outcome: Failure
Notes:
Code: Failure, withdrawal



Complexity: Three steps branching, two layers with interrelations.
Assumptions:
Issues and options:
Actors and interests:
Response: Withdrawal, UNFCCC defunded, fragmented responses, coalitions of the willing
Outcome: Failure
Notes:
Code: Failure, withdrawal

Respondent 23 – Failure scenario



Complexity: One step, two layers including parallel conditions
Assumptions:
Issues and options:
Actors and interests: States, UNFCCC
Response: Failure of international cooperation on climate change
Outcome: Failure
Notes: Muddling along, UNFCCC slowly becomes irrelevant: UNFCCC becomes a vestige of the past. Institutional and objective failure
Code: Failure, failure of international cooperation on climate change

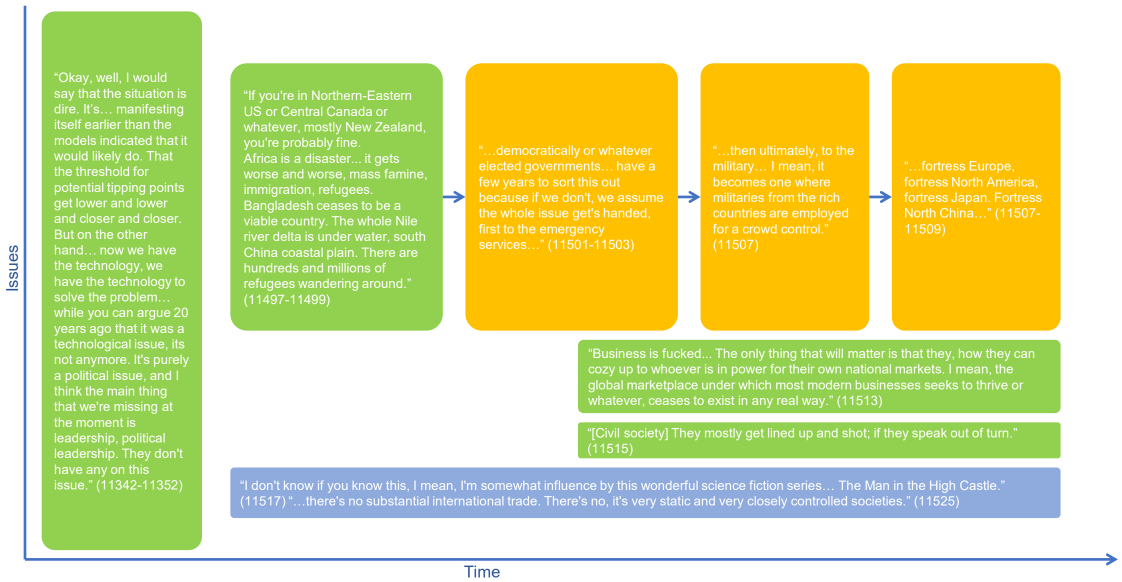
Respondent 24 – Failure scenario

Complexity: Four steps linear, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Impacts, fragmentation, adaptation, SRM, social unrest
Outcome: Failure
Notes:
Code: Failure, social unrest

Respondent 24 – Failure scenario

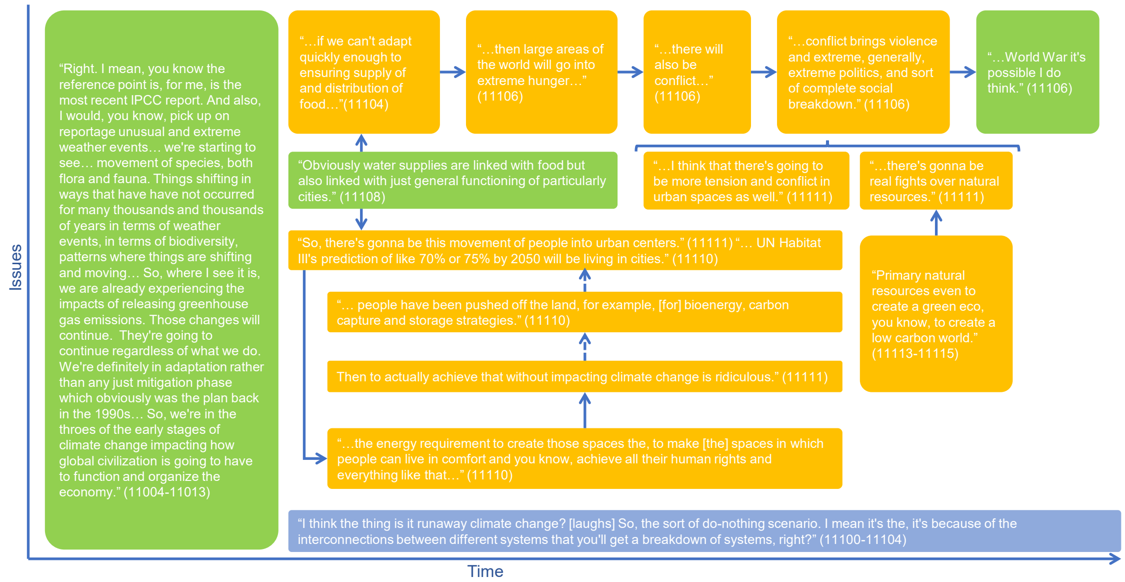
Complexity: Three steps, two layers, including assumptions
Assumptions:
Issues and options: Locked in climate change above safe limits, SRM
Actors and interests:
Response: Amend to allow SRM
Outcome: Failure,
Notes:
Code: Failure, amend

Respondent 25 – Failure scenario



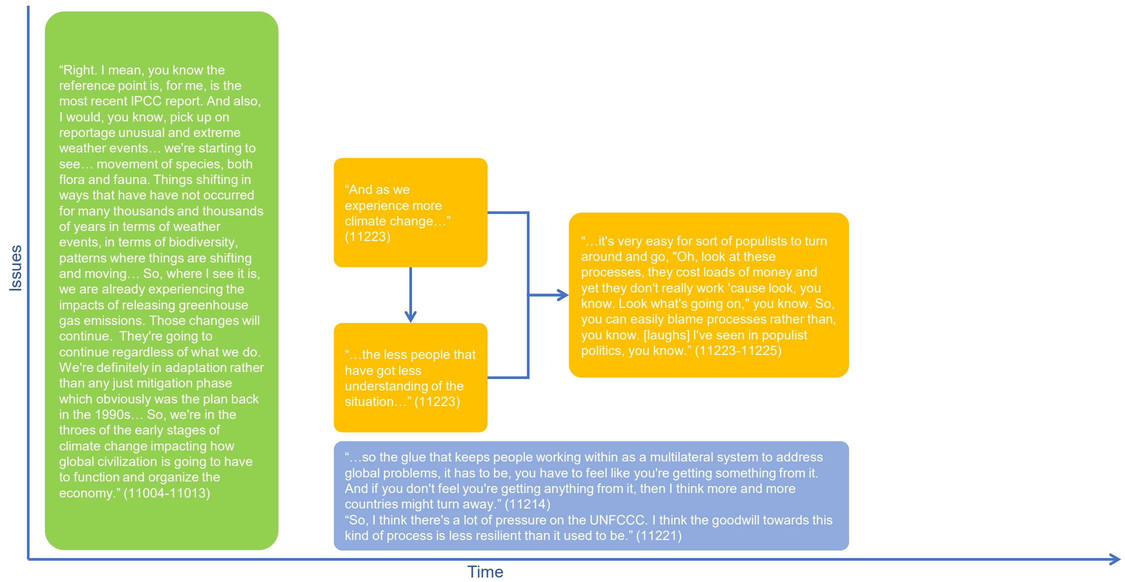
Complexity: Four steps linear, four layers with parallel conditions and assumptions
Assumptions:
Issues and options:
Actors and interests: Responsibility moves from civilian government to military. Africa, US, Canada, New Zealand, China
Response: Insecurity, defence
Outcome: Failure
Notes:
Code: Failure, defence, fragmentation

Respondent 26 – Failure scenario



Complexity: Five steps merging, seven layers interrelated including assumptions
Assumptions:
Issues and options: Food insecurity, hunger, GHG removals and land, resources, systemic risk
Actors and interests: GHG removals, land rights, urban versus rural interests
Response: Defence, conflict, negative impacts of climate action
Outcome: Failure
Notes:
Code: Failure, defence, extreme politics, conflict

Respondent 26 – Failure scenario

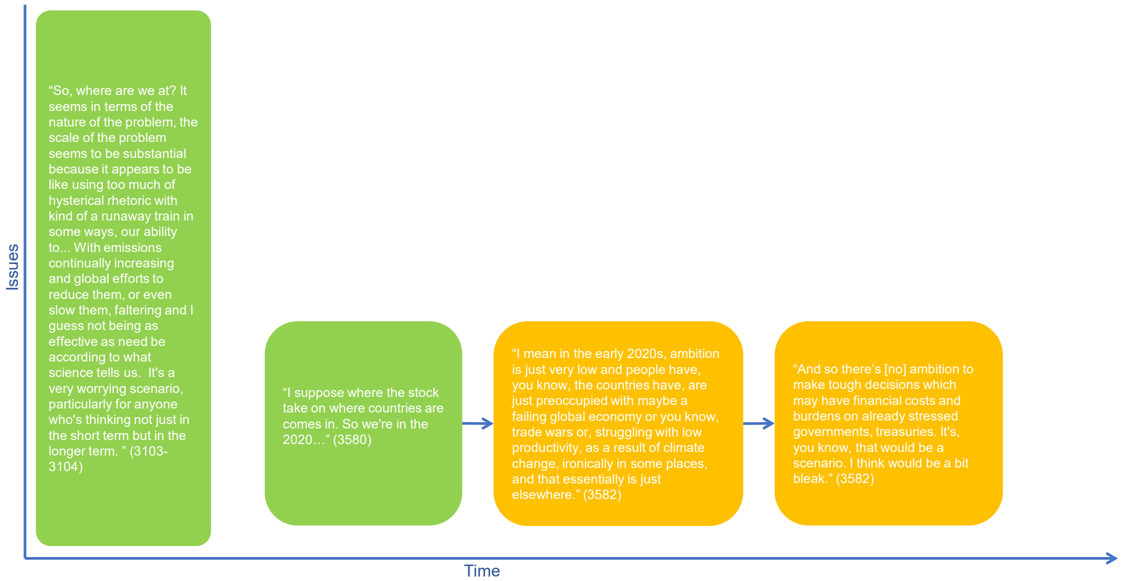


Complexity: Two steps merging, three layers including assumptions
Assumptions:
Issues and options: Ignorance on climate change, increased climate change impacts
Actors and interests: Populists blame the process and highlight that it has not worked
Response: Withdrawal
Outcome: Failure
Notes:
Code: Failure, withdrawal

Respondent 27 – Failure scenario

Complexity: Two steps linear, one layer
Assumptions:
Issues and options: Trade agreements
Actors and interests: States non-state actors want their own forums
Response: Fragmentation
Outcome: Failure
Notes: Regional forums, parallel responses
Code: Failure, fragmentation

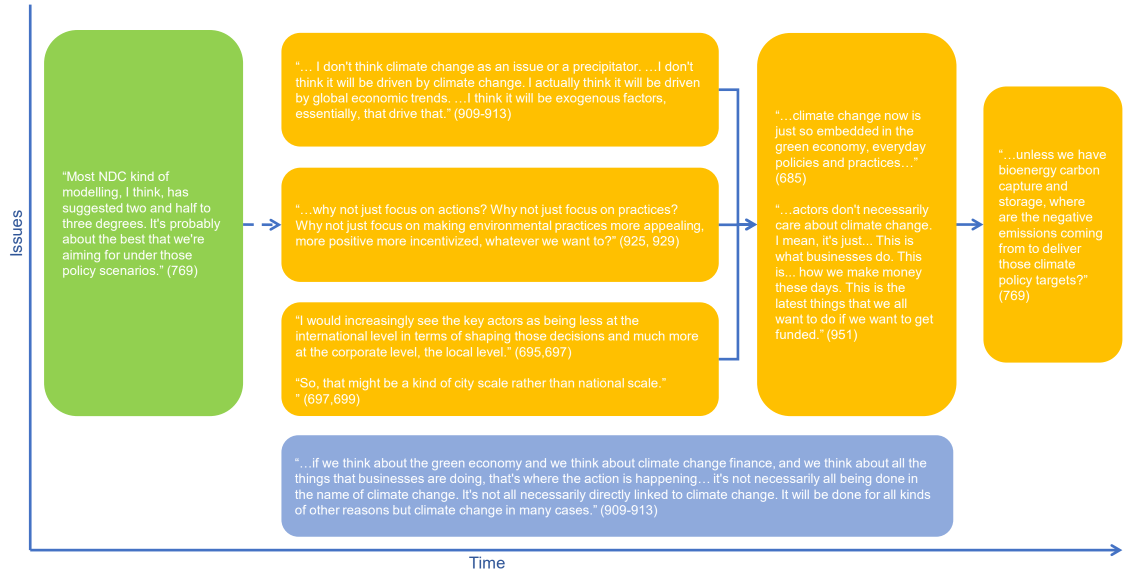
Respondent 27 – Failure scenario



Complexity: Three steps, one layer
Assumptions:
Issues and options: Trade and economic issues distract
Actors and interests: Cost avoidance
Response: Failure of international cooperation on climate change
Outcome: Failure
Notes: Low ambition, cost avoidance
Code: Failure, failure of international cooperation on climate change

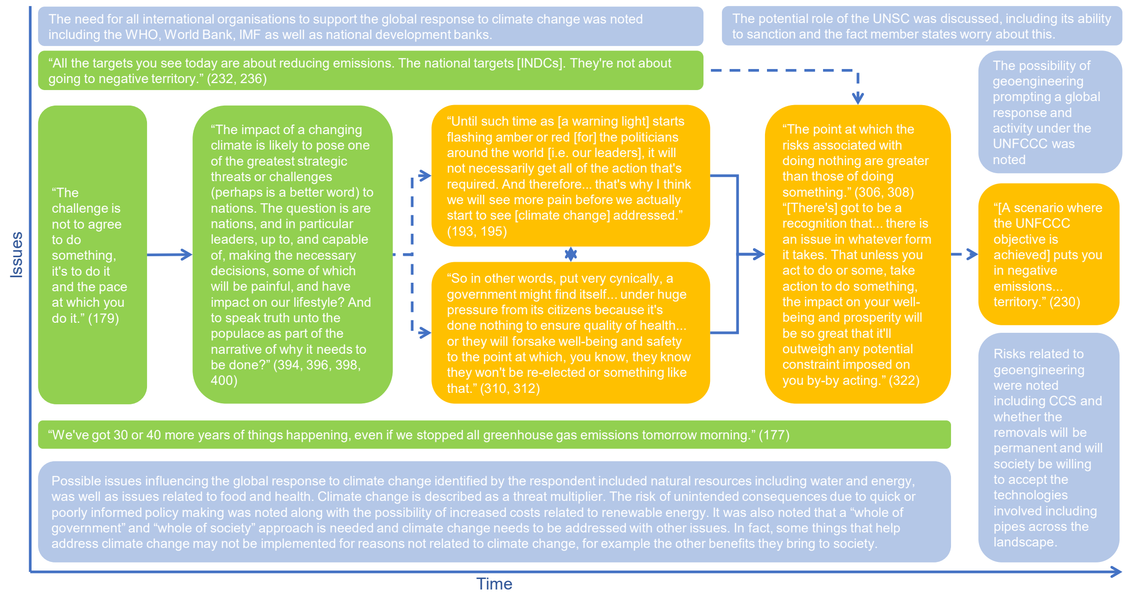
Appendix R: Success scenarios

Respondent 1 – Success scenario



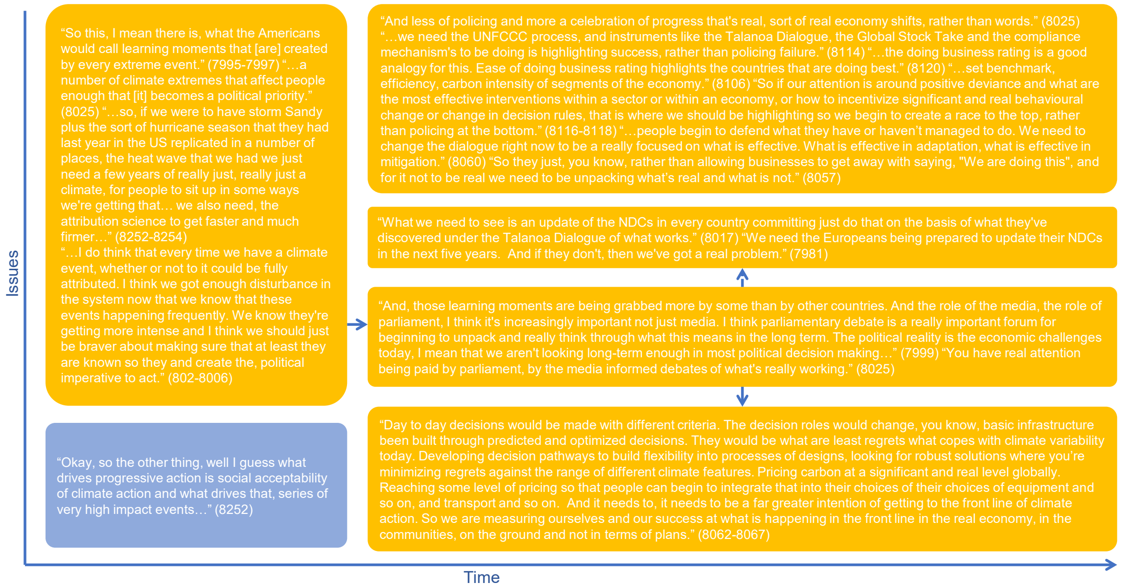
Complexity: Four steps merging, four layers with assumptions
Assumptions:
Issues and options:
Actors and interests: Business, local government,
Response: Business and economy, governance, GHG removals,
Outcome: Success
Notes: The respondent indicates that economic trends drives the global response, and while the respondent might not have used the term commercially driven, it is consistent with the expression
Code: Success, business and economic activity, commercial viability

Respondent 2 – Success scenario



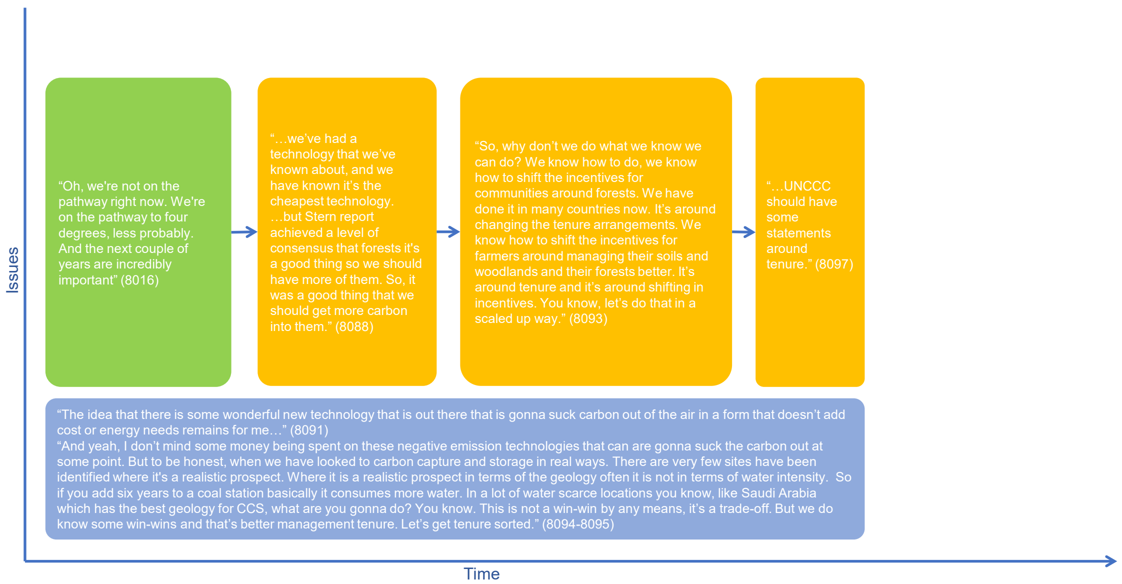
Complexity: Five steps, branching and merging, six layers with interrelations, with parallel conditions and assumptions
Assumptions:
Issues and options: Climate change challenge, health, wellbeing, prosperity, climate action, GHG removals
Actors and interests: Governments, society
Response: Impact response, political will and policy, GHG removals, security
Outcome: Success
Notes:
Code: Success, political will and policy

Respondent 3 – Success scenario



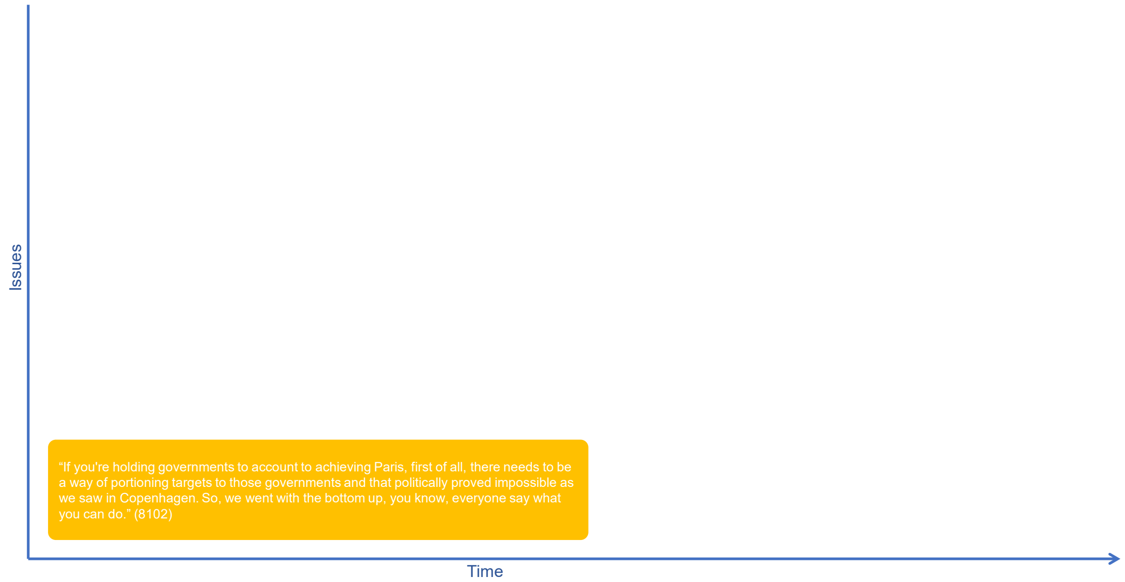
Complexity: Two steps, branching, four layers with parallel conditions and assumptions
Assumptions:
Issues and options: Climate change impacts
Actors and interests: States have a learning moment
Response: Impact response, international regime,
Outcome: Success,
Notes: Learning system, scaling up what works
Code: Success, international regime, impact response

Respondent 3 – Success scenario



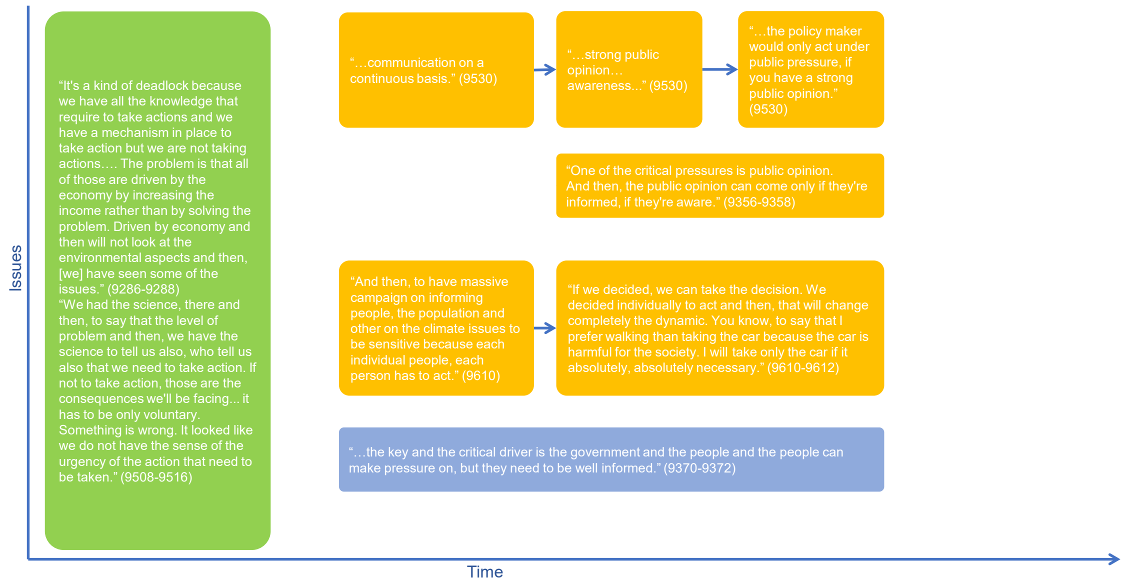
Complexity: Four steps, linear, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: GHG removals, natural removals
Outcome: Success
Notes:
Code: Success, removals

Respondent 3 – Success scenario



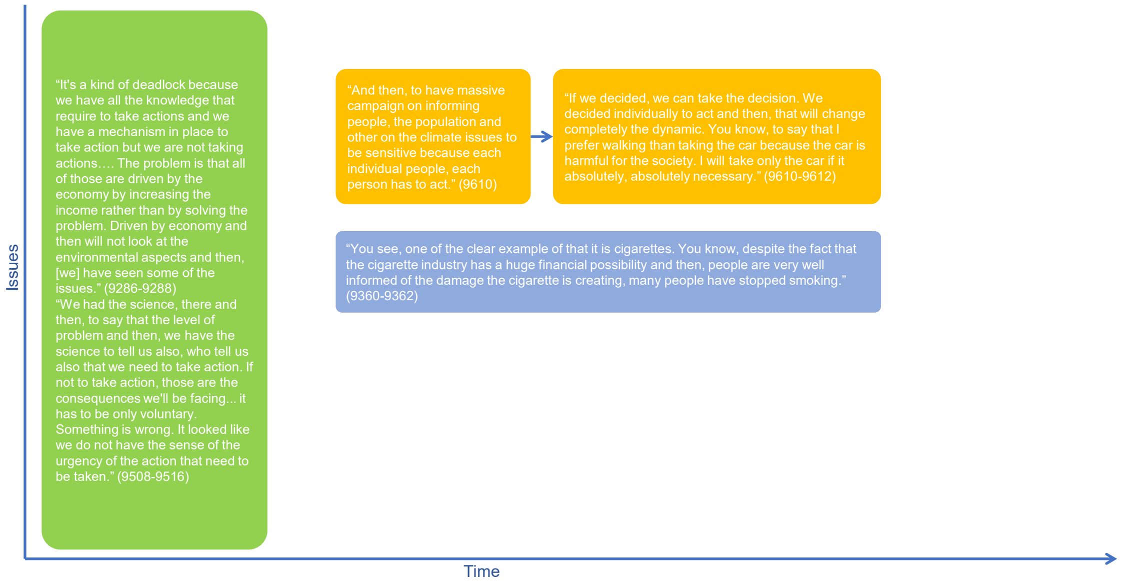
Complexity: One step, one layer.
Assumptions:
Issues and options:
Actors and interests:
Response: Stringent enforced agreement, budgets
Outcome: Success
Notes:
Code: Success, stringent enforced agreement

Respondent 5 – Success scenario



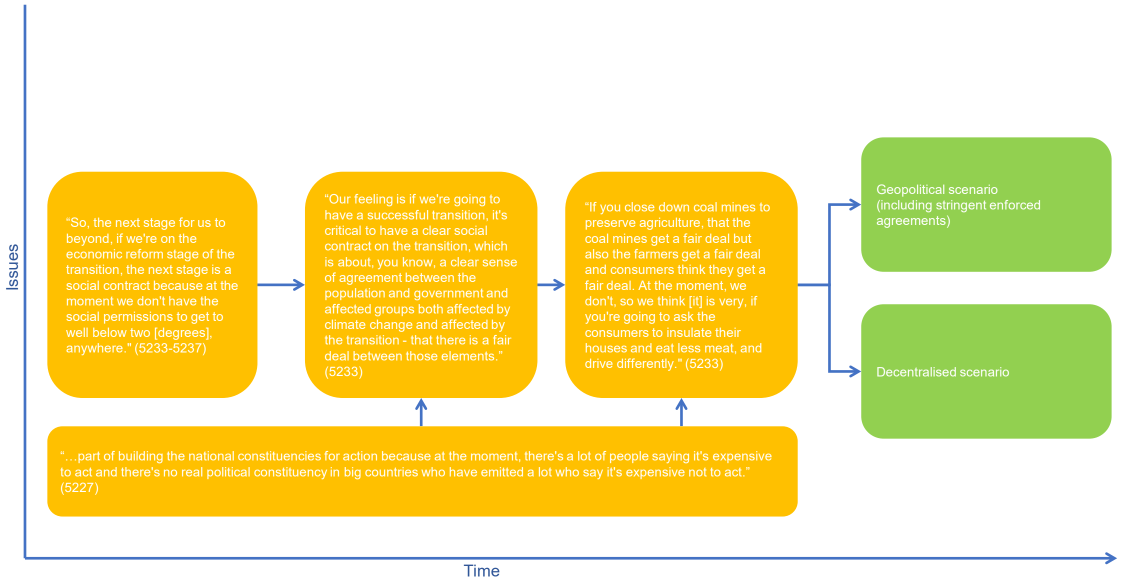
Complexity: Three steps, linear, four layers with parallel conditions and assumptions.
Assumptions:
Issues and options:
Actors and interests:
Response: Risk response, information, social change, behaviour, political will and policy,
Outcome: Success,
Notes:
Code: Success, social change, policy

Respondent 5 – Success scenario



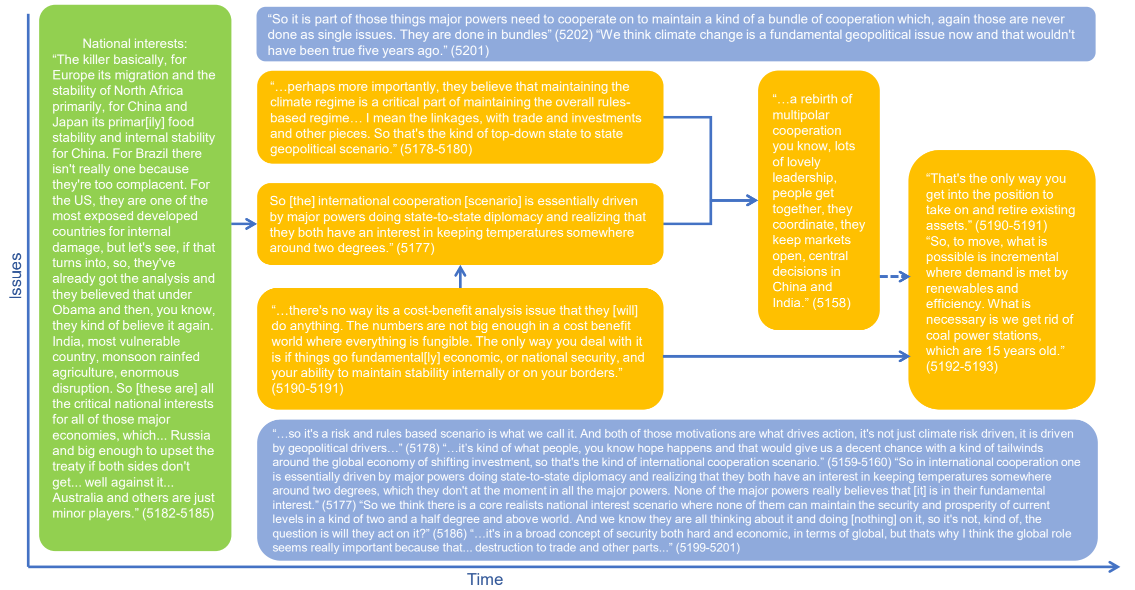
Complexity: Two steps linear, two layers with assumptions.
Assumptions:
Issues and options: Communication like with cigarettes.
Actors and interests:
Response: information, social change
Outcome: Success,
Notes:
Code: Success, social change

Respondent 6 – Success scenario



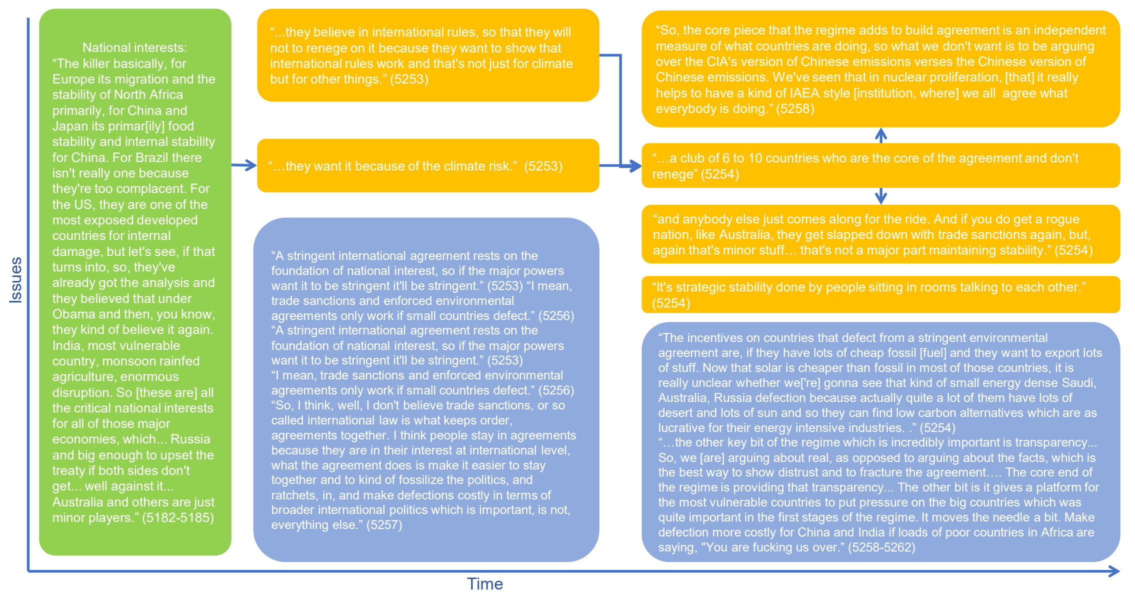
Complexity: Four steps, branching and merging, three layers with interrelations.
Assumptions:
Issues and options: Fairness
Actors and interests: Affected groups, farmers,
Response: Social change, political will and policy
Outcome: Success,
Notes: Subnational coalitions, social contract, compensation
Code: Success, social change, social contract

Respondent 6 – Success scenario



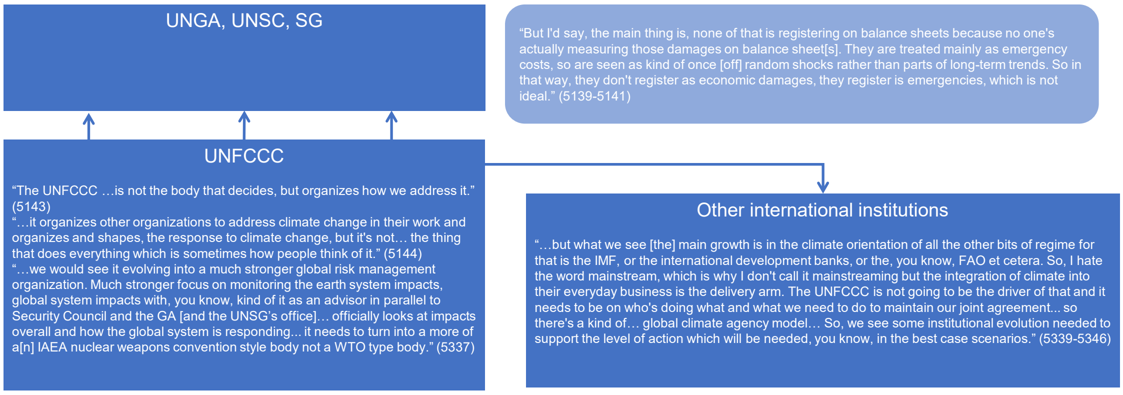
Complexity: Four step multiple merging points, five layers, interrelations, with assumptions
Assumptions:
Issues and options: International cooperation as well as energy sources and capital, including early retirement of coal fired power plants
Actors and interests: Major geopolitical powers looking after wider security interests.
Response: risk response, international cooperation, technology,
Outcome: Success
Notes: Renewable energy, early retirement of coal fired power plants
Code: International cooperation

Respondent 6 – Success scenario



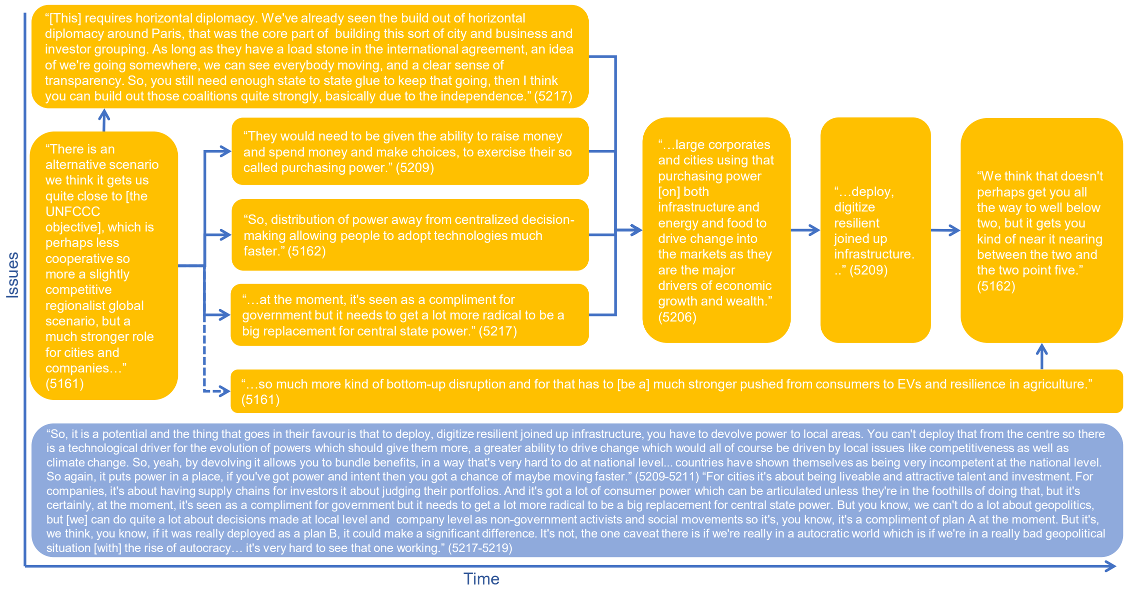
Complexity: Three steps, branching and merging, five layers with parallel conditions and assumptions.
Assumptions:
Issues and options: International cooperation
Actors and interests: Australia, China, India, large powers
Response: Risk response, stringent enforced agreement, international cooperation, geopolitical power, information
Outcome: Success
Notes:
Code: Success, international cooperation, risk response

Respondent 6 – Success scenario (organogram)



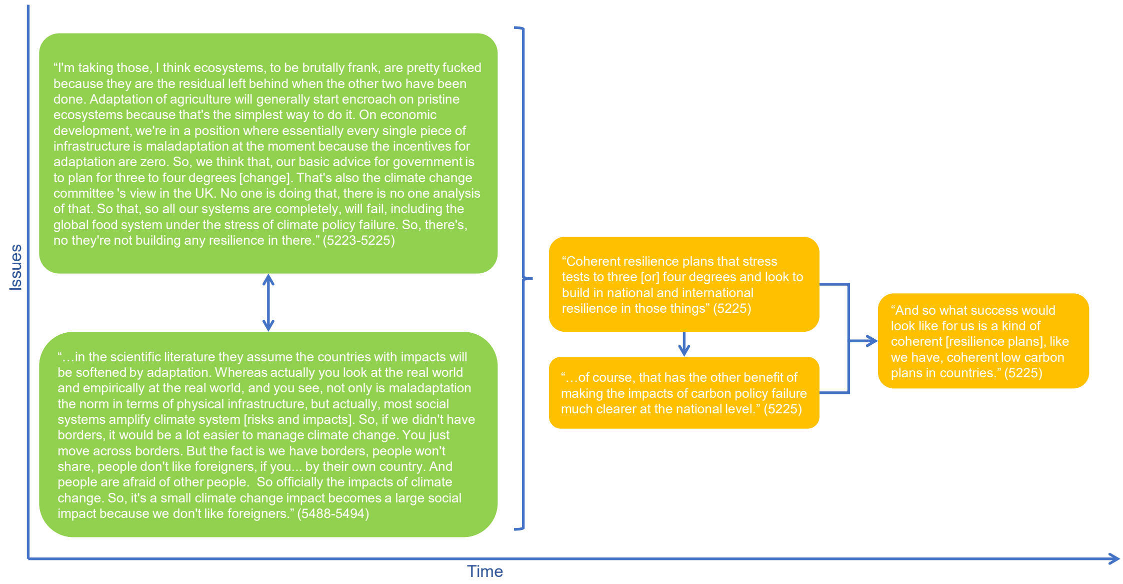
Complexity: Organogram
Assumptions:
Issues and options: How to organise the international regime supporting the global response to climate change.
Actors and interests: UNSC, UNGA, UNFCCC, IMF, FAO, MDBs
Response: international regime,
Outcome: Success
Notes:
Code: Success, international cooperation

Respondent 6 – Success scenario



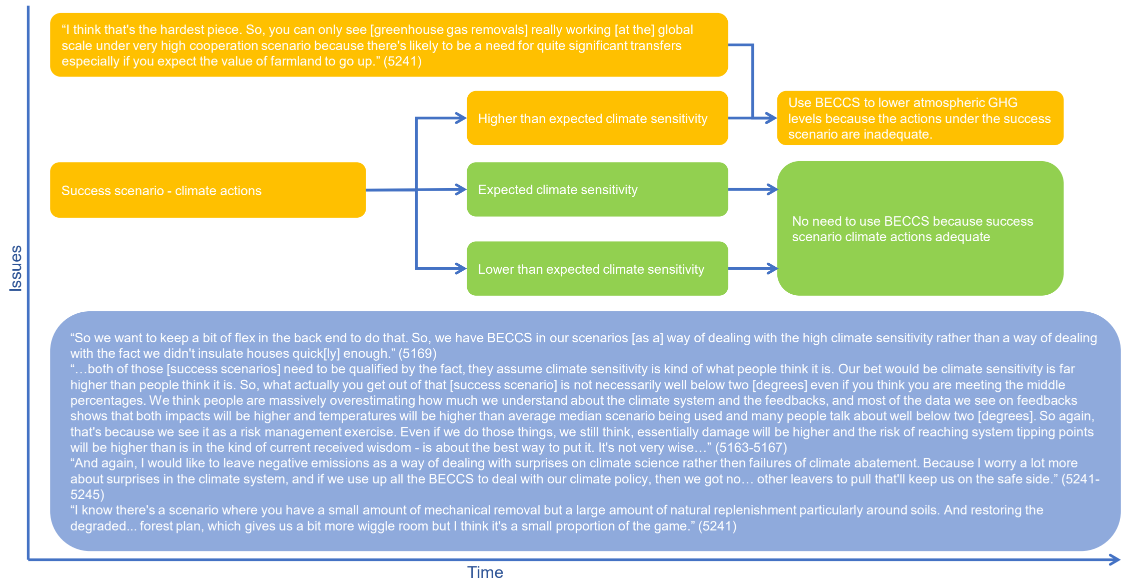
Complexity: Five steps, branching and merging, six layers with interrelations and assumptions.
Assumptions:
Issues and options: Governance and the roles of local government and business in society
Actors and interests: Local government, business
Response: Coupled business and local government, business and economy, social change,
Outcome: Success
Notes:
Code: Success, localisation, policy and business

Respondent 6 – Success scenario



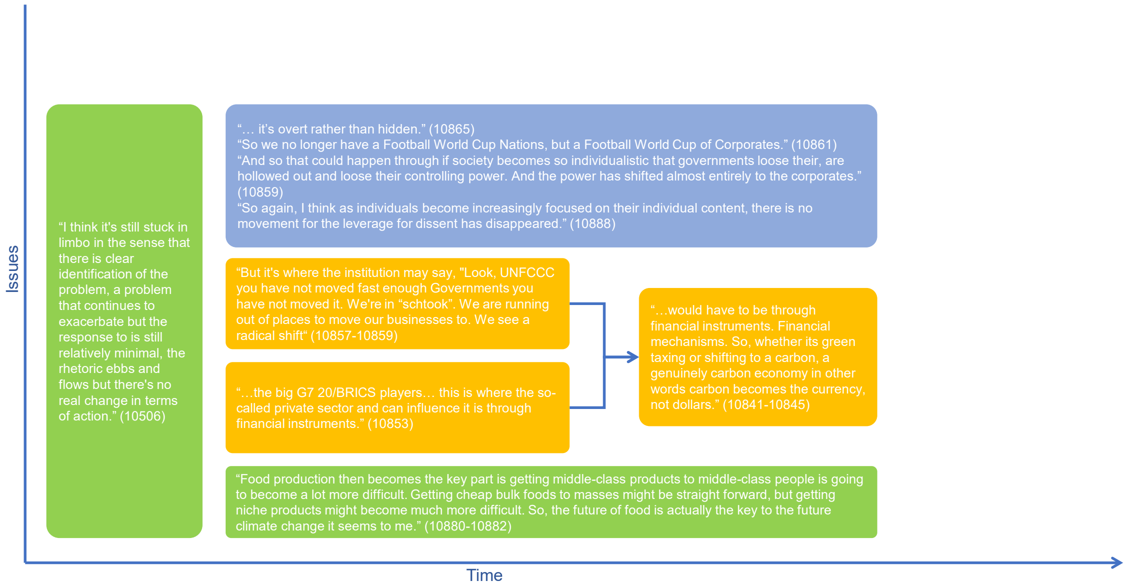
Complexity: Three steps, merging, two layers with interrelations
Assumptions:
Issues and options: Climate resilience plans, low carbon development plans
Actors and interests: Governments
Response: Political will and policy
Outcome: Success
Notes:
Code: Success, policy

Respondent 6 – Success scenario



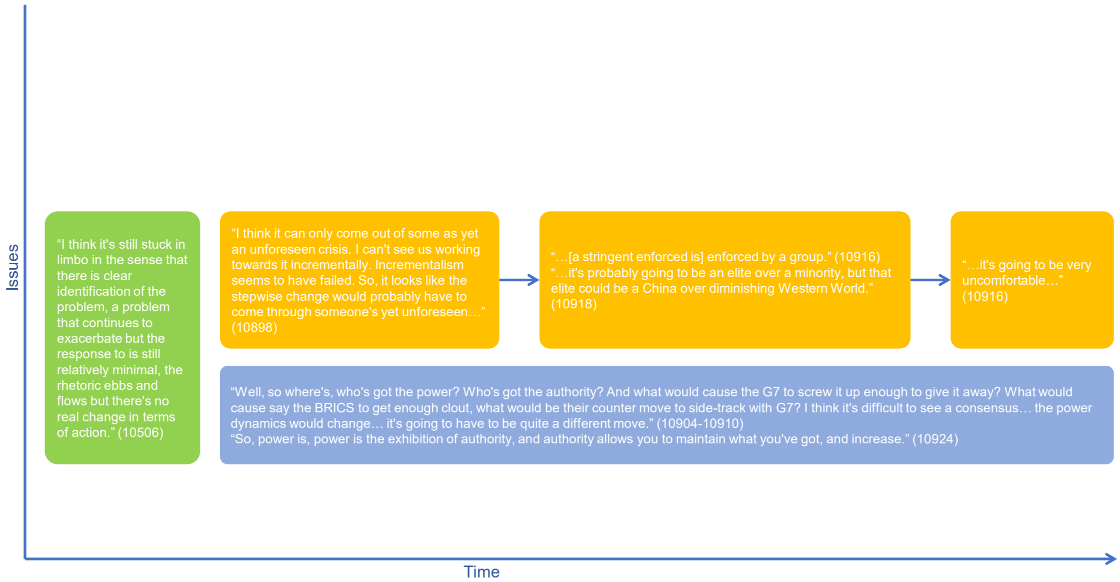
Complexity: Three steps, branched and merging, five layers with assumptions
Assumptions:
Issues and options: Backup (in case of higher climate sensitivity)
Actors and interests:
Response: GHG removals, technology
Outcome: Success
Notes: BECCS
Code: Success, removals, technology

Respondent 7 – Success scenario



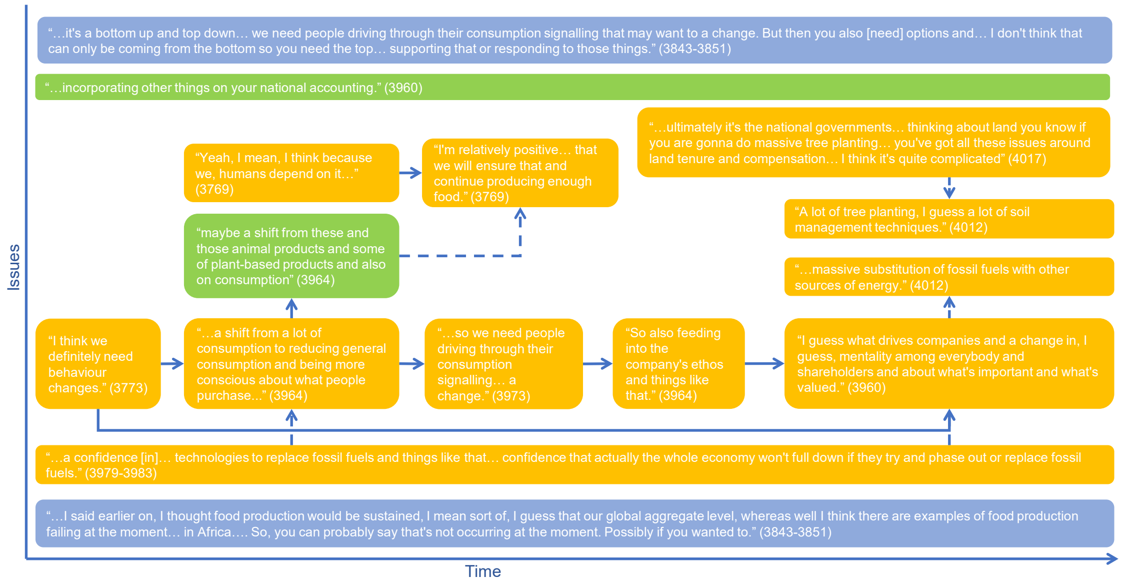
Complexity: Two steps, merging, four layers with parallel conditions and assumptions
Assumptions:
Issues and options: Finance, carbon tax
Actors and interests:
Response: Business and economy, geopolitical power
Outcome: Success
Notes:
Code: Success, business and economic activity, carbon price, finance

Respondent 7 – Success scenario



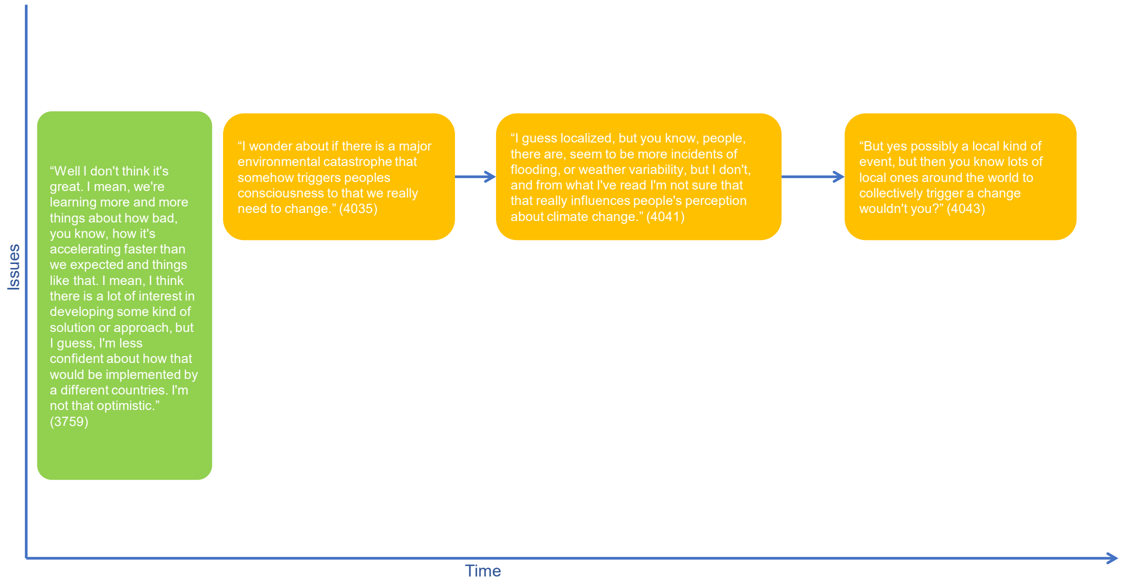
Complexity: Three steps, linear, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests: BRICS
Response: Risk response, stringent enforced agreement
Outcome: Success
Notes:
Code: Success, stringent enforced agreement, risk response

Respondent 8 – Success scenario



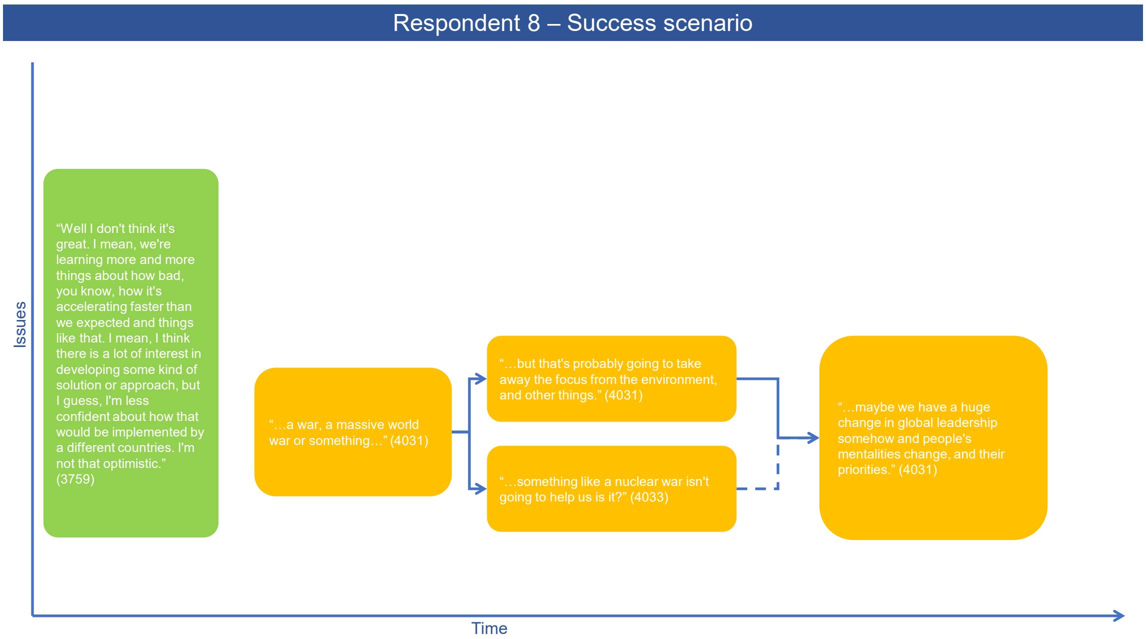
Complexity: Five steps, merging, eight layers with interrelations, parallel conditions and assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Behaviour, technology, business and economy, political will and policies
Outcome: Success
Notes: Consumption changes, belief, substitution of animal protein, ecological restoration, clean energy
Code: Success, social change

Respondent 8 – Success scenario

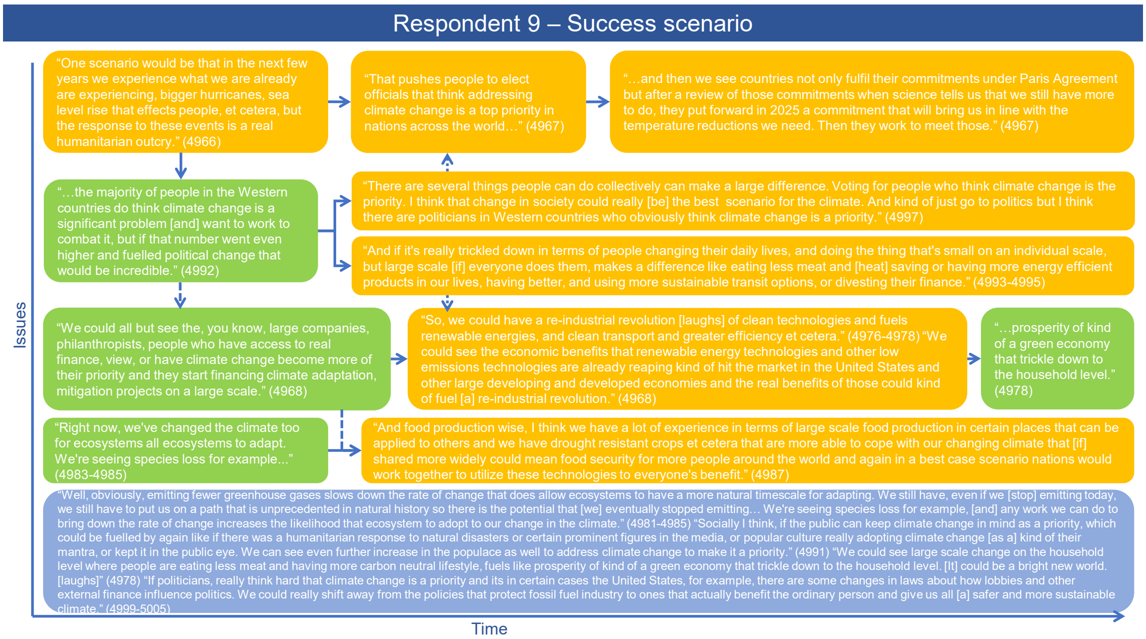


Complexity: Three steps linear, one layer
Assumptions:
Issues and options:
Actors and interests:
Response: Impact response
Outcome: Success
Notes:
Code: Success, impact response

Success scenarios

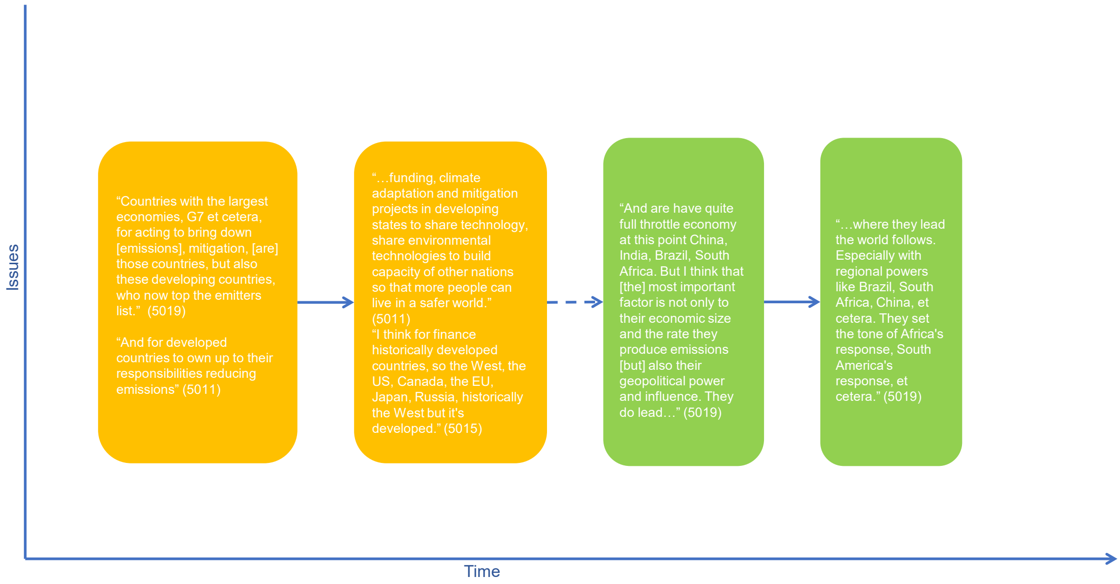


Complexity: Three steps, two layers
Assumptions:
Issues and options: War or some other calamity affecting humanity
Actors and interests: Humanity
Response: Enlightenment
Outcome: Success
Notes:
Code: Success, enlightenment, impact response



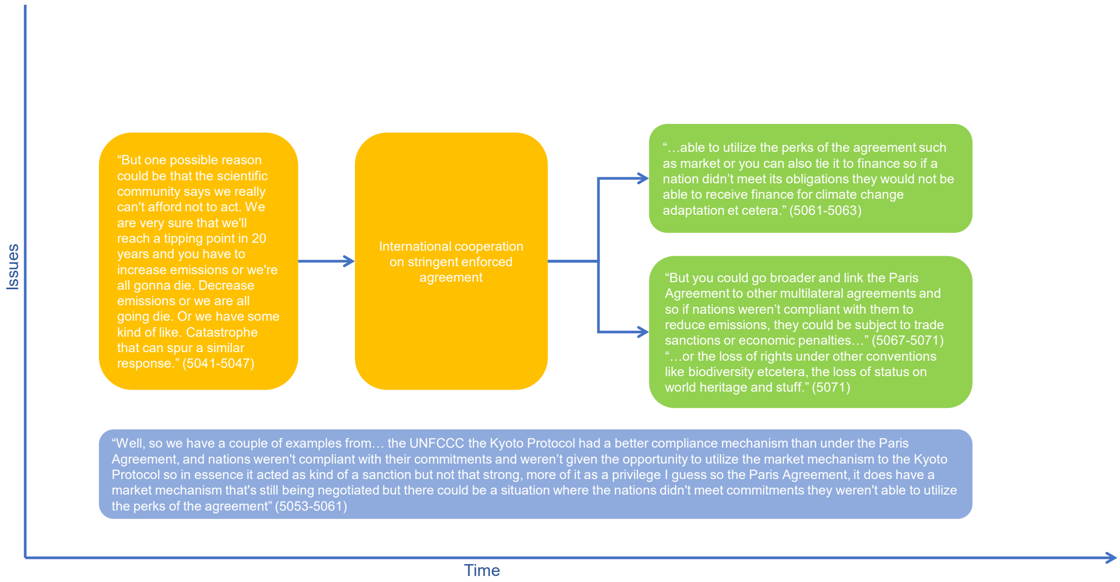
Complexity: Three steps, branching, six layers with interrelations and assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: impact response, social change, technology, behaviour, political will and policy, business and economy, re-industrial revolution
Outcome: Success
Notes: Behaviours include energy efficiency, heat savings, eating less meat, voting for people that prioritise climate change, sustainable transport, divesting. Re-industrial revolution regards clean technologies and fuels, renewable energy, clean transport, energy efficiency
Code: Success, social change, impact response

Respondent 9 – Success scenario



Complexity: Four steps, linear, one layer
Assumptions:
Issues and options:
Actors and interests: Large geopolitical powers and influencers, developed countries, developing countries, China, India, Brazil, South Africa, G7
Response: international cooperation, geopolitical power, business and economy, technology, security
Outcome: Success
Notes: Finance, adaptation, mitigation, technology transfer, capacity development
Code: Success, international cooperation

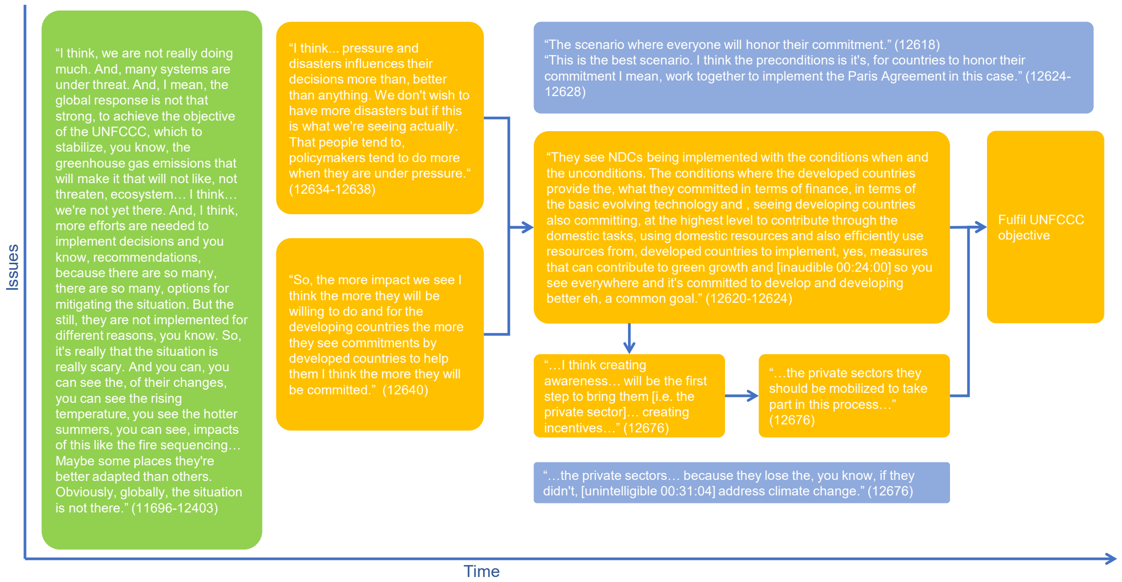
Respondent 9 – Success scenario



Complexity: Three steps, branching, three layers with options and assumptions.
Assumptions:
Issues and options:
Actors and interests:
Response: Risk response, stringent enforced agreement, penalties and sanctions
Outcome: Success
Notes:
Code: Success, stringent enforced agreement, risk response

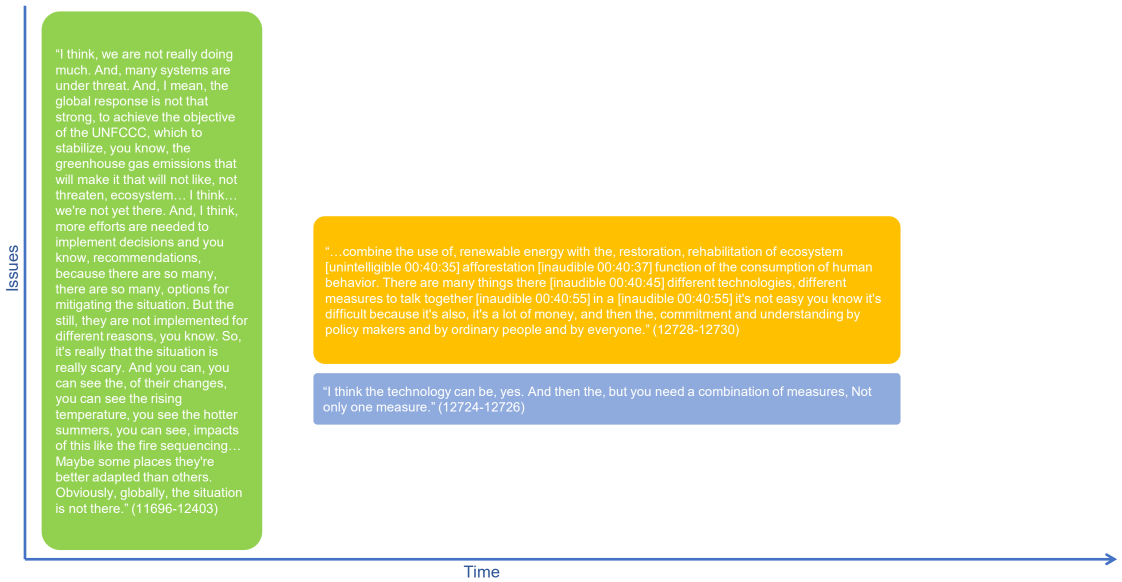
Success scenarios

Respondent 10 – Success scenario



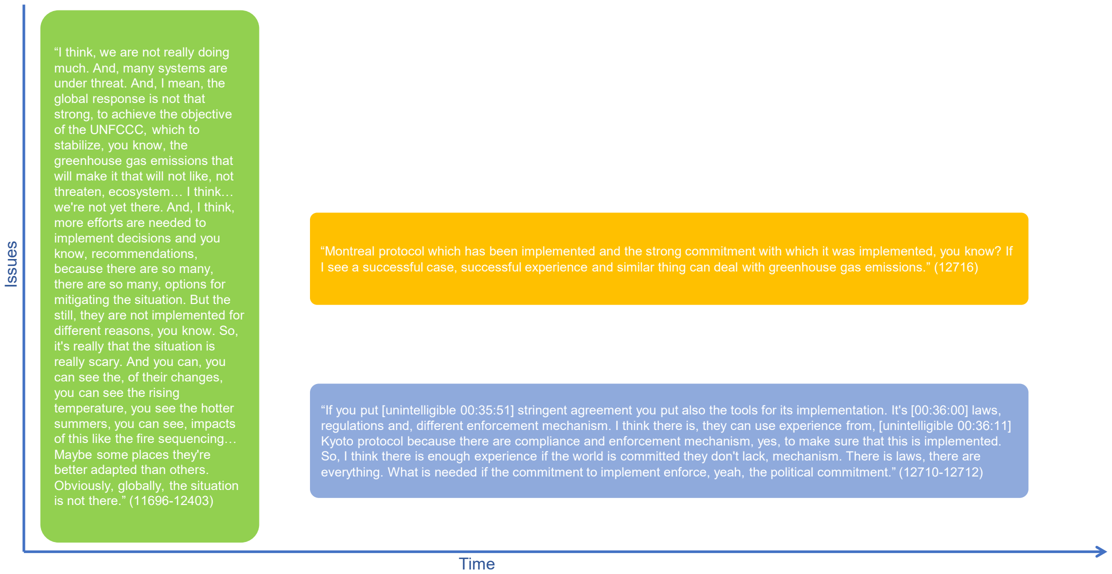
Complexity: Four steps, branched and merging, four layers with assumptions
Assumptions:
Issues and options: Climate finance, support for NDCs
Actors and interests: Developing countries and condition NDCs
Response: Impact response, political will and policy
Outcome: Success
Notes:
Code: Success, political will and policy, ambition

Respondent 10 – Success scenario



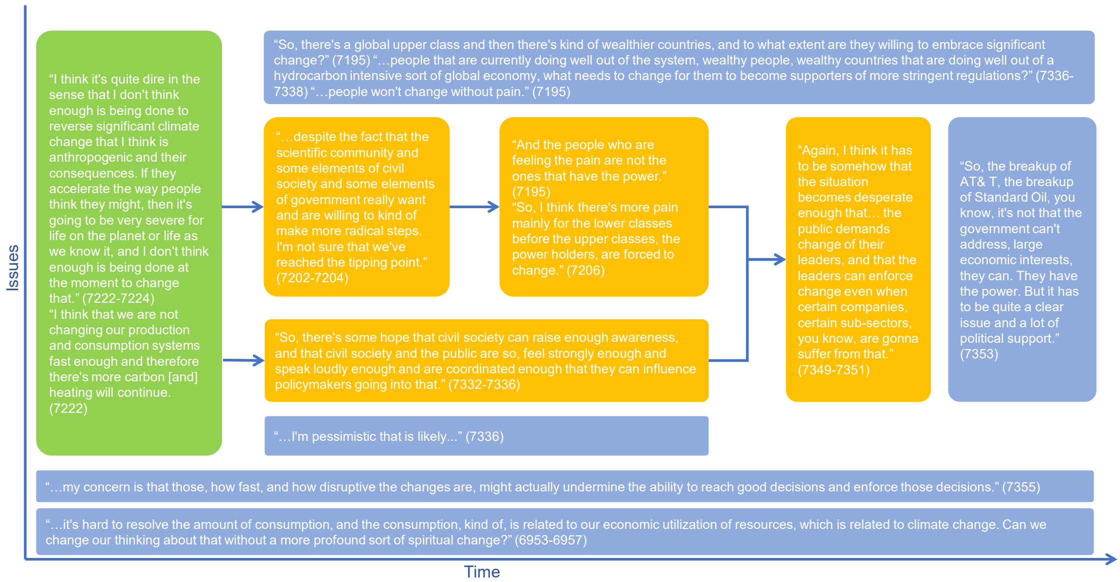
Complexity: One step, two layers with assumptions
Assumptions:
Issues and options: Ecosystems
Actors and interests:
Response: GHG removals, technology, behaviour, society change
Outcome: Success
Notes:
Code: Success, social change

Respondent 10 – Success scenario



Complexity: One step, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Stringent enforced agreement
Outcome: Success
Notes:
Code: Success, stringent enforced agreement

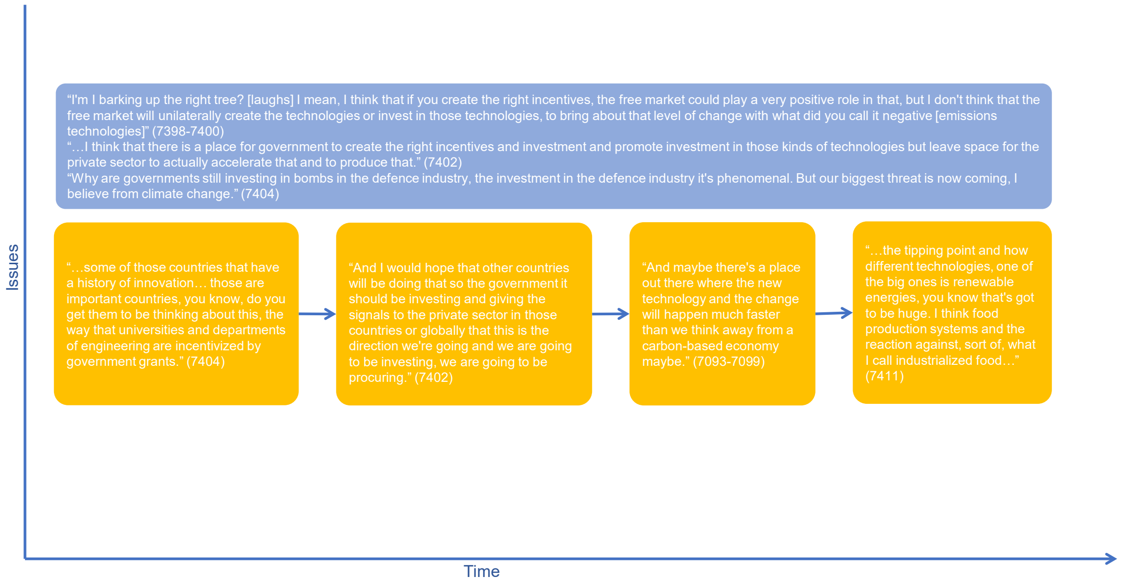
Respondent 11 – Success scenario



Complexity: Four steps, merging, six layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Impact response, social change, political will and policy
Outcome: Success
Notes: Activism, political change
Code: Success, social change, activism, impact response

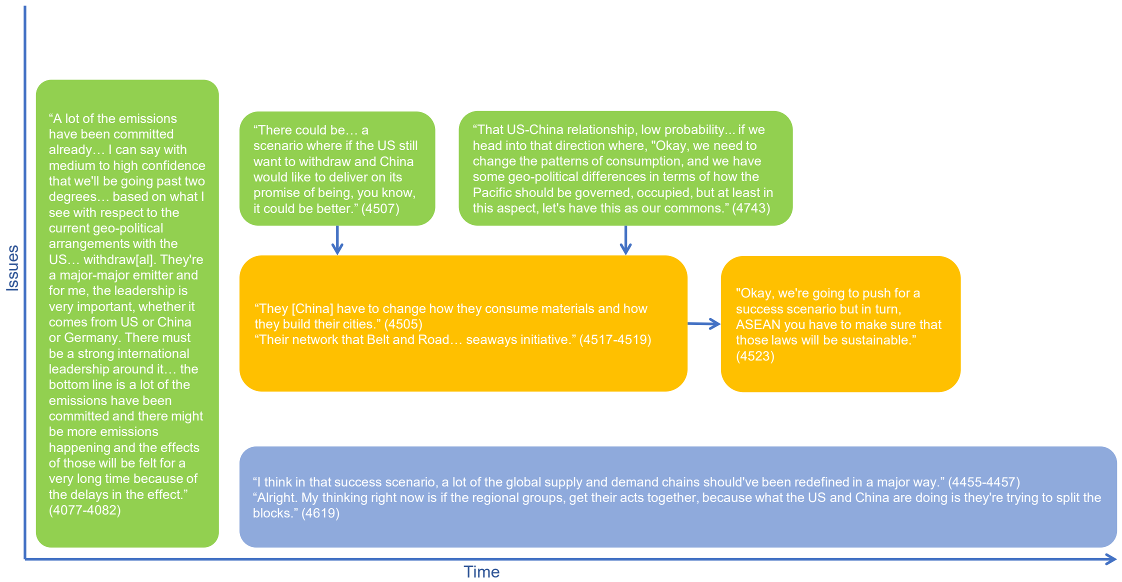
Success scenarios

Respondent 11 – Other scenario



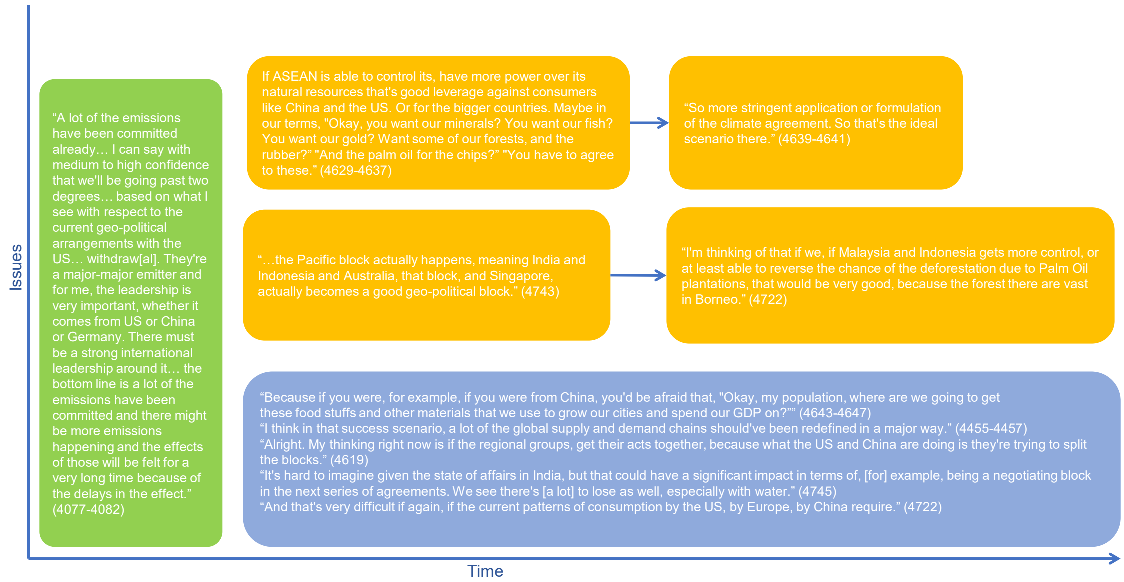
Complexity: Four steps linear, two layers including assumptions
Assumptions:
Issues and options: Investment signals, technological innovation
Actors and interests: Governments, businesses
Response: Political will and policy, technology, business and economy
Outcome: Other, success, technology tipping point (energy and food)
Notes: Technological research, development and investment
Coding: Success, political will and policy, technology

Respondent 12 – Success scenario



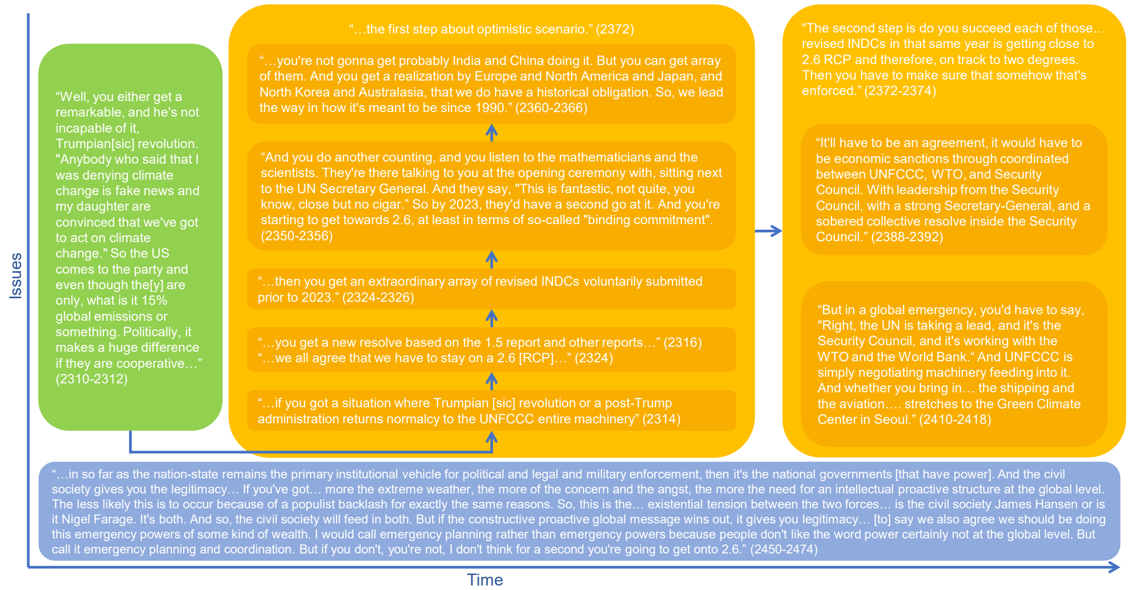
Complexity: Two steps, linear, three layers with interrelations and assumptions
Assumptions:
Issues and options: Inputs to production, production methods
Actors and interests: China, US, ASEAN
Response: Leadership, geopolitical power
Outcome: Success
Notes:
Code: Success, leadership

Respondent 12 – Success scenario



Complexity: Two steps, linear, three layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Regional responses
Outcome: Success
Notes:
Code: Success, regional response

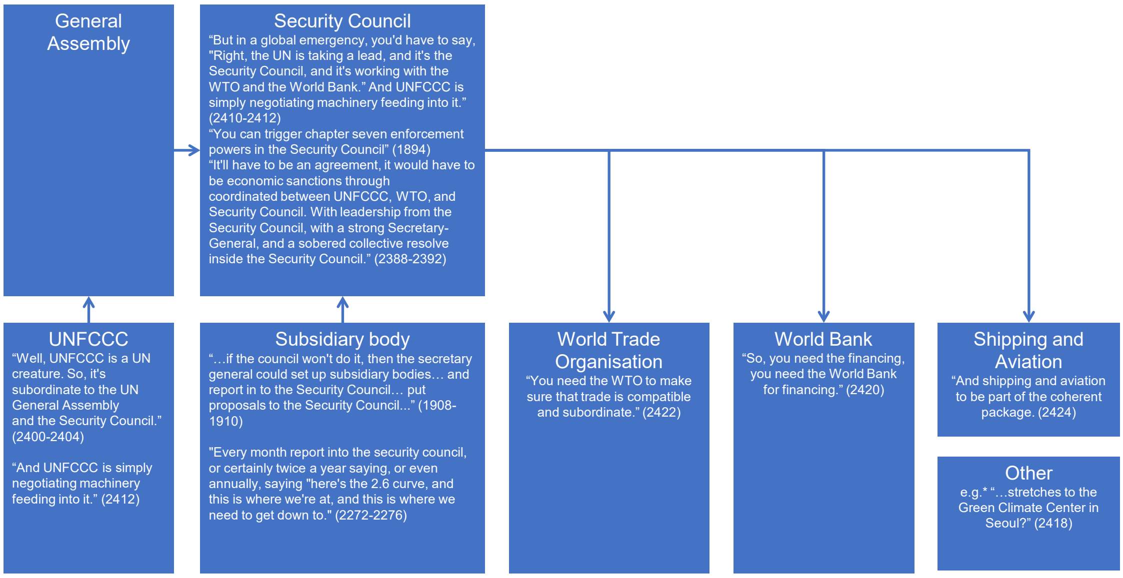
Respondent 13 – Success scenario



Complexity: Three large steps, multiple small steps, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests: States
Response: Ambition, international cooperation
Outcome: Success
Notes:
Code: Success, ambition, international cooperation

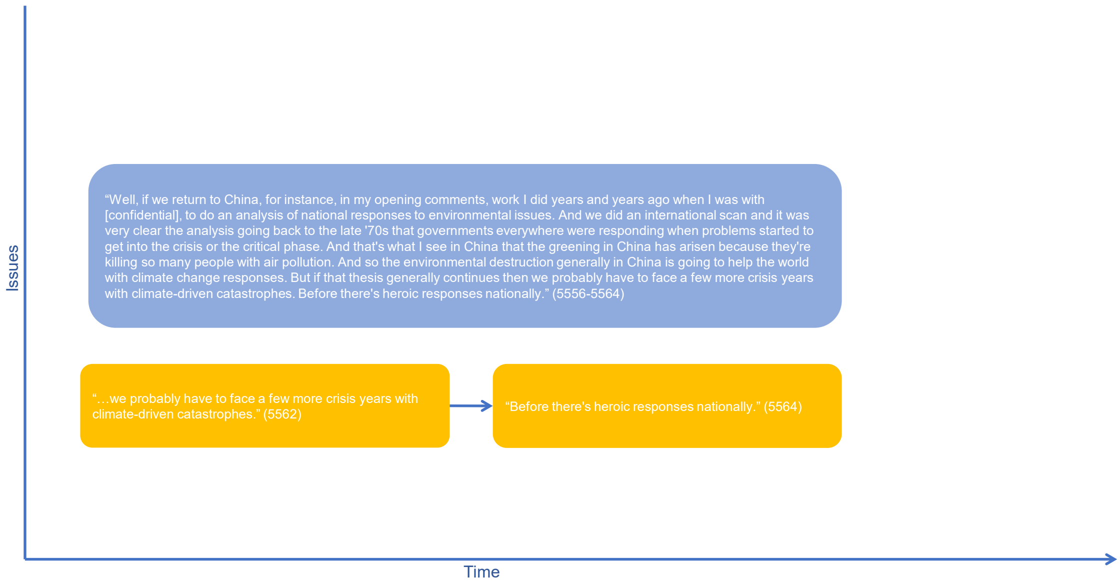
Success scenarios

Respondent 13 – Success scenario (organogram)



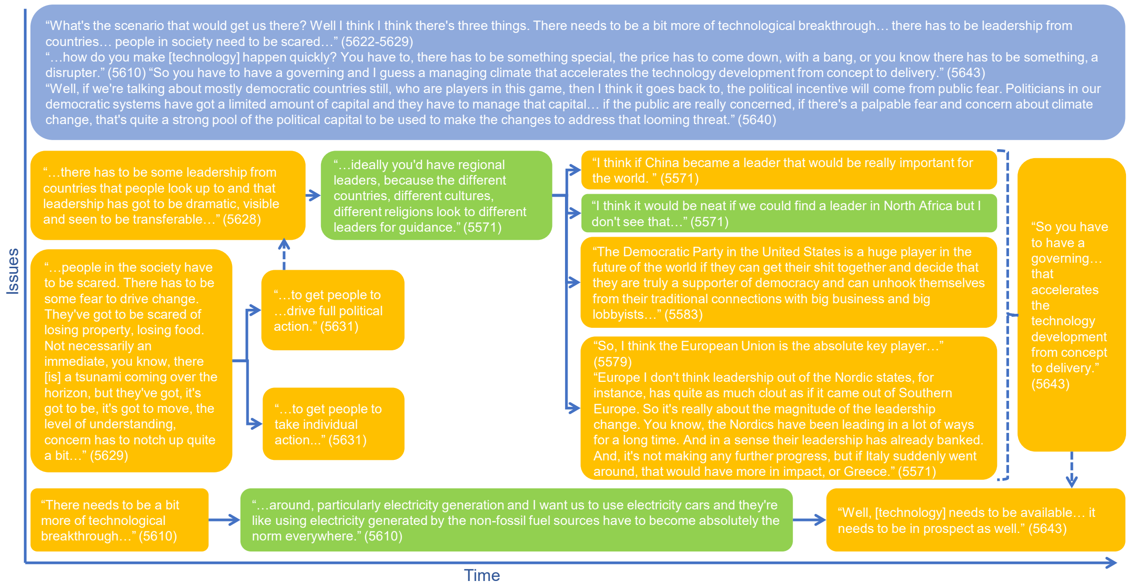
Complexity: Organogram
Assumptions:
Issues and options:
Actors and interests: UNFCCC, UNGA, UNSC, WTO, World Bank, UN subsidiary body, other
Response: International regime
Outcome: Success
Notes:
Code: Success, international cooperation

Respondent 14 – Success scenario



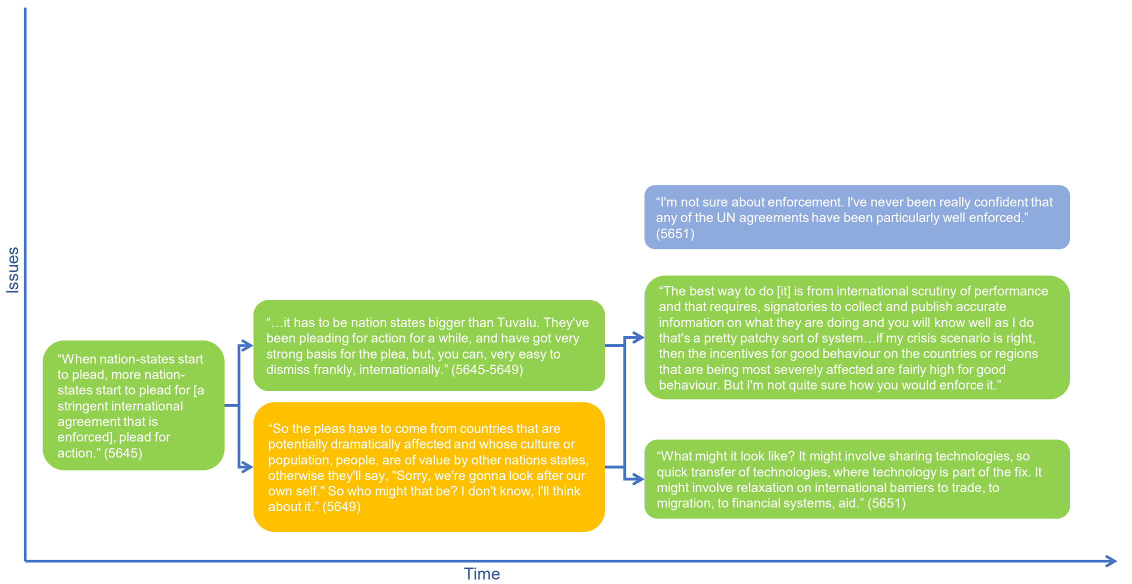
Complexity: Two steps, two layers with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Impact response, domestic responses
Outcome: Success
Notes:
Code: Success, impact response

Respondent 14 – Success scenario



Complexity: Four steps, branching and merging, six layers with interrelations and assumptions
Assumptions:
Issues and options: Climate risk, policies and technology
Actors and interests: China, USA, Europe, Africa, society want climate change to be addressed, political leaders want to meet societies demands, political leaders are interested in supporting technology
Response: Risk response, social change, leadership (political and regional), technology, business and economy
Outcome: Success
Notes: Fear leads to risk response. Regional leadership, government support of technology. Technological disruption: electric cars and clean energy
Code: Success, social change

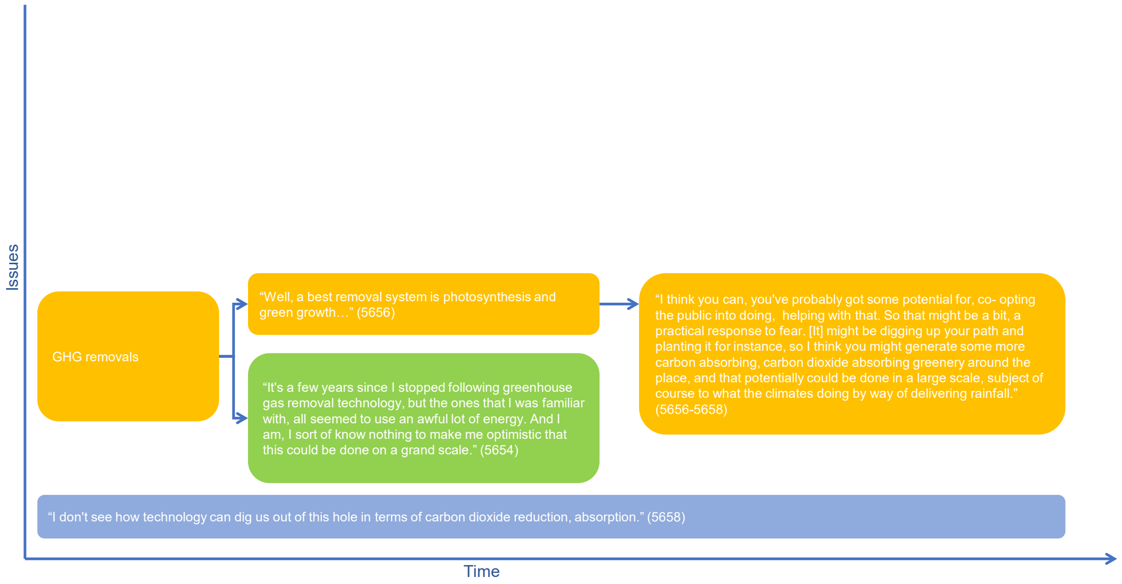
Respondent 14 – Success scenario



Complexity: Three steps, branching, three layers with interrelations and assumptions.
Assumptions:
Issues and options:
Actors and interests:
Response: coalitions, geopolitical power, stringent enforced agreement
Outcome: Success
Notes:
Code: Success, stringent enforced agreement, coalitions

Success scenarios

Respondent 14 – Success scenario

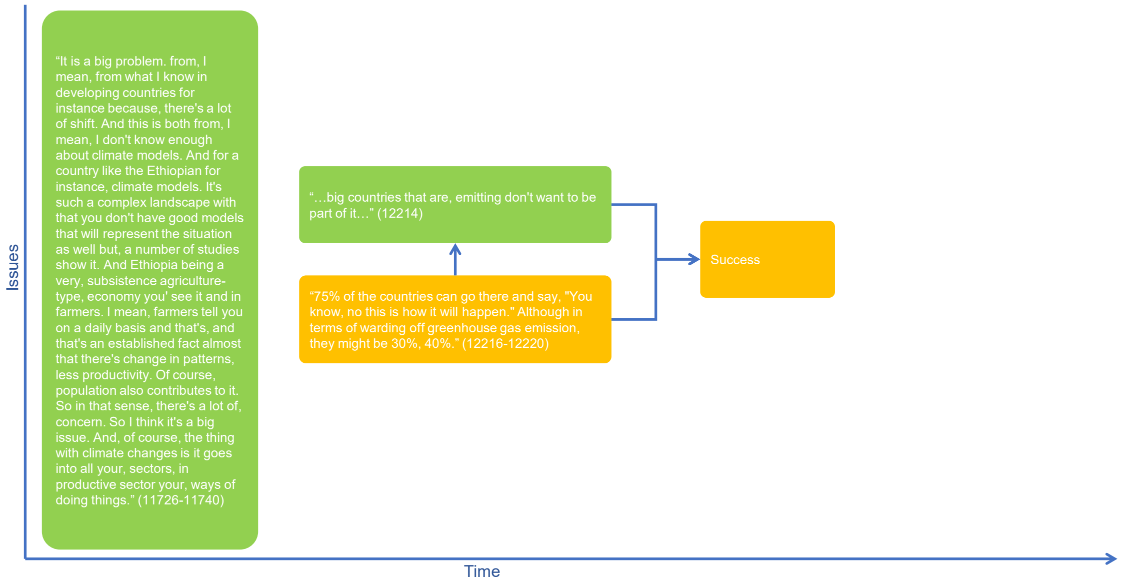


Complexity: Three steps, branching, two layers with assumptions
Assumptions:
Issues and options: Scale and methods
Actors and interests:
Response: GHG removals, natural removals
Outcome: Success
Notes:
Code: Success, removals, natural removals

Respondent 15 – Success scenario

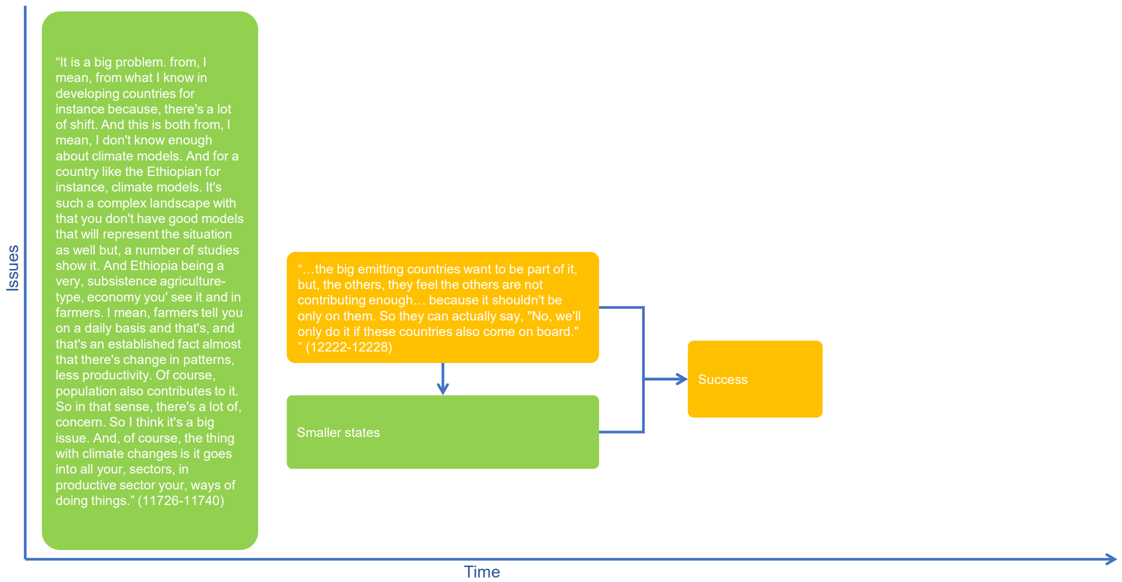
Complexity: Two steps, linear, three layers with conditions and assumptions
Assumptions:
Issues and options: Information and monitoring, geo-engineering contingencies
Actors and interests:
Response: Geoengineering, GHG removals, SRM, technology
Outcome: Success
Notes:
Code: Success, geoengineering, removals, solar radiation management

Respondent 16 – Success scenario



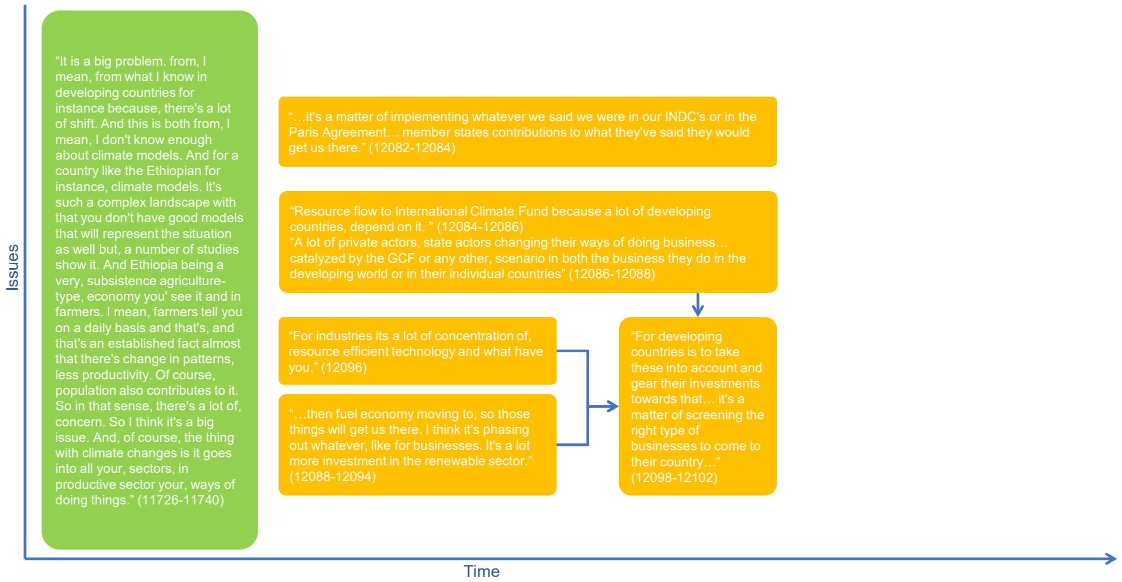
Complexity: Two steps, merging, two layers
Assumptions:
Issues and options:
Actors and interests:
Response: Geopolitical coalition, stringent enforced agreement
Outcome: Success
Notes:
Code: Success, stringent enforced agreement, coalitions

Respondent 16 – Success scenario



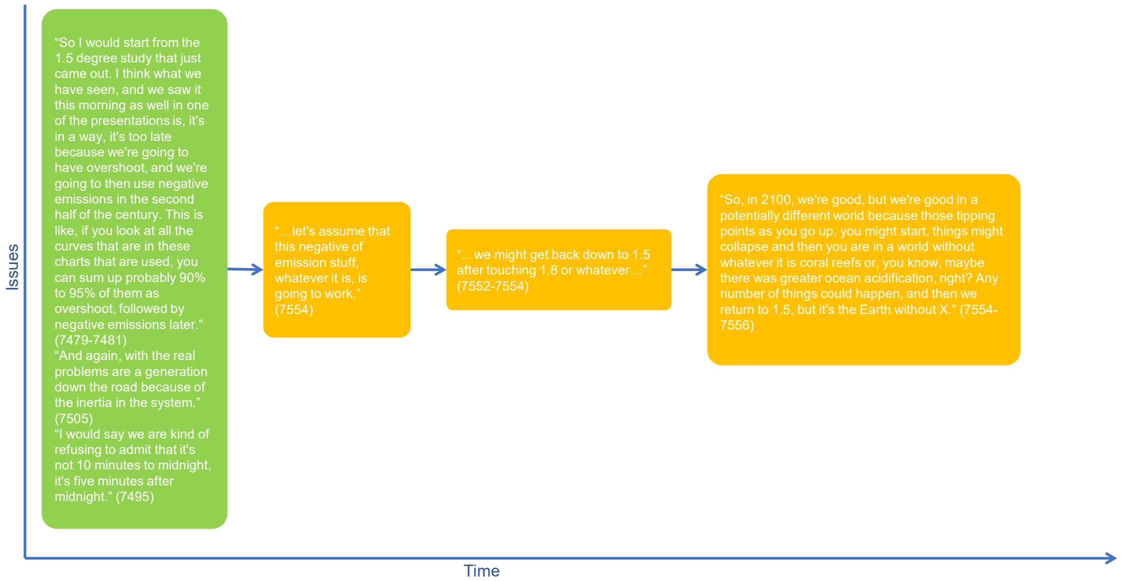
Complexity: Two steps, merging, two layers
Assumptions:
Issues and options:
Actors and interests: States
Response: Geopolitical power, stringent enforced agreement
Outcome: Success
Notes:
Code: Success, stringent enforced agreement

Respondent 16 – Success scenario



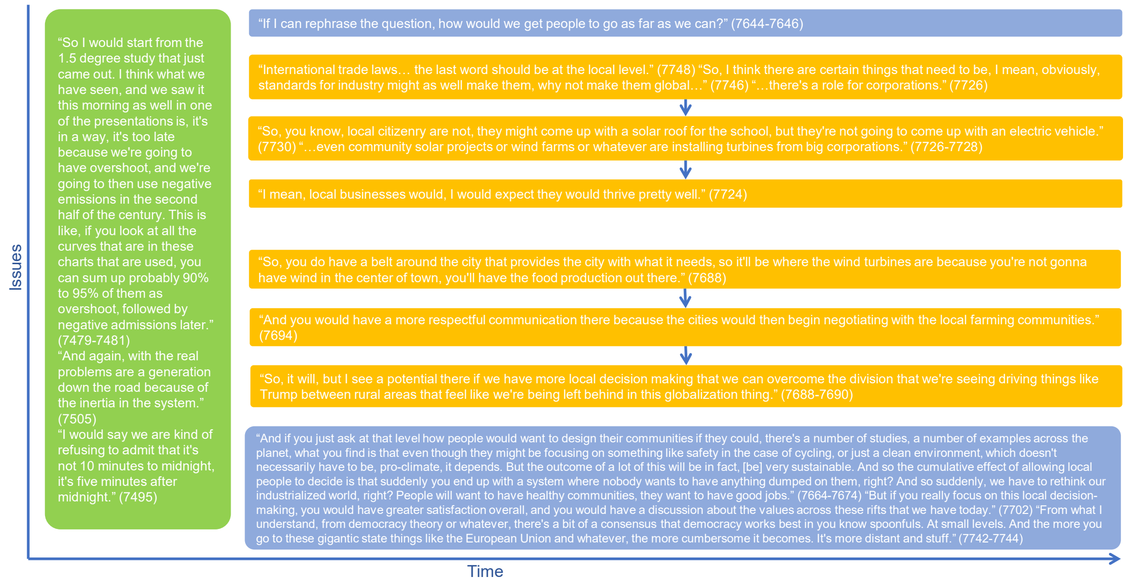
Complexity: Two steps, merging, four layers with parallel conditions
Assumptions:
Issues and options: Technology and energy efficiency, renewable energy
Actors and interests: Developing countries and regulation of business
Response: Political will and policy
Outcome: Success
Notes:
Code: Success, policy, technology

Respondent 17 – Success scenario



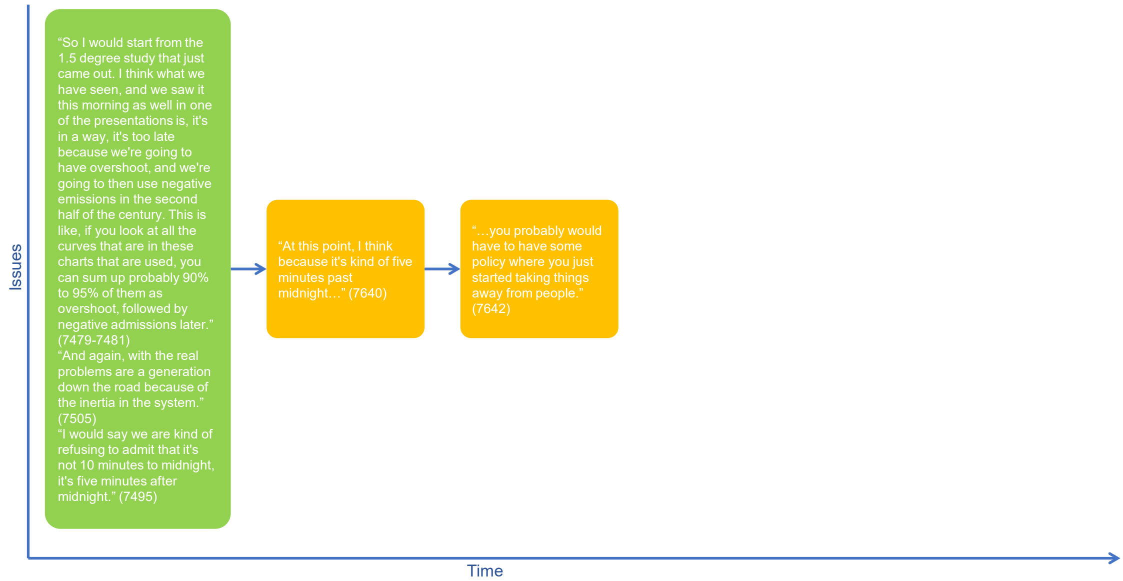
Complexity: Four steps, linear, one layer
Assumptions:
Issues and options: Losses inevitable, tipping points still possible
Actors and interests:
Response: GHG removals
Outcome: Success
Notes: Questioning what is success
Code: Success, what success looks like

Respondent 17 – Success scenario



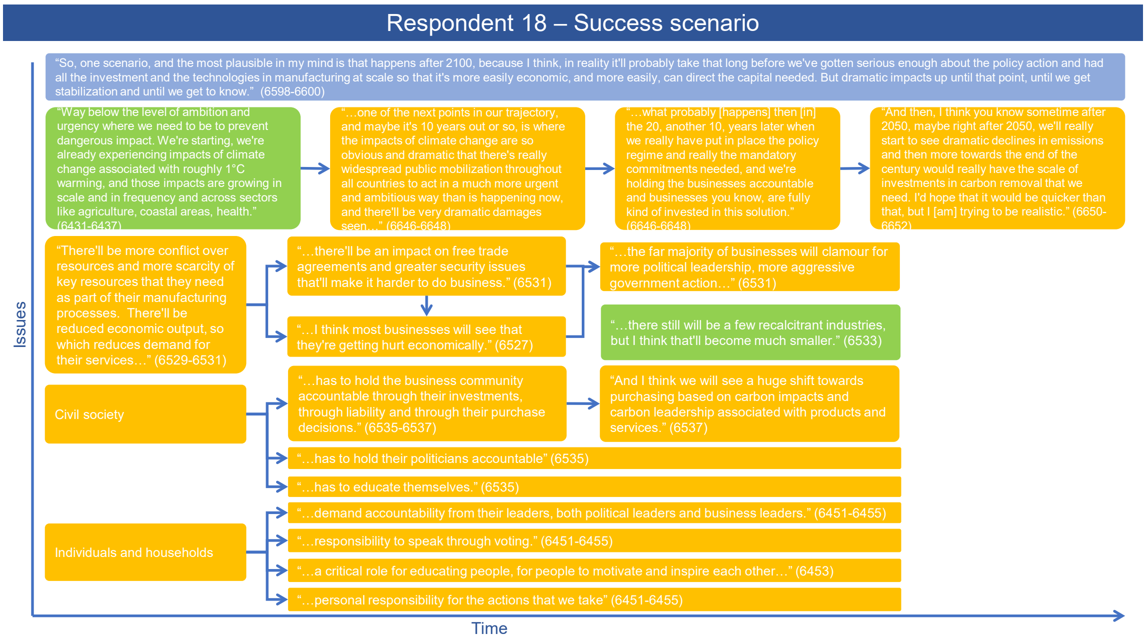
Complexity: One step, eight layers and interrelations and assumptions
Assumptions:
Issues and options: Law and which parties are favoured
Actors and interests: Communities, cities, business, central governments, courts
Response: Localisation, international standards
Outcome: Success
Notes:
Code: Success, localisation

Respondent 17 – Success scenario

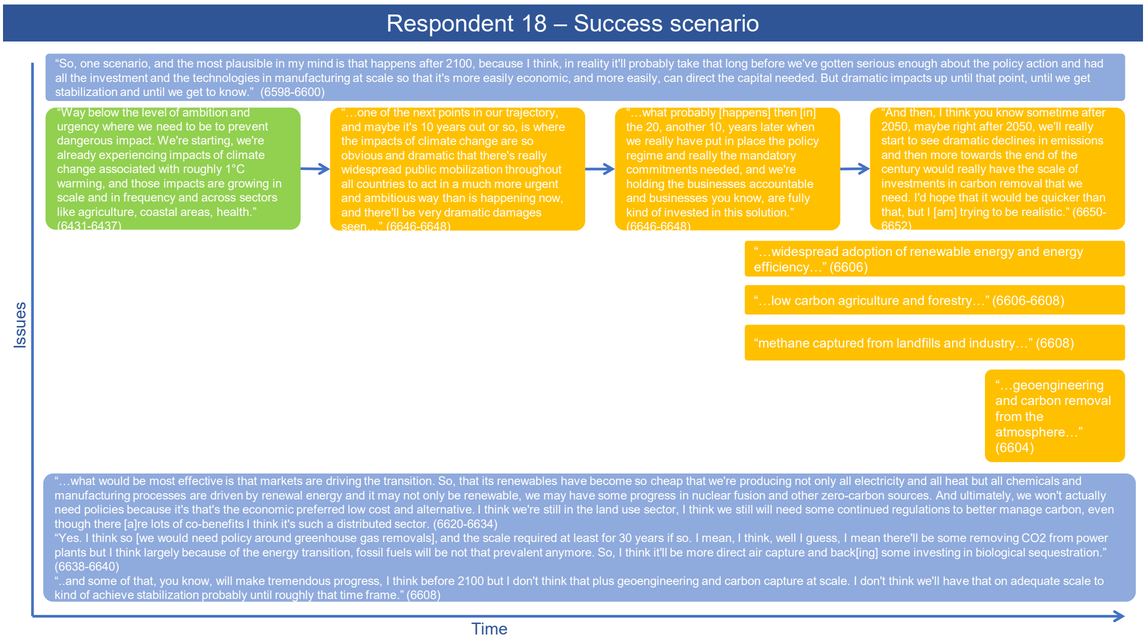


Complexity: Three steps, linear, one layer
Assumptions:
Issues and options:
Actors and interests:
Response: Stringent enforced agreement, budgets
Outcome: Success
Notes:
Code: Success, stringent enforced agreement

Success scenarios



Complexity: Four steps, branching and merging, eleven layers with parallel conditions, assumptions and options
Assumptions:
Issues and options:
Actors and interests: Individuals and households, civil society, businesses,
Response: Impact response, activism, social change, leadership (political)
Outcome: Success
Notes:
Code: Success, social change, activism, leadership, impact response

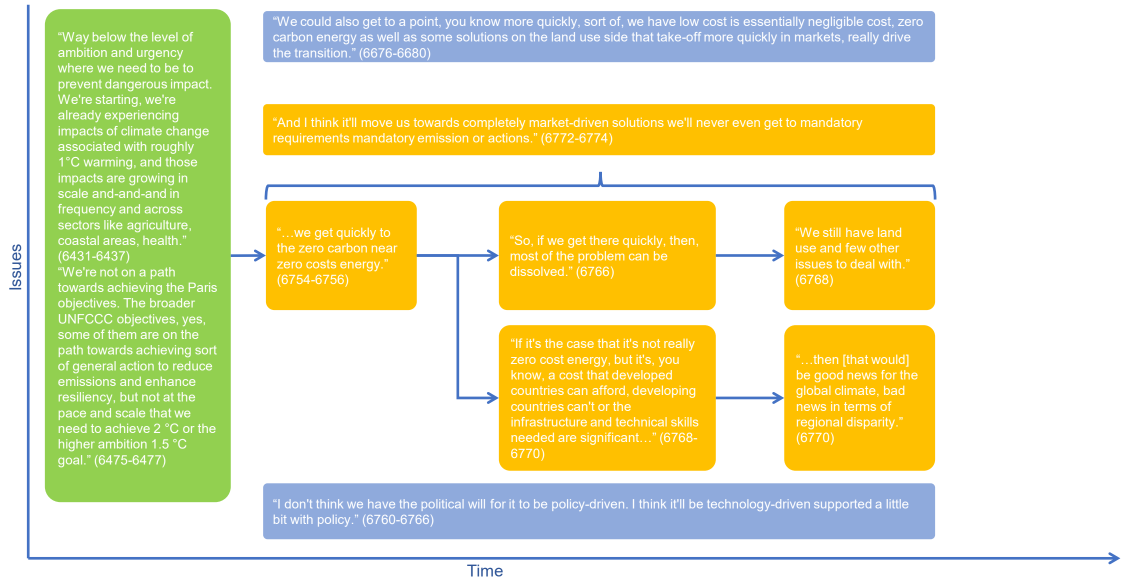


Complexity: Four steps, seven layers parallel conditions and assumptions
Assumptions:
Issues and options: Waste management, agriculture and forestry, renewable energy
Actors and interests:
Response: International cooperation, technology, GHG removals
Outcome: Success
Notes:
Code: Success, social change, technology, practices

Respondent 18 – Success scenario

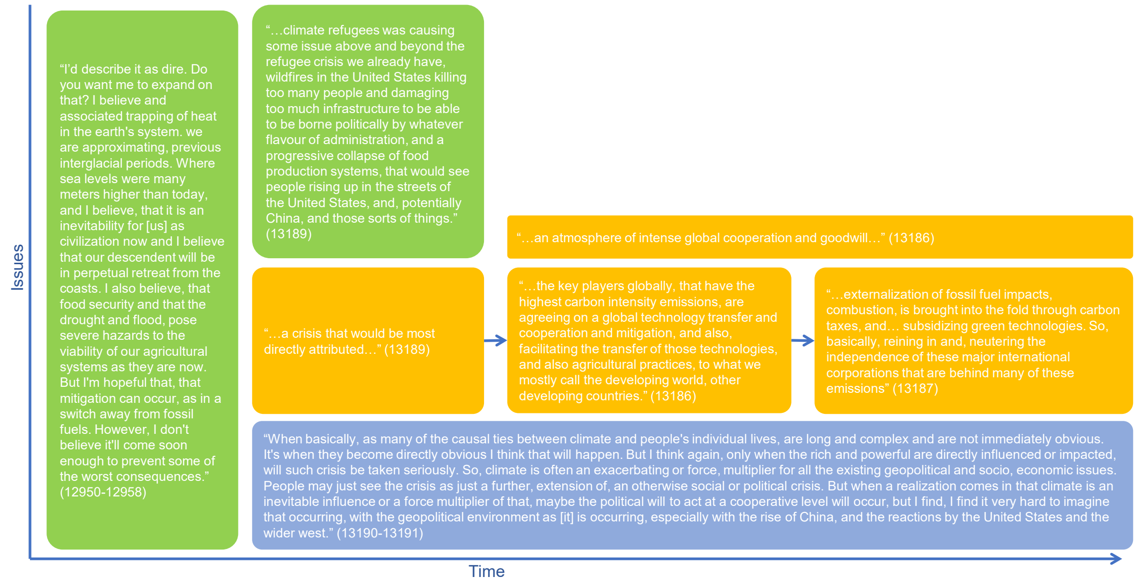
Complexity: Two steps, multiple branching points, fourteen layers including interrelations, many options, with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: International regime
Outcome: Success
Notes: Options
Code: Success, international cooperation

Respondent 18 – Success scenario



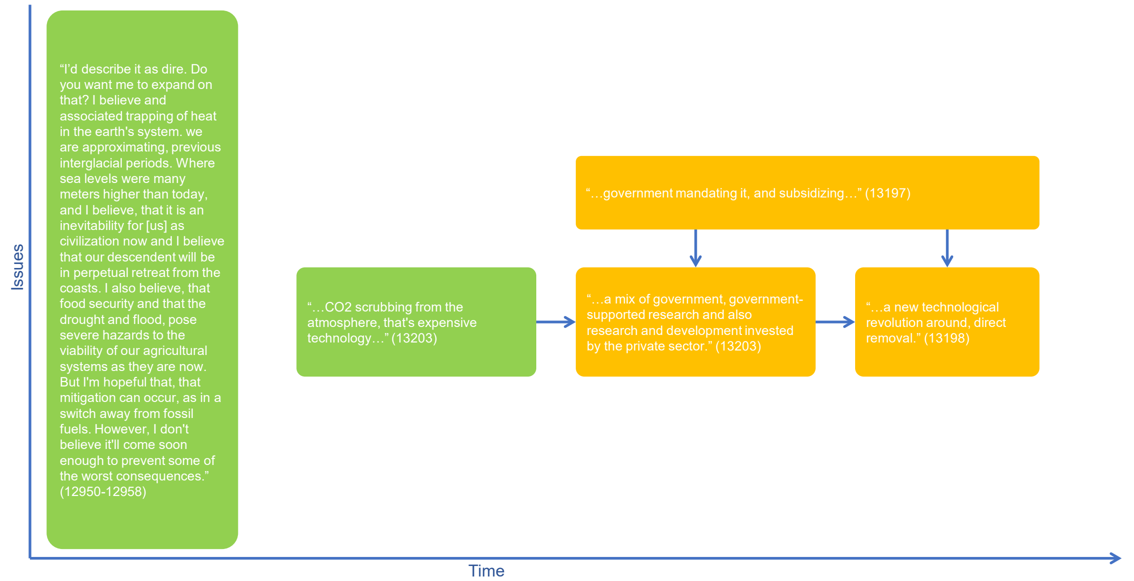
Complexity: Four steps, multiple branching, five layers with assumptions
Assumptions:
Issues and options: Very cheap clean energy solves a large part of the problem, but if there are technical issues or costs then developing countries will be at a disadvantage
Actors and interests:
Response: Technology, business and economy
Outcome: Success
Notes:
Code: Success, technology, commercial

Respondent 20 – Success scenario



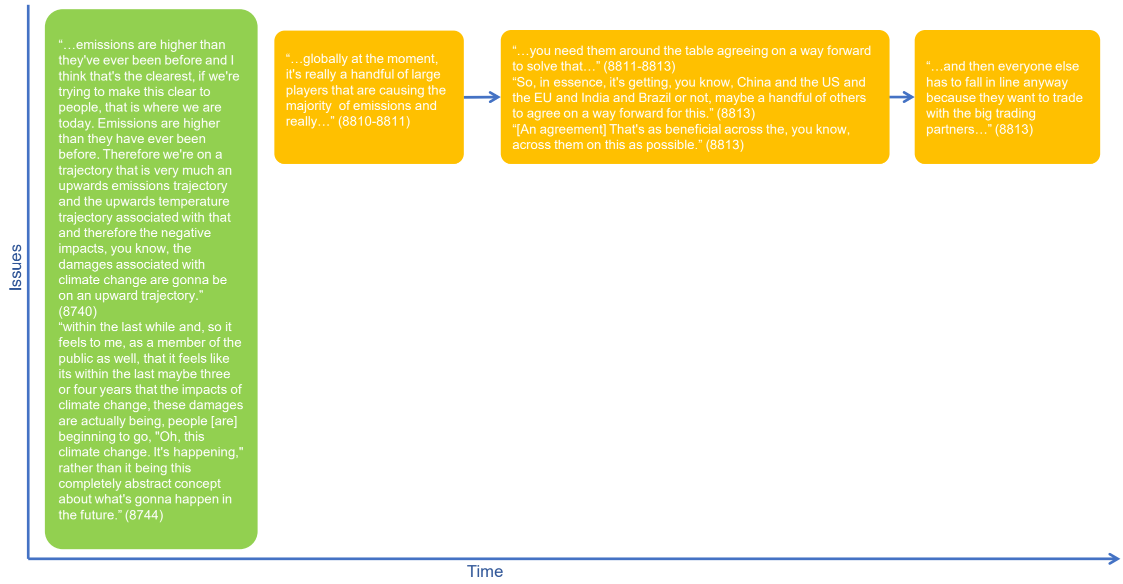
Complexity: Three steps linear, three layers with parallel conditions and assumptions
Assumptions:
Issues and options: Impacts affecting society, unrest, taxes and subsidies
Actors and interests: Large geopolitical powers want to limit unrest and climate change impacts.
Response: Impact response, political will and policy, international cooperation, technology, ambition, subsidies, carbon tax
Outcome: Success
Notes:
Code: Success, international cooperation, activism, impact response

Respondent 20 – Success scenario



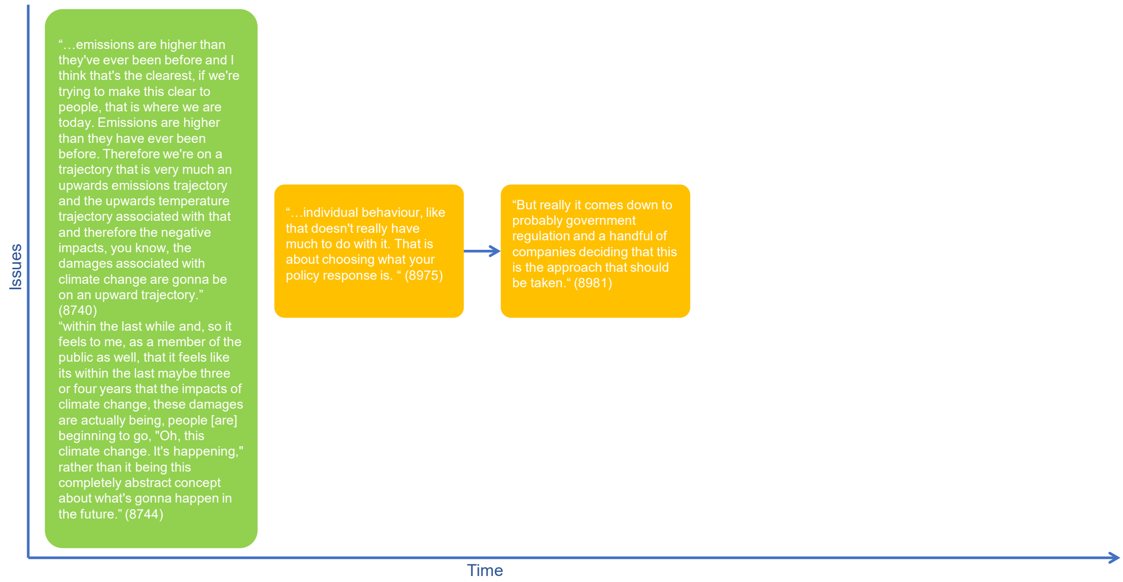
Complexity: Three steps, merging, two layers
Assumptions:
Issues and options: Technology research
Actors and interests: Government, business
Response: GHG removals, technology
Outcome: Success
Notes:
Code: Success, removals, technology

Respondent 21 – Success scenario



Complexity: Three steps, linear, one layer
Assumptions:
Issues and options:
Actors and interests: Geopolitical powers want an agreement, other states want to trade with geopolitical powers
Response: International cooperation, international regime
Outcome: Success
Notes:
Code: Success, international cooperation, policy

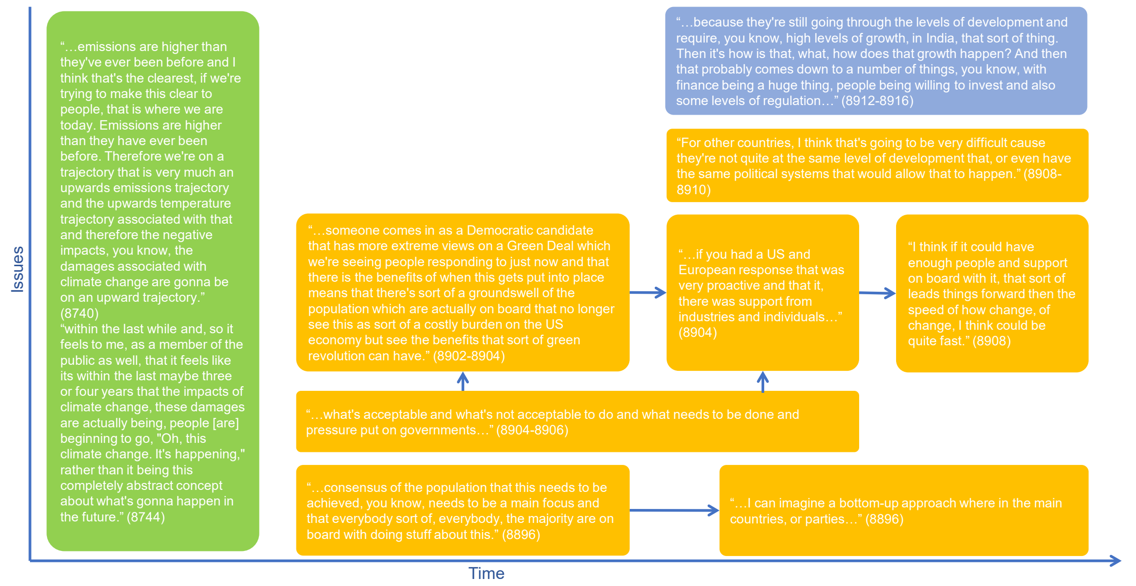
Respondent 21 – Success scenario



Complexity: Two steps, linear, one layer
Assumptions:
Issues and options: Behaviour change is ineffective, need policy
Actors and interests: Individuals, governments
Response: Political will and policy
Outcome: Success
Notes: Regulation
Code: Success, policy

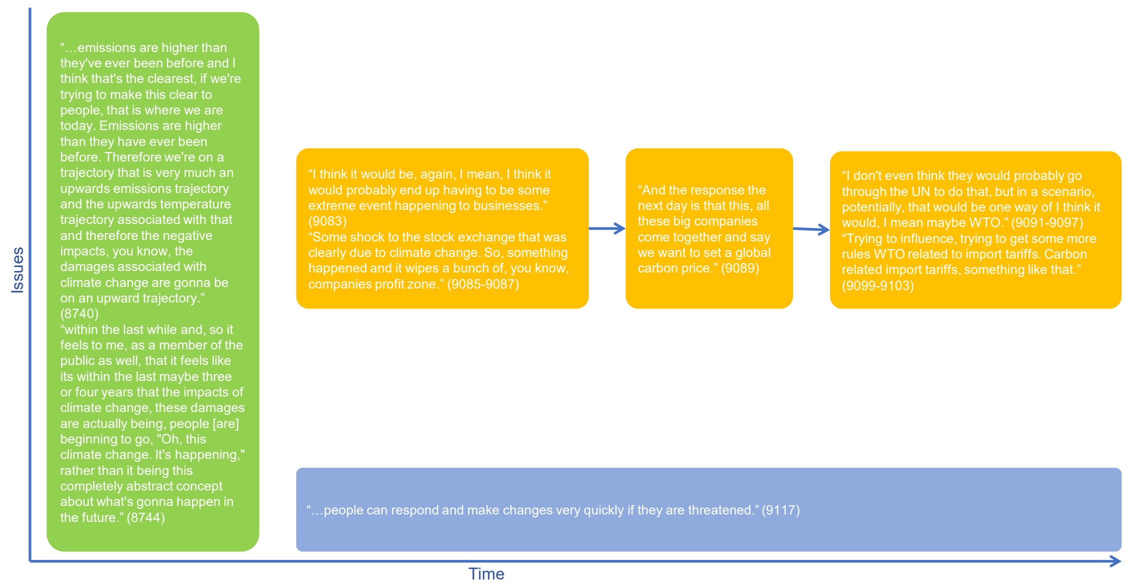
Success scenarios

Respondent 21 – Success scenario



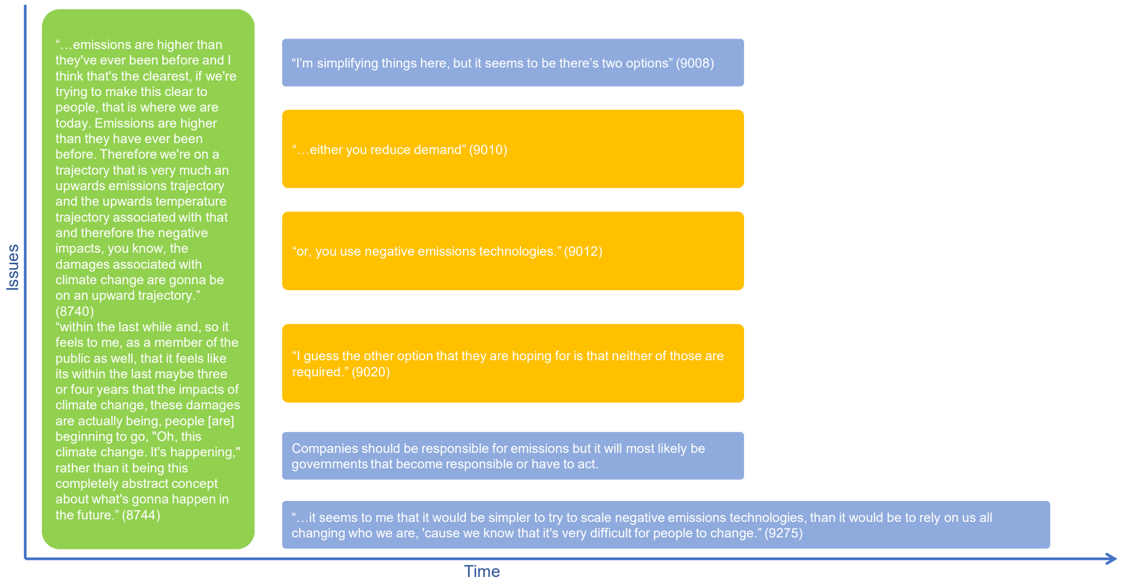
Complexity: Three steps, five layers with interrelations, parallel conditions and assumptions
Assumptions:
Issues and options:
Actors and interests: Society want to see climate change addressed. USA and EU want to address the issue
Response: social change, policy response, international cooperation (US-EU)
Outcome: Success
Notes:
Code: Success, social change

Respondent 21 – Success scenario



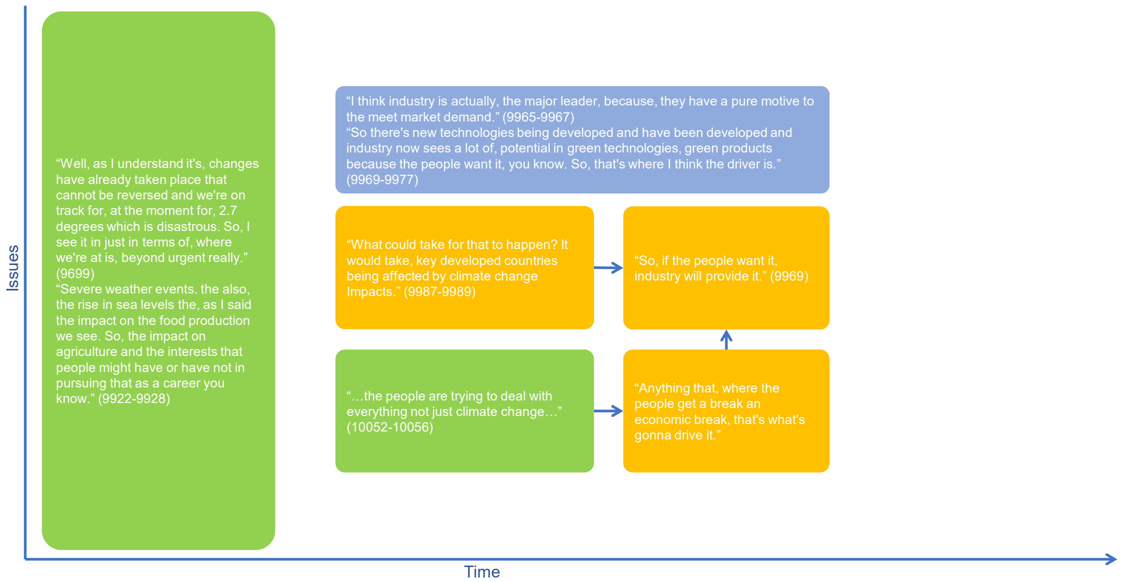
Complexity: Three steps, linear, two layers with assumptions
Assumptions:
Issues and options: Governance and international agreements
Actors and interests: Business
Response: Impact response, stringent enforced agreement, business and economy
Outcome: Success
Notes:
Code: Success, business and economic activity, commercial, stringent enforced agreement, impact response

Respondent 21 – Success scenario



Complexity: One step, six layers including options and assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: GHG removals, technology
Outcome: Success
Notes:
Code: Success, removals, technology

Respondent 22 – Success scenario



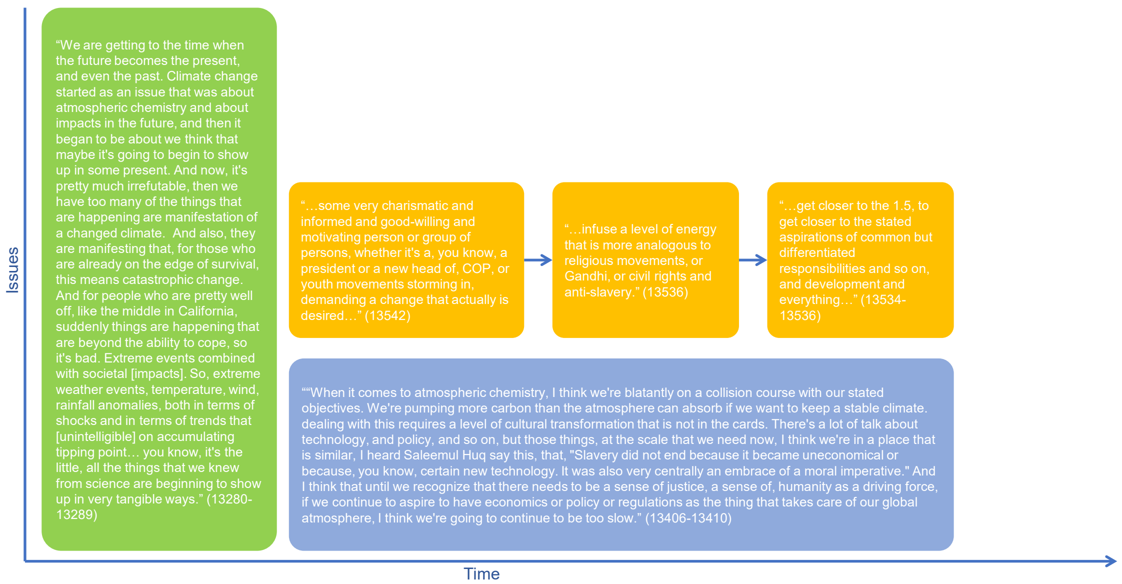
Complexity: Two steps, linear, three layers with interrelations and assumptions.
Assumptions:
Issues and options: Climate change one of many issues
Actors and interests: Consumers want climate resilient low carbon products
Response: Impact response, business and economy, leadership
Outcome: Success
Notes: commercial response to people (consumers)
Code: Success, business and economic activity, commercial, consumers, impact response

Success scenarios

Respondent 23 – Success scenario

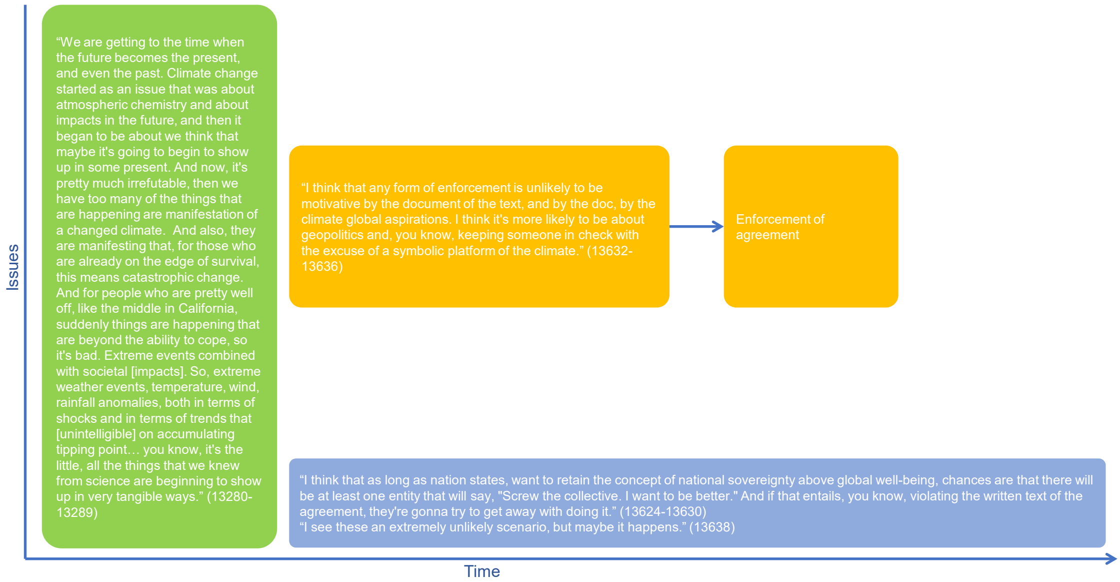
Complexity: Four steps, linear, three layers with parallel conditions and assumptions
Assumptions:
Issues and options: Something really bad happens
Actors and interests: Humanity
Response: Enlightenment
Outcome: Success
Notes:
Code: Success, enlightenment

Respondent 23 – Success scenario



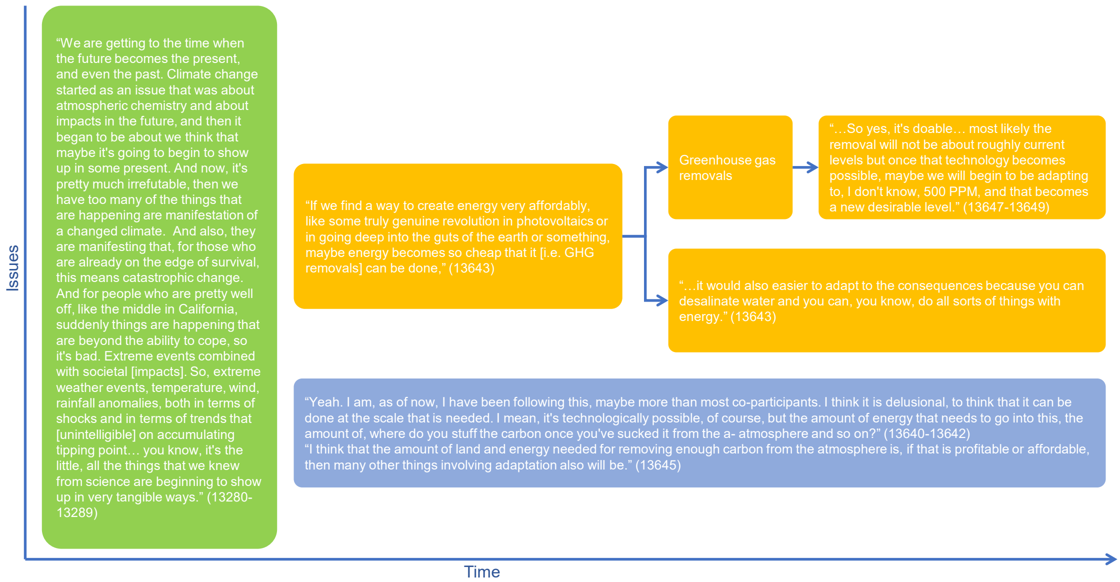
Complexity: Three steps, linear, two layers with assumptions
Assumptions: A movement is required if the global response is to be fast enough and at scale, policy processes are too slow
Issues and options:
Actors and interests: Youth, leaders
Response: Activism, leadership, social change (movement), ambition, amendment
Outcome: Success
Notes:
Code: Success, social change

Respondent 23 – Success scenario

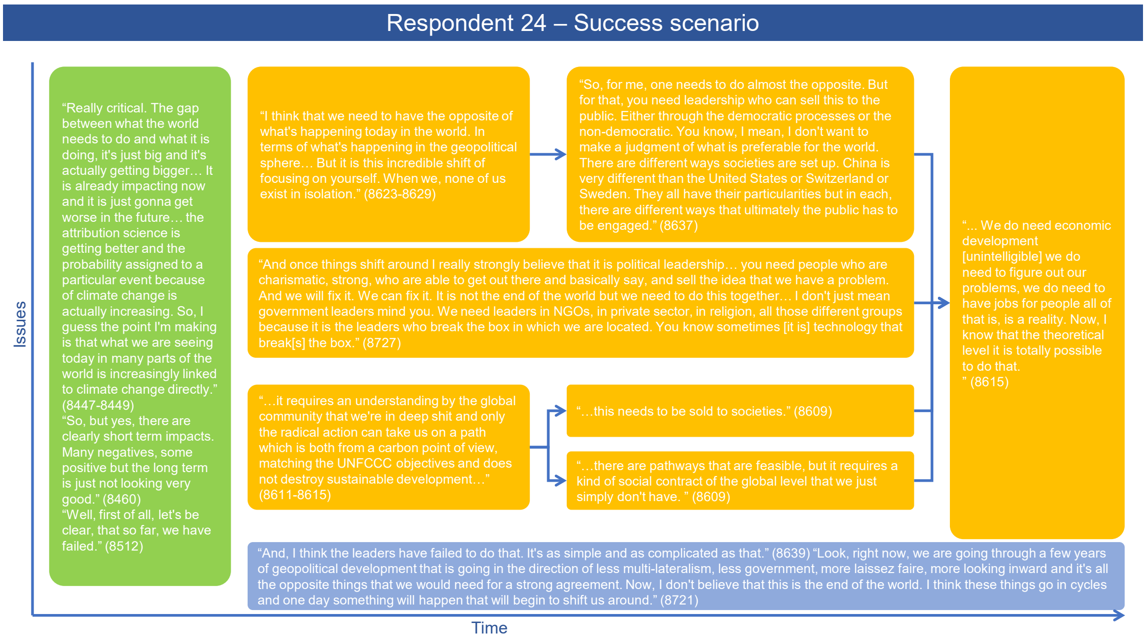


Complexity: Two steps, two layers linear with assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: Geopolitical power, stringent enforced agreement
Outcome: Success
Notes:
Code: Success, stringent enforced agreement, geopolitical

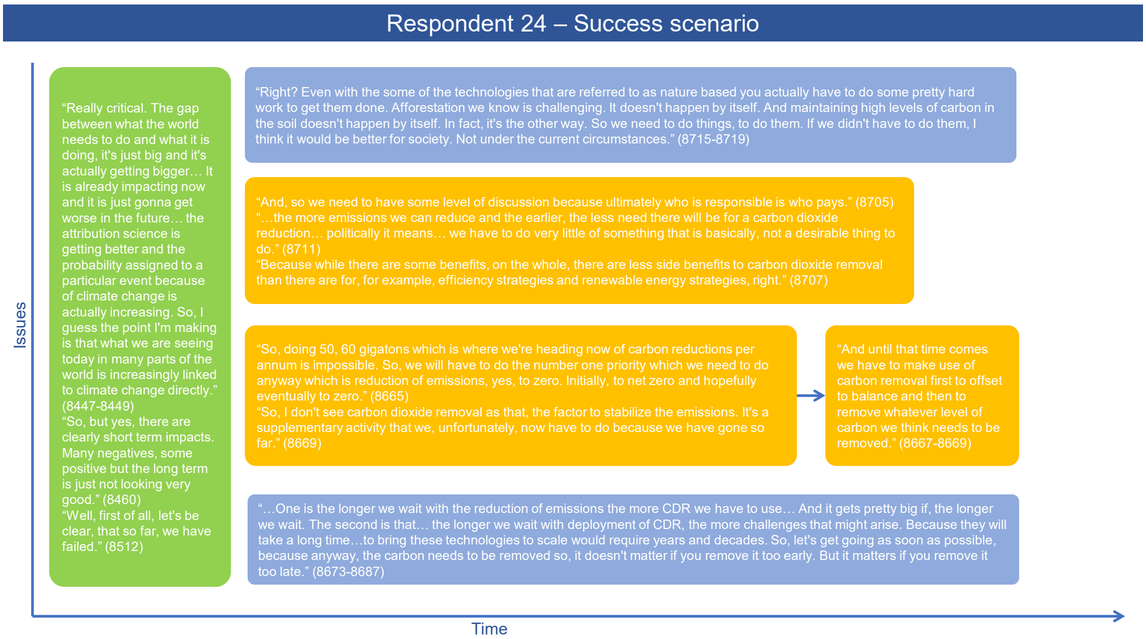
Respondent 23 – Success scenario



Complexity: Three steps, branching, three layers with assumptions
Assumptions:
Issues and options: Cost of energy for removals versus other adaptation options
Actors and interests:
Response: GHG removals, technology, cheap energy, adaptation
Outcome: Success
Notes:
Code: Success, removals, technology

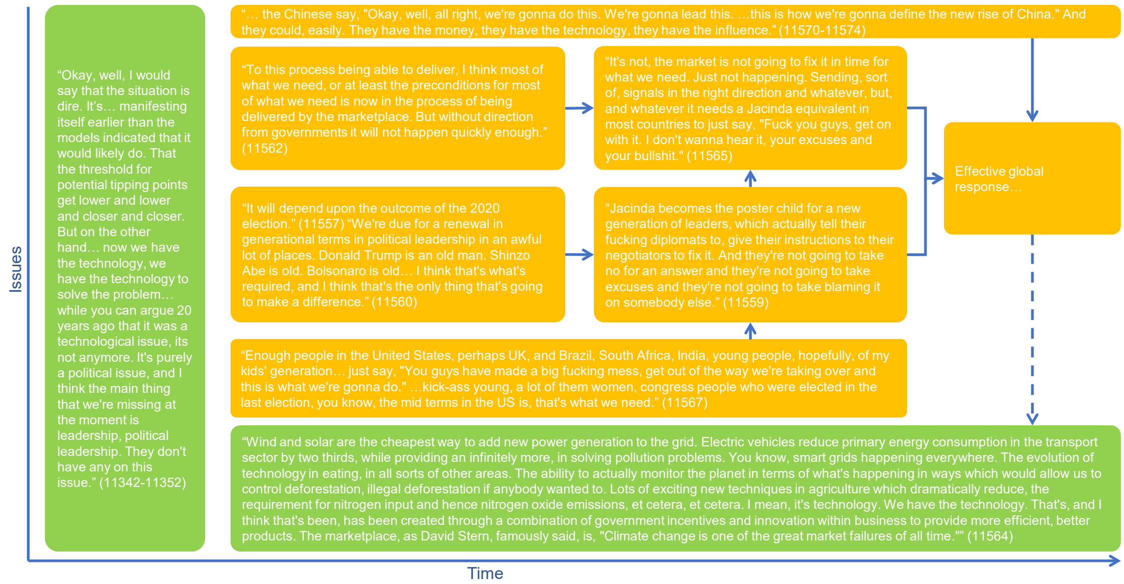


Complexity: Three steps, branching and merging, five layers with assumptions
Assumptions:
Issues and options:
Actors and interests: Government leaders, NGO leaders, business leaders
Response: Leadership (political), social change
Outcome: Success
Notes: Political leadership, social contract
Code: Success, political leadership, social contract



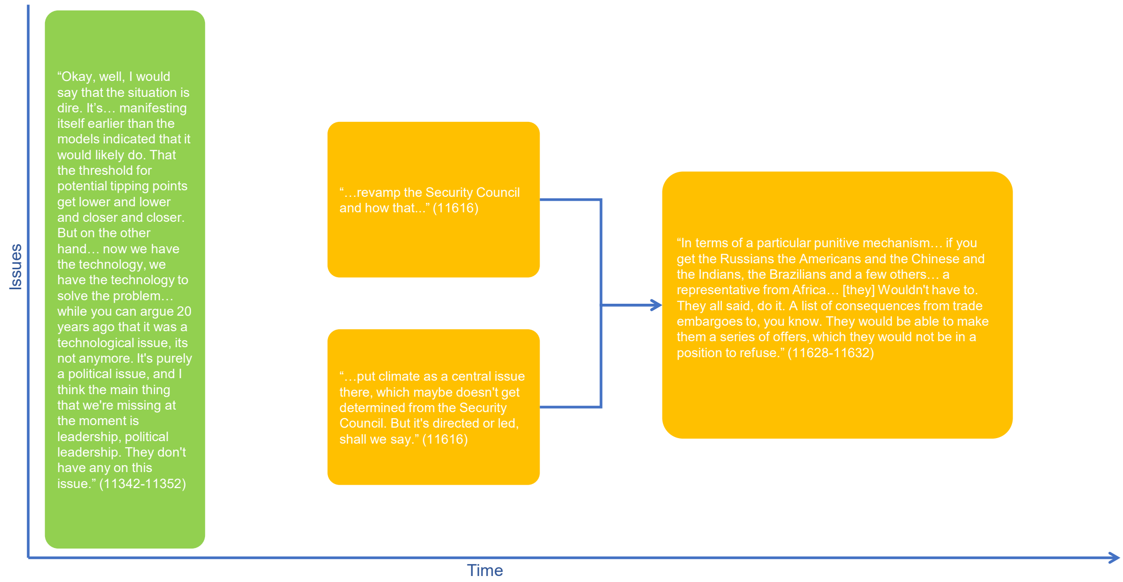
Complexity: Two steps, linear, four layers with parallel conditions and assumptions
Assumptions:
Issues and options:
Actors and interests:
Response: GHG removals, technology
Outcome: Success
Notes:
Code: Success, removals, technology

Respondent 25 – Success scenario



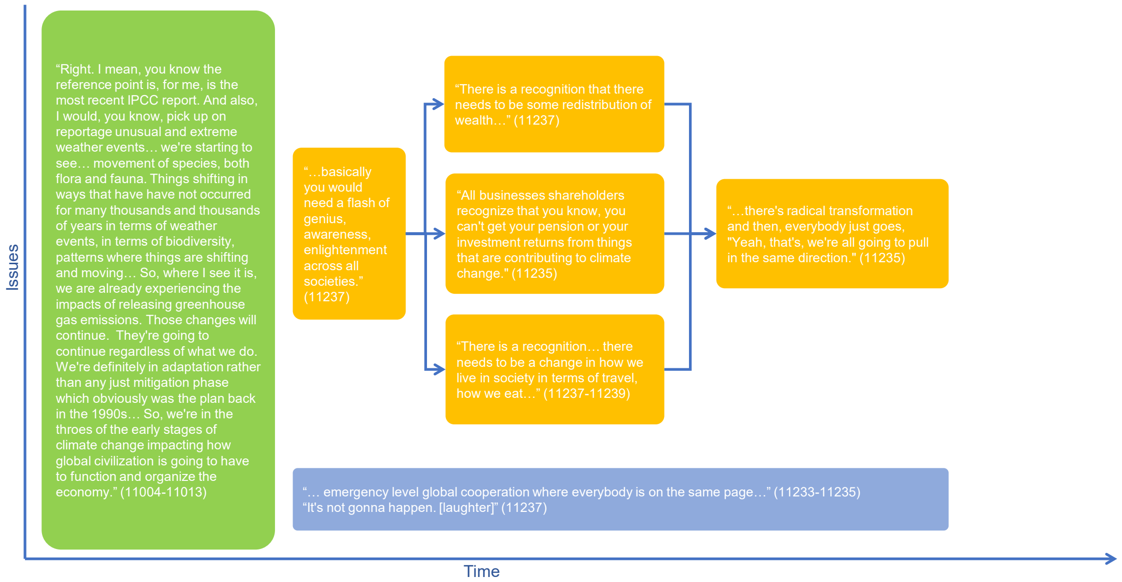
Complexity: Three steps, merging, five layers with interrelations and parallel conditions
Assumptions:
Issues and options:
Actors and interests: US, Brazil, UK, South Africa, India, China, Jacinda
Response: Leadership (political), technology
Outcome: Success
Notes: Youth
Code: Success, political leadership

Respondent 25 – Success scenario



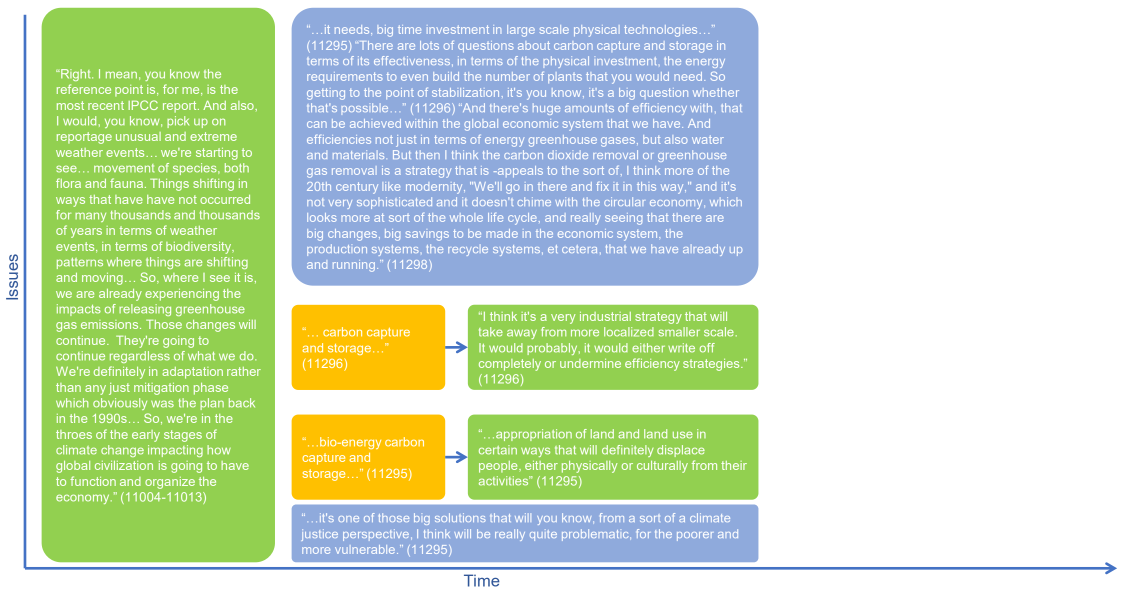
Complexity: Two steps, merging, two layers.
Assumptions:
Issues and options:
Actors and interests: UNSC
Response: Geopolitical power, stringent enforced agreement
Outcome: Success
Code: Success, stringent enforced agreement

Respondent 26 – Success scenario



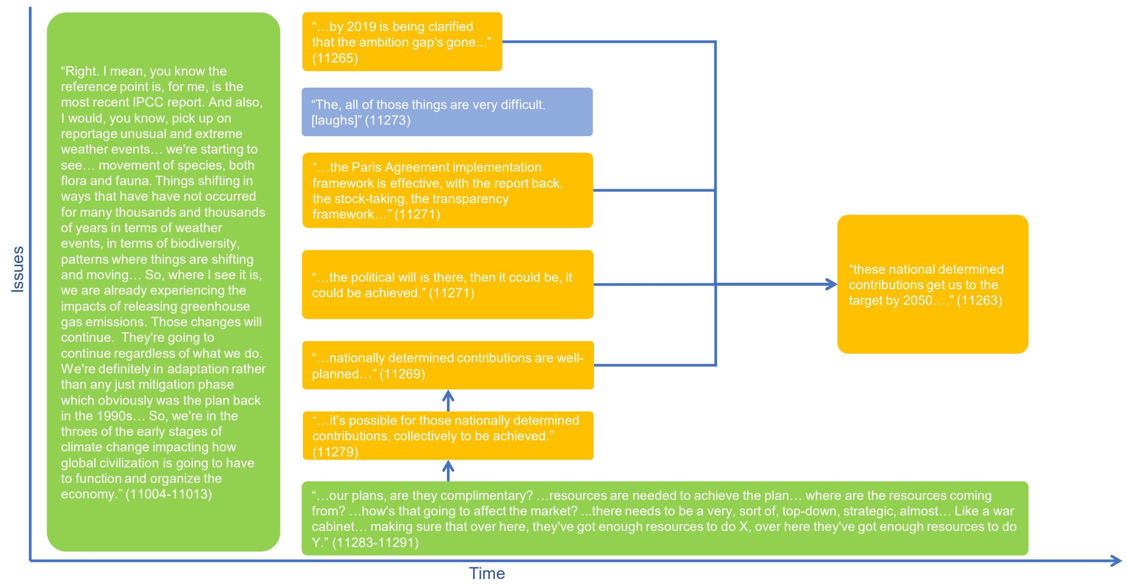
Complexity: Three steps, branching and merging, four layers including assumptions
Assumptions:
Issues and options:
Actors and interests: Humanity recognises need for change in lifestyles as well as the need for redistribution, business realise that profits can not come at the cost of the environment
Response: Enlightenment, behavioural change, business and economy
Outcome: Success
Notes:
Code: Success, enlightenment, movement

Respondent 26 – Success scenario



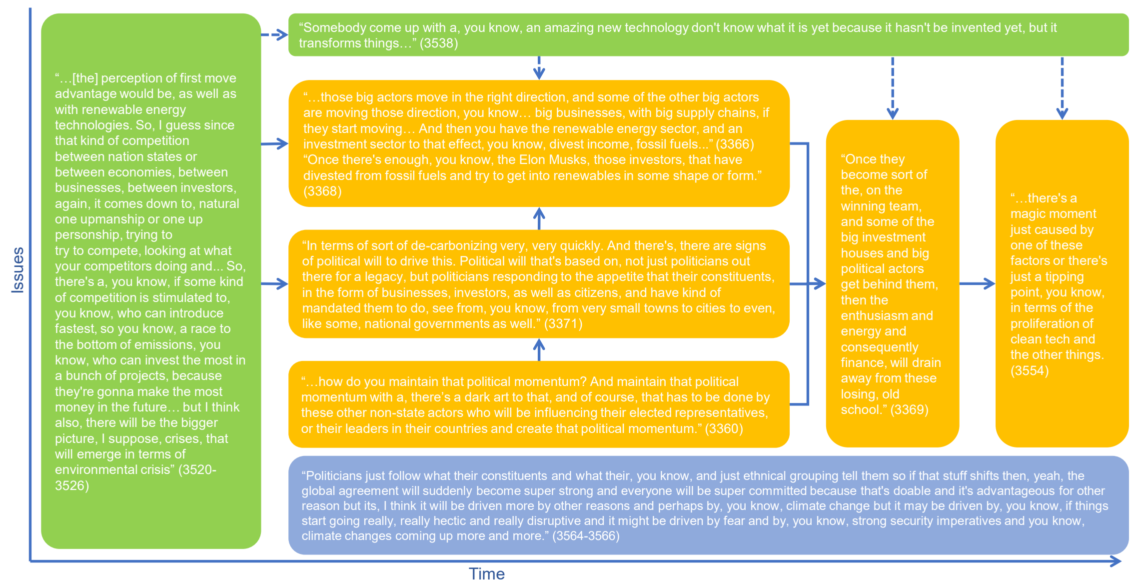
Complexity: Two steps, assumptions, four layers
Assumptions:
Issues and options: Injustice, undermine efficiency efforts
Actors and interests: Small landholders
Response: GHG removals
Outcome: Success
Notes: Is UNFCCC objective success masking wider failure? e.g justice and other issues
Code: Success, removals

Respondent 26 – Success scenario



Complexity: Two steps, merging, seven layers with interrelations and assumptions.
Assumptions:
Issues and options:
Actors and interests:
Response: Stringent enforced agreement
Outcome: Success
Notes:
Code: Success, stringent enforced agreement

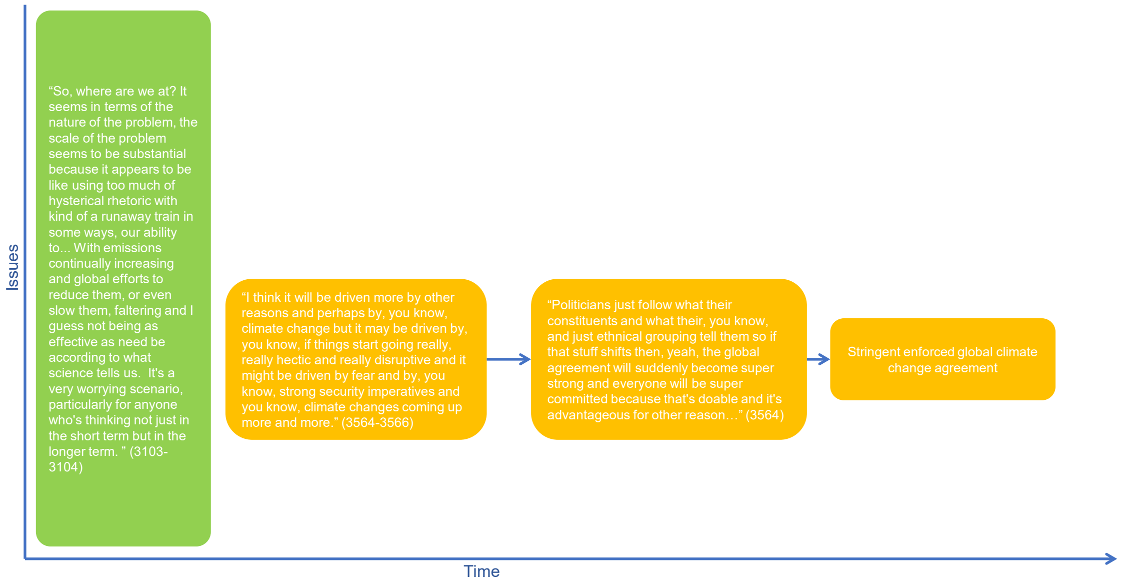
Respondent 27 – Success scenario



Complexity: Four steps, merging, five layers with interrelations and assumptions
Assumptions:
Issues and options: Technology creates now opportunities and coalitions between politicians and business interests. The could be a technological tipping point
Actors and interests: Politicians, big business
Response: Political will and policy, technology, business and economy
Outcome: Success
Notes:
Code: Success, political will and policy, finance

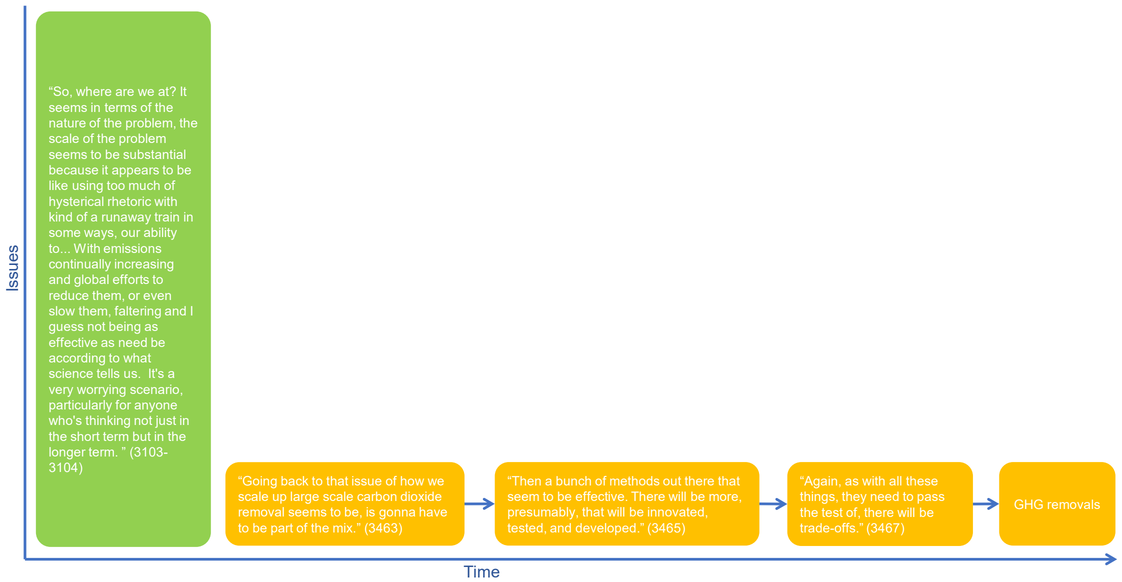
Success scenarios

Respondent 27 – Success scenario



Complexity: Three steps, linear, one layer
Assumptions:
Issues and options:
Actors and interests:
Response: Stringent enforced agreement, impact response
Outcome: Success
Notes:
Code: Success, stringent enforced agreement, impact response

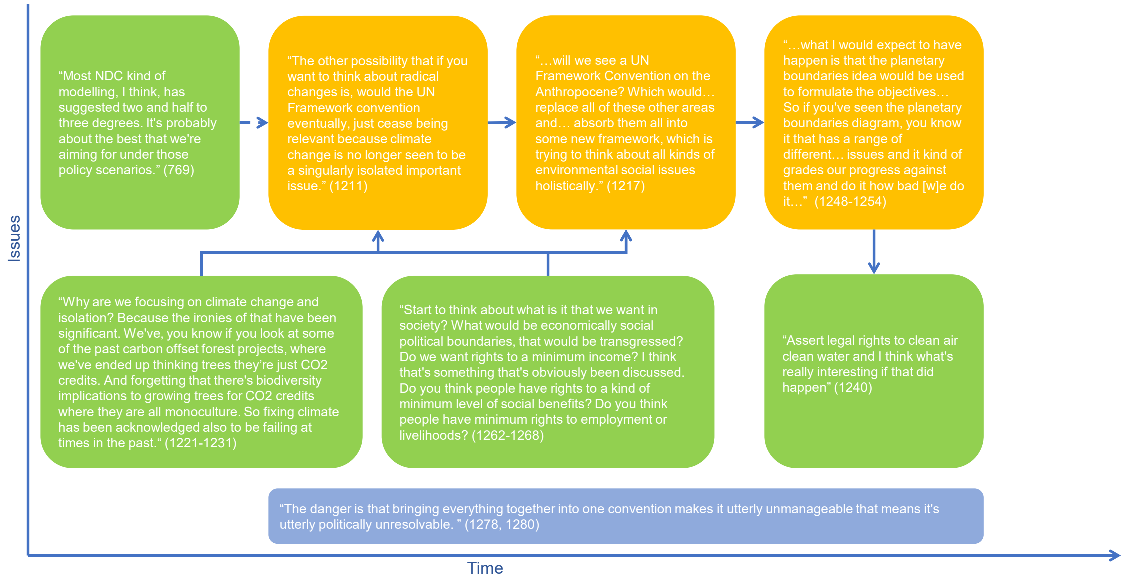
Respondent 27 – Success scenario



Complexity: Four steps linear, one layer
Assumptions:
Issues and options: Trade-offs, innovation, scale, mix
Actors and interests:
Response: GHG removals
Outcome: Success
Notes: The scenario does not specify whether this includes technology or natural removals
Code: Success, removals

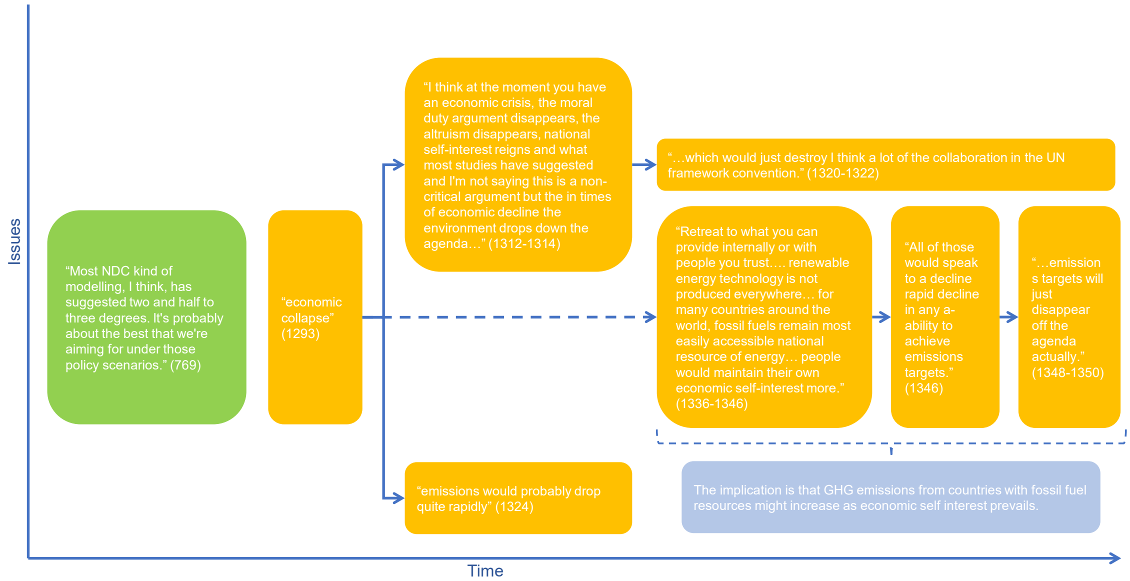
Appendix S: Other scenarios

Respondent 1 – Other scenario



Complexity: Four steps merging, three layers including interrelations including assumptions
Assumptions:
Issues and options: Why privilege climate change ahead of other environmental issues, why not focus on planetary boundaries in all areas.
Actors and interests:
Response: International regime, international cooperation
Outcome: Other
Notes: United Nations Framework Convention on the Anthropocene
Coding: Other, international regime

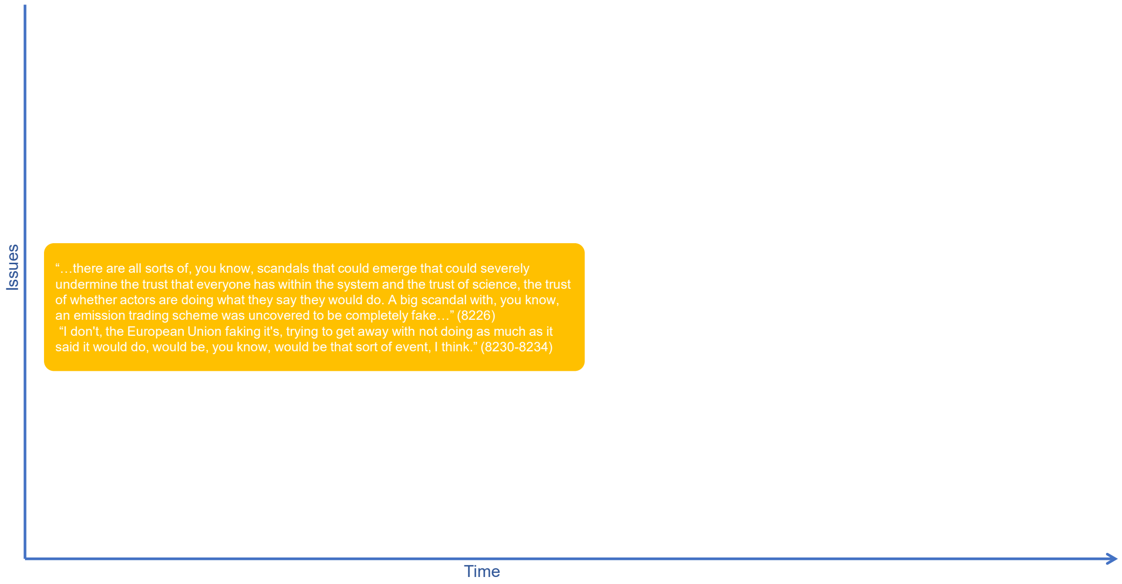
Respondent 1 – Other scenario



Complexity: Five steps branching, three layers including assumptions
Assumptions:
Issues and options:
Actors and interests: States
Response: Failure of international cooperation
Outcome: Other
Notes:
Coding: Other, failure of international cooperation on climate change

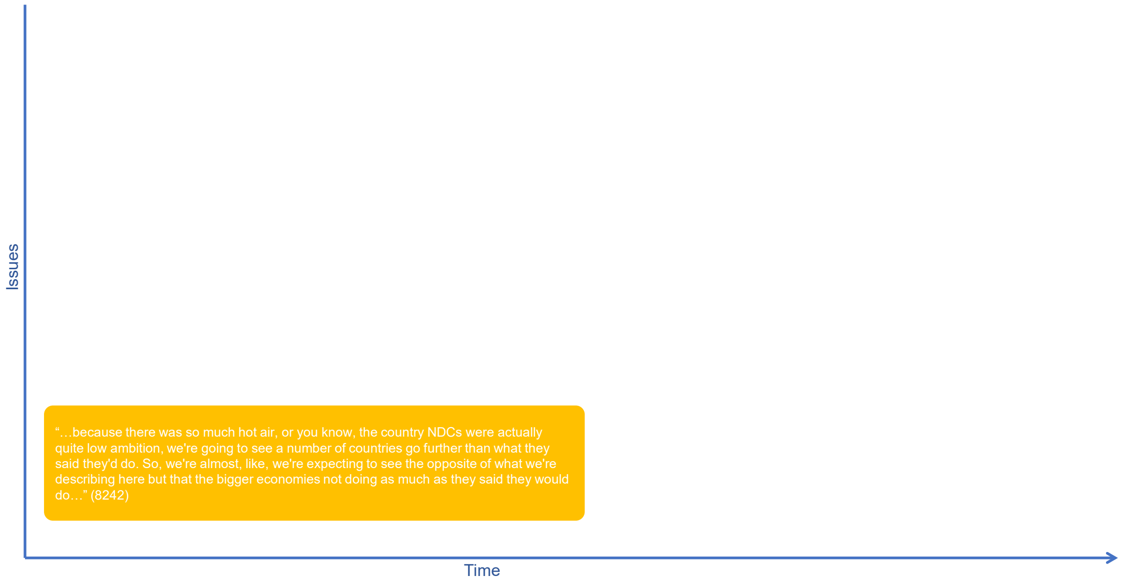
Other scenarios

Respondent 3 – Other scenario



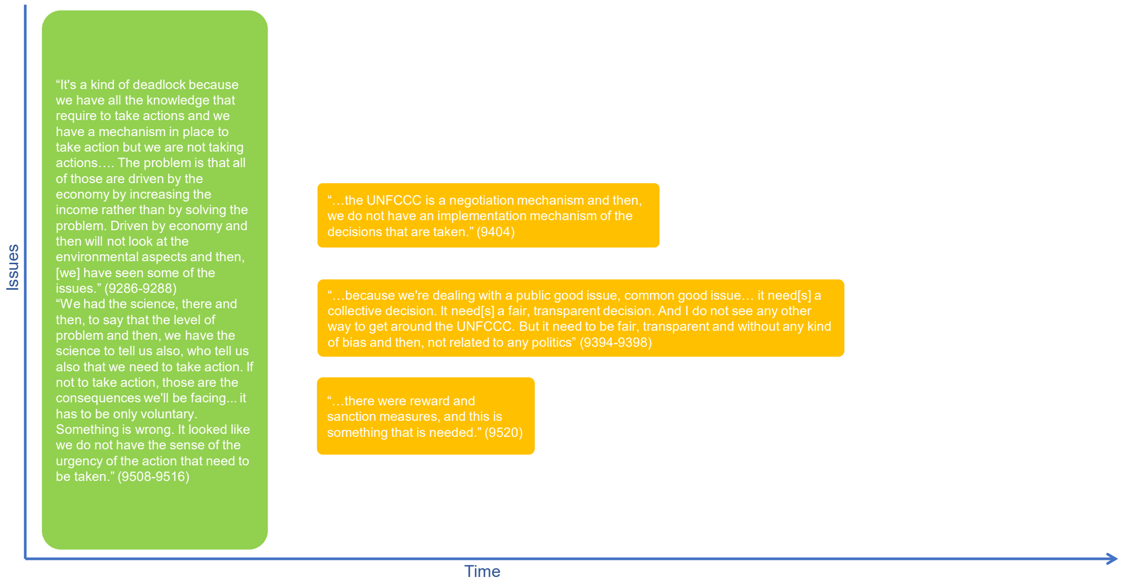
Complexity: One step, one layer
Assumptions:
Issues and options: Fraudulent carbon markets
Actors and interests: Loss of societal trust
Response: Social change
Outcome: Other
Notes:
Coding: Other, social change

Respondent 3 – Other scenario



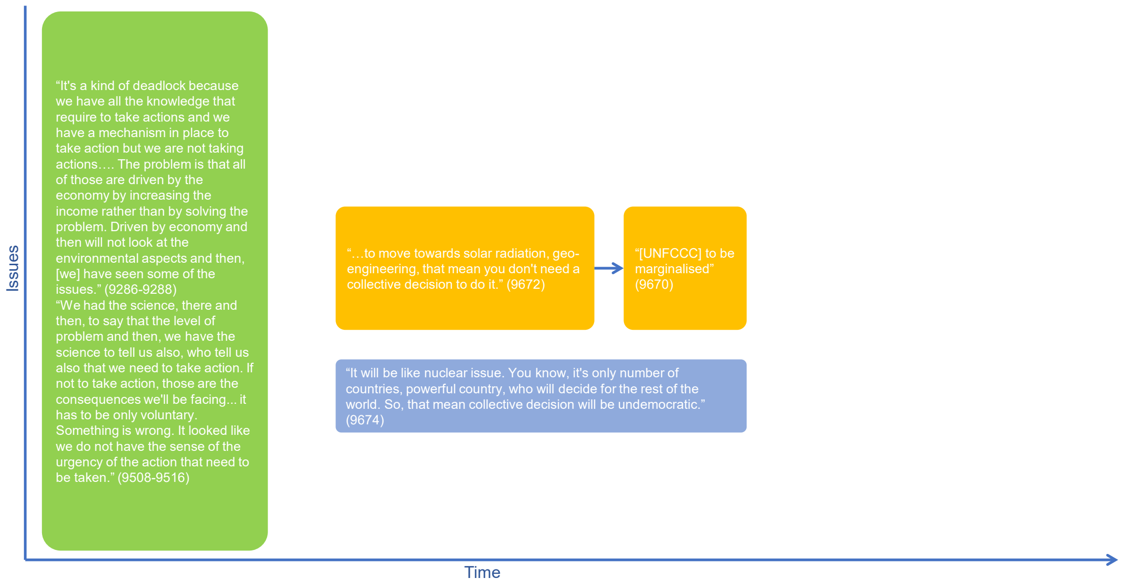
Complexity: One step, one layers
Assumptions:
Issues and options: Low ambition NDCs
Actors and interests:
Response: International cooperation, surpassing NDCs
Outcome: Other
Notes:
Coding: Other, international cooperation

Respondent 5 – Other scenario



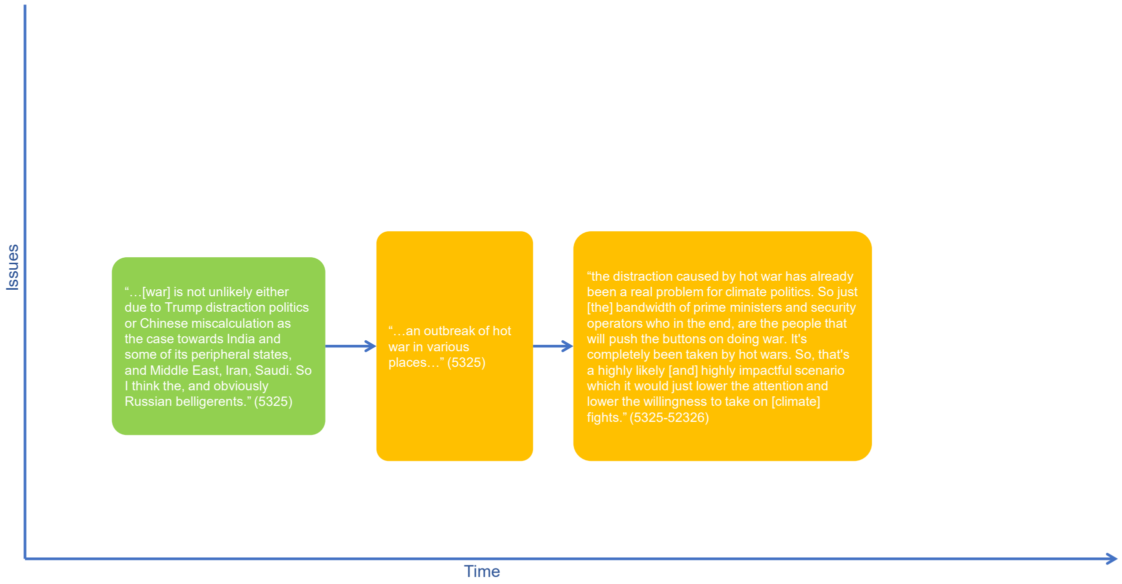
Complexity: One step, three layers
Assumptions:
Issues and options: Climate is a public good issue, but has been politicised
Actors and interests: UNFCCC a negotiations mechanism, politically driven
Response: International regime
Outcome: Other
Notes:
Coding: Other, international regime

Respondent 5 – Other scenario



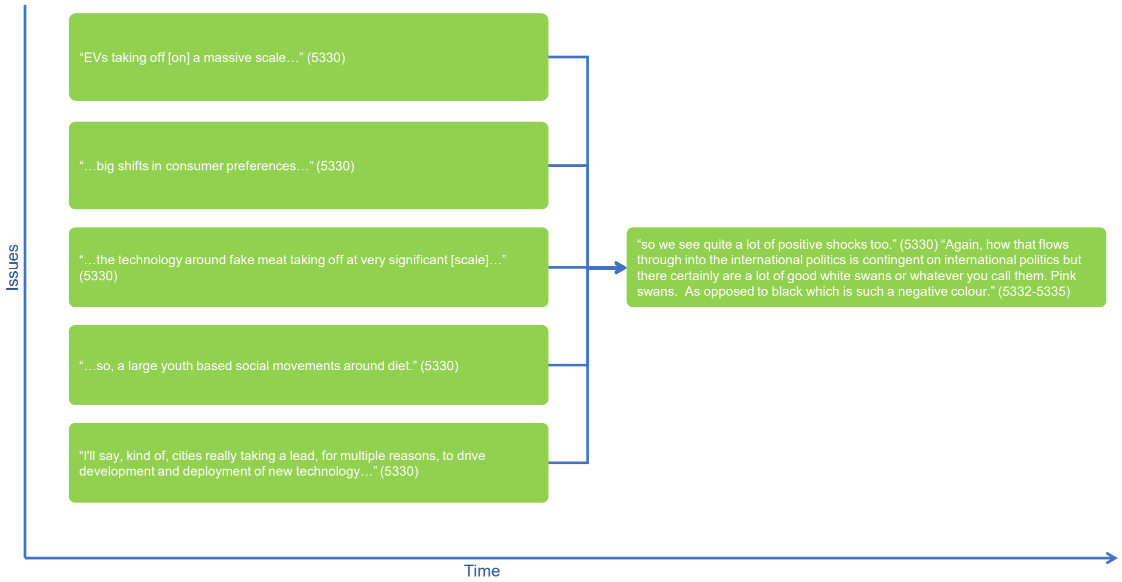
Complexity: Two steps linear, two layers including assumptions
Assumptions:
Issues and options:
Actors and interests: Powerful states will decide and impact other countries. UNFCCC could be marginalised.
Response: Failure of international cooperation, geoengineering, solar radiation management
Outcome: Other
Notes: UNFCCC (marginalised)
Coding: Other, failure of international cooperation on climate change

Respondent 6 – Other scenario



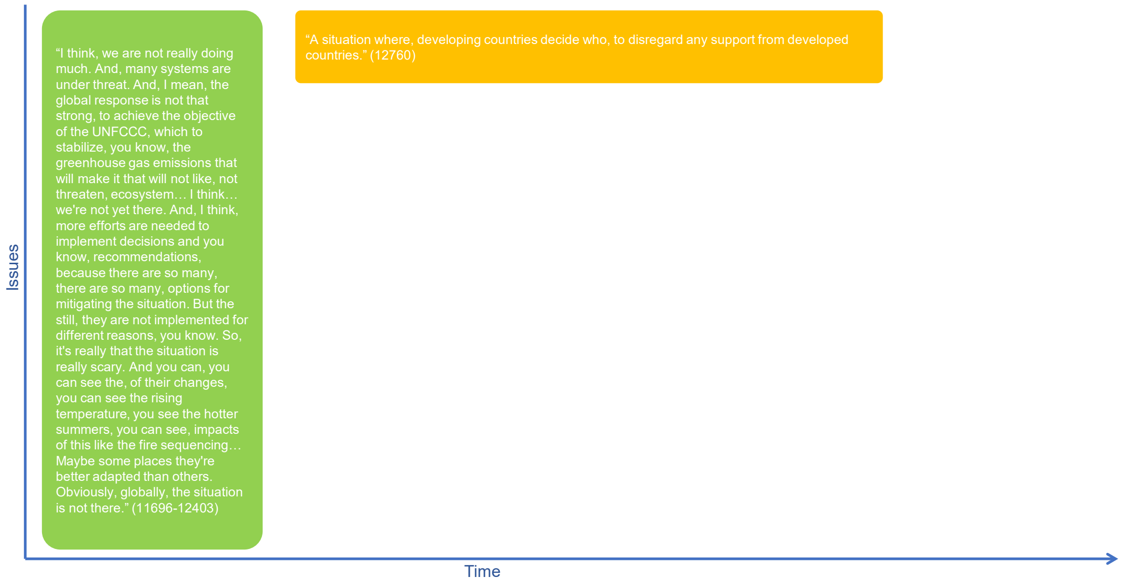
Complexity: Three steps linear, one layer
Assumptions:
Issues and options: Other change, crisis or catastrophe. Hot war in various places
Actors and interests: Governments attention completely taken up by the war
Response: Conflict
Outcome: Other
Notes: Climate change ignored. No time or space for consideration of climate change issues [mitigation or GHG removals – resilience could be a consideration]
Coding: Other, other change, crisis or catastrophe

Respondent 6 – Other scenario



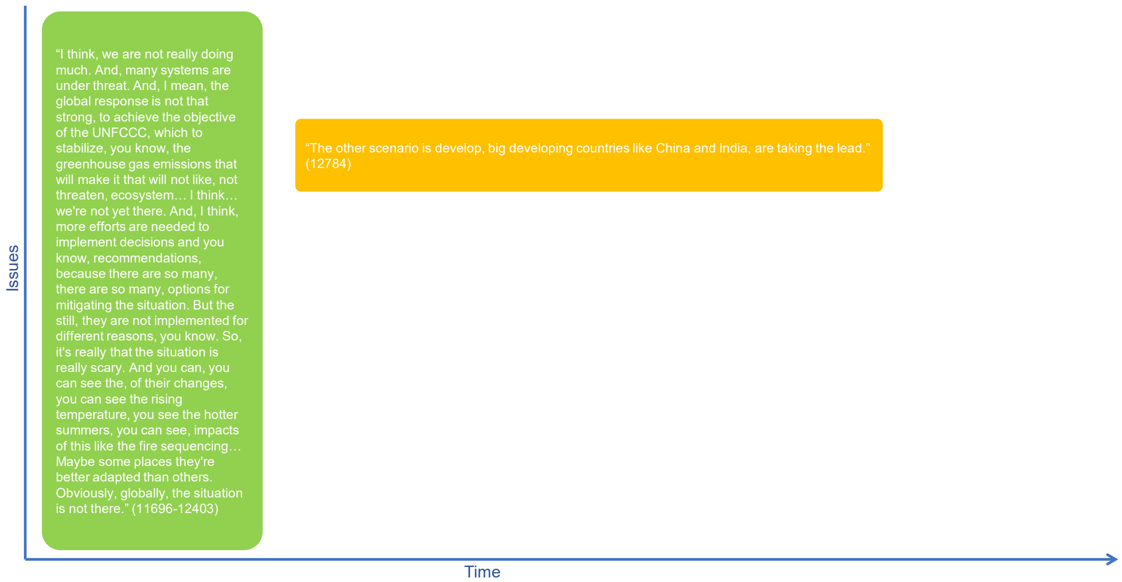
Complexity: Two steps merging, five layers, options
Assumptions: Positive low probability high impact changes are also possible
Issues and options:
Actors and interests: Youth shaping the future they want, consumers, cities
Response: Behaviour
Outcome: Other
Notes: EV uptake, changes in consumer preferences, consumption of meat alternatives, youth movements, city development and technology
Coding: Other, behaviour

Respondent 10 – Other scenario



Complexity: One step, one layer
Assumptions:
Issues and options:
Actors and interests:
Response: International cooperation
Outcome: Other
Notes:
Coding: Other, international cooperation

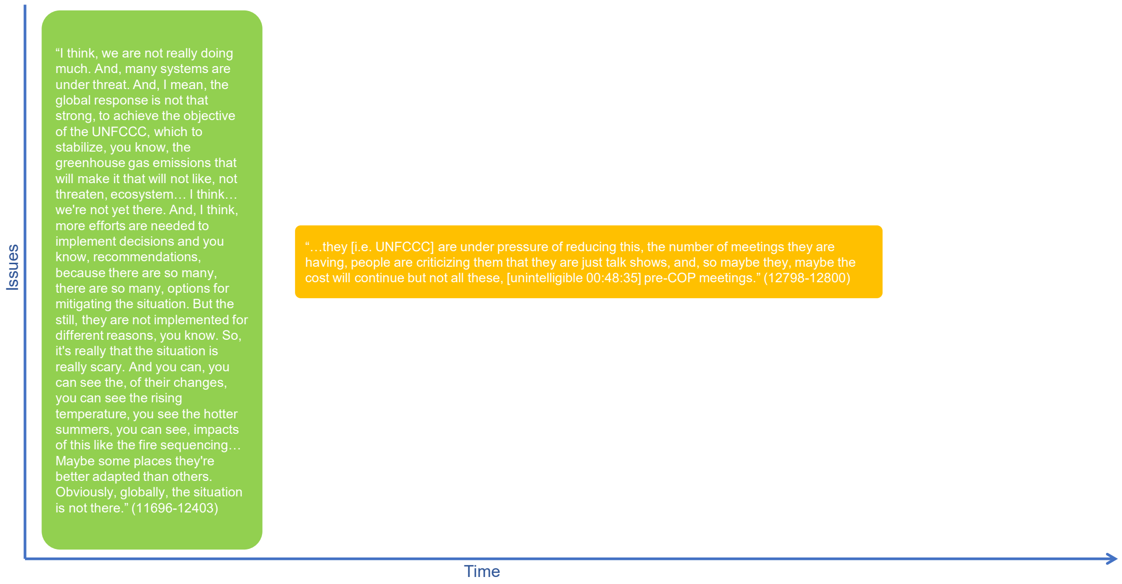
Respondent 10 – Other scenario



Complexity: One step, one layer
Assumptions:
Issues and options:
Actors and interests: Big developing countries e.g. China and India
Response: Leadership
Outcome: Other
Notes:
Coding: Other, leadership

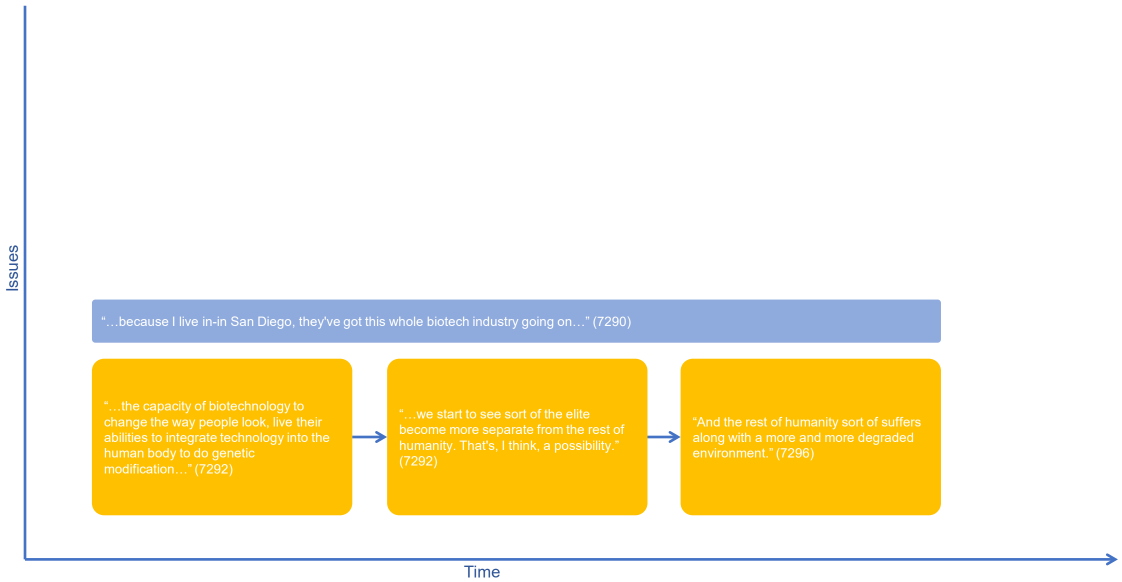
Other scenarios

Respondent 10 – Other scenario



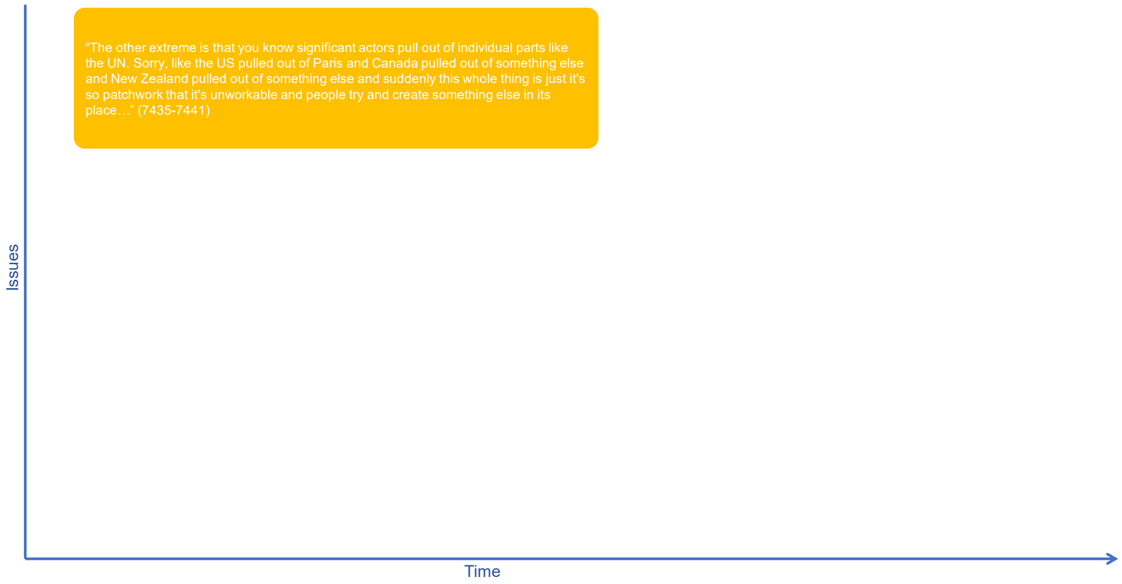
Complexity: One step, one layer
Assumptions:
Issues and options:
Actors and interests:
Response: Failure of international cooperation
Outcome: Other
Notes: Reduction in number of UNFCCC related meetings
Coding: Other, failure of international cooperation on climate change

Respondent 11 – Other scenario



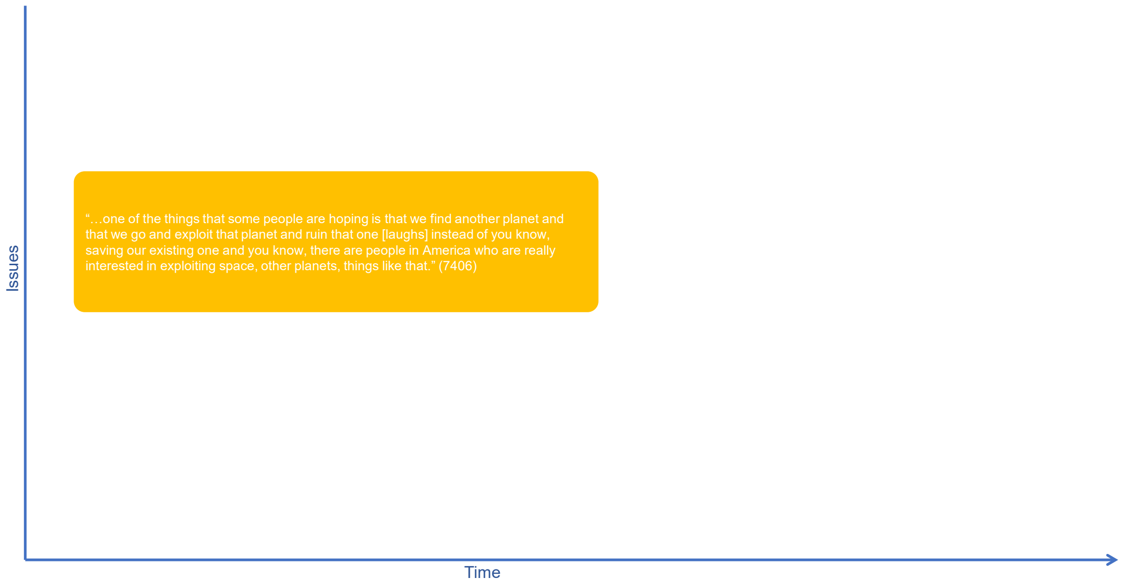
Complexity: Three steps linear, two layers including assumptions
Assumptions:
Issues and options: Biotechnological advance and application to people
Actors and interests: Wealthy and poor
Response: Technology, inequality
Outcome: Other
Notes:
Coding: Other, technology

Respondent 11 – Other scenario



Complexity: One step, one layer
Assumptions:
Issues and options:
Actors and interests: States
Response: Fragmentation of international cooperation, withdrawal
Outcome: Other
Notes: States start pulling out of parts of the United Nations system, UN system collapse (patchwork collapse)
Coding: Other, withdrawal, fragmentation of international cooperation

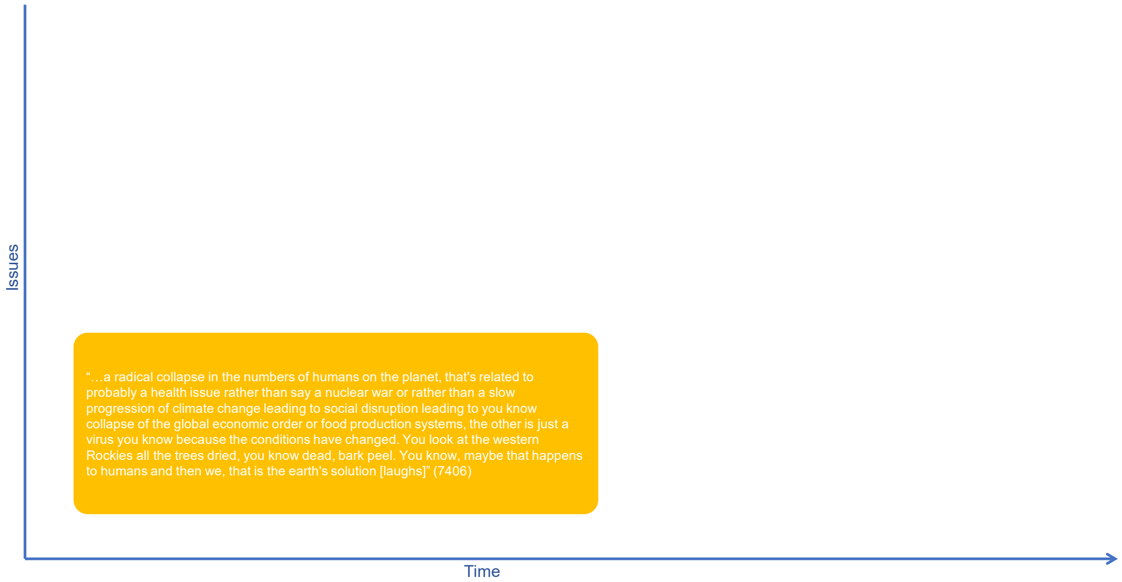
Respondent 11 – Other scenario



Complexity: One step, one layer
Assumptions:
Issues and options:
Actors and interests:
Response: Space colonisation
Outcome: Other
Notes: Space exploration, colonisation of planets (and moon?)
Coding: Other, space exploration

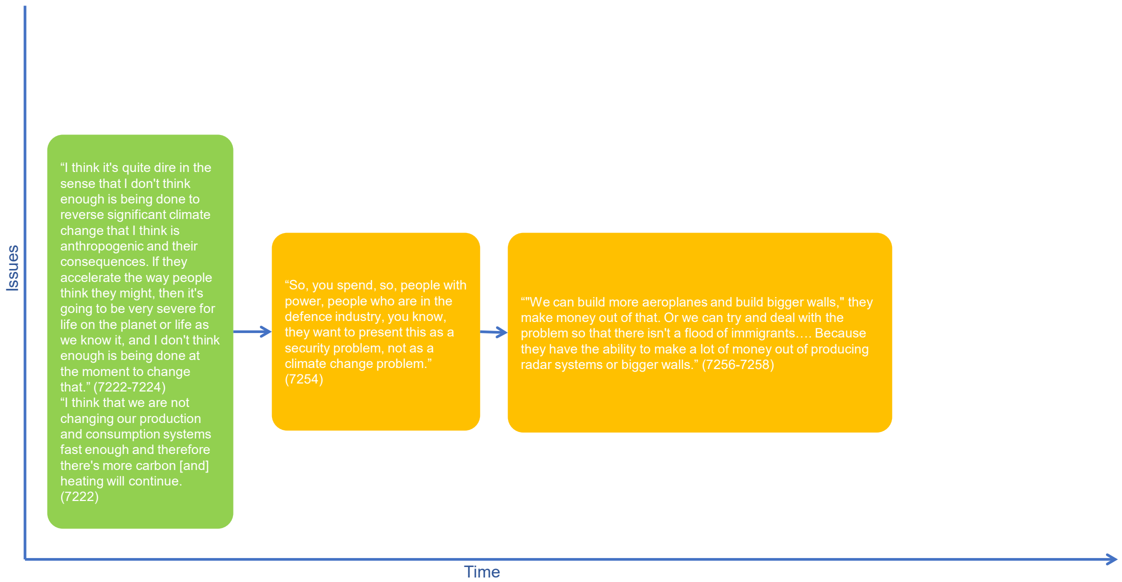
Other scenarios

Respondent 11 – Other scenario



Complexity: One step, one layer
Assumptions:
Issues and options: Other change, crisis or catastrophe. Collapse of human population
Actors and interests:
Response:
Outcome: Other
Notes:
Coding: Other, other change, crisis or catastrophe

Respondent 11 – Other scenario

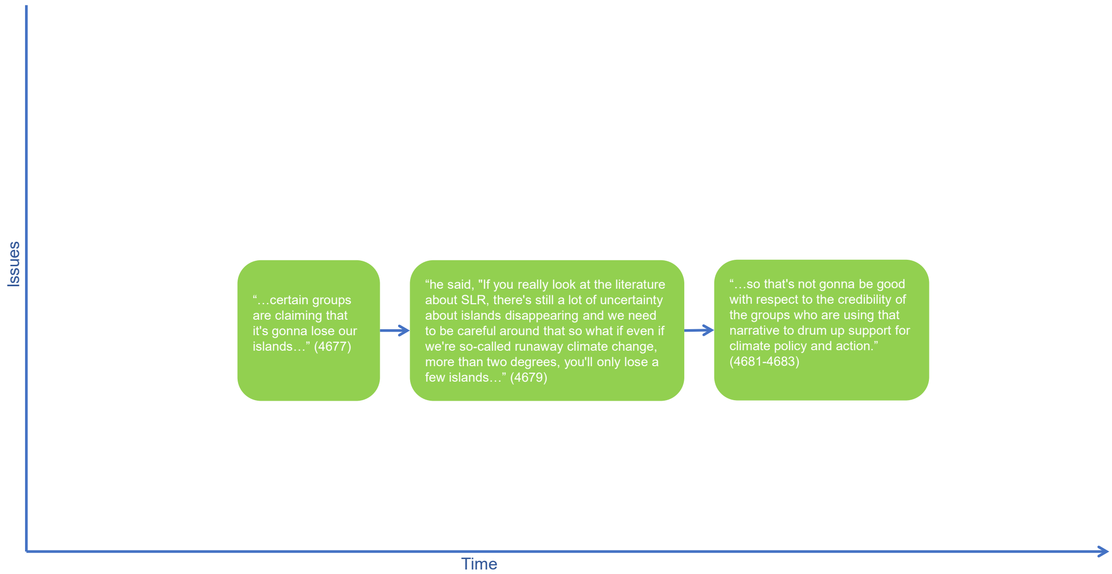


Complexity: Three steps linear, one layer
Assumptions:
Issues and options:
Actors and interests: Security sector see climate change as a security issue (military industrial complex)
Response: Defence, technology, business and economy
Outcome: Other
Notes: Defensive technologies
Coding: Other, defence

Respondent 12 – Other scenario

Complexity: Three steps linear, two layers including assumptions
Assumptions:
Issues and options: Climate sensitivity lower than expected, more time to organise, respond, learn and adapt.
Actors and interests:
Response: Adaptation
Outcome: Other
Notes:
Coding: Other, climate sensitivity

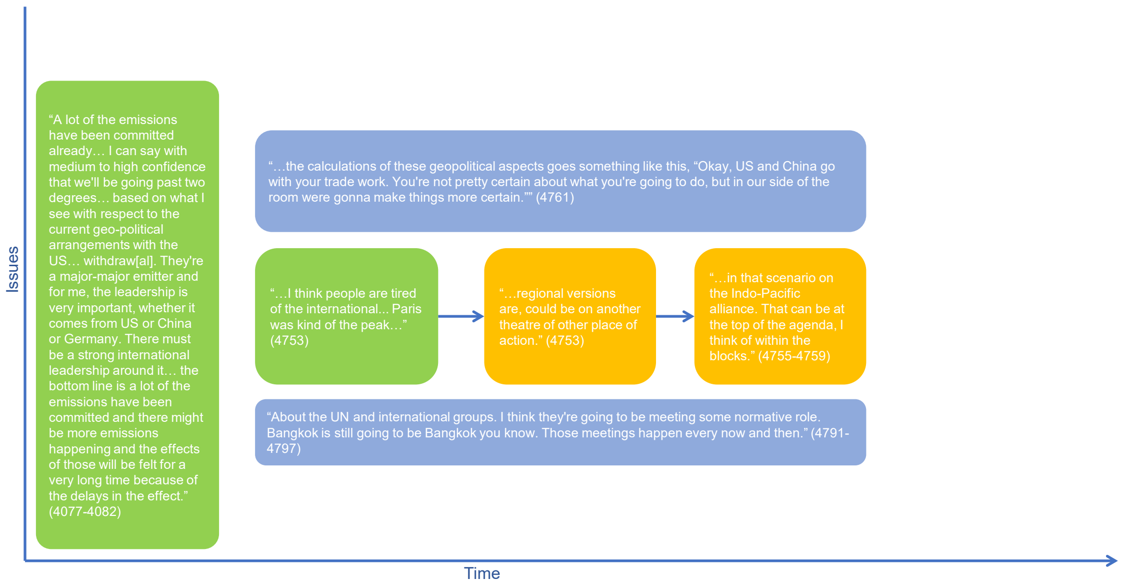
Respondent 12 – Other scenario



Complexity: Three steps linear, one layer
Assumptions:
Issues and options: Sea level rise lower than expected
Actors and interests:
Response:
Outcome: Other, loss of climate change research and policy credibility
Notes:
Coding: Other, social change

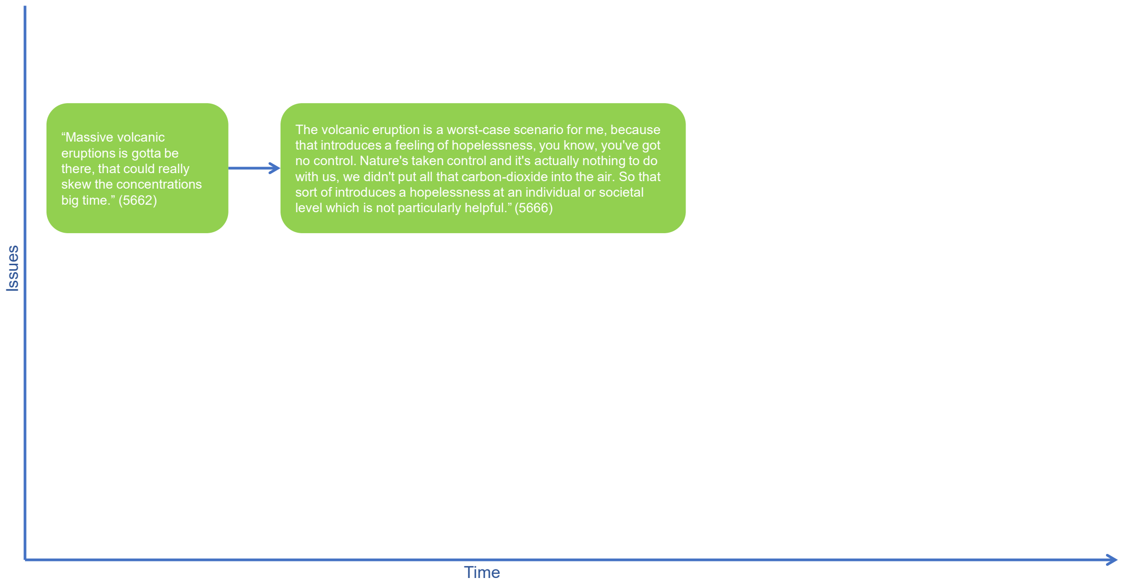
Other scenarios

Respondent 12 – Other scenario



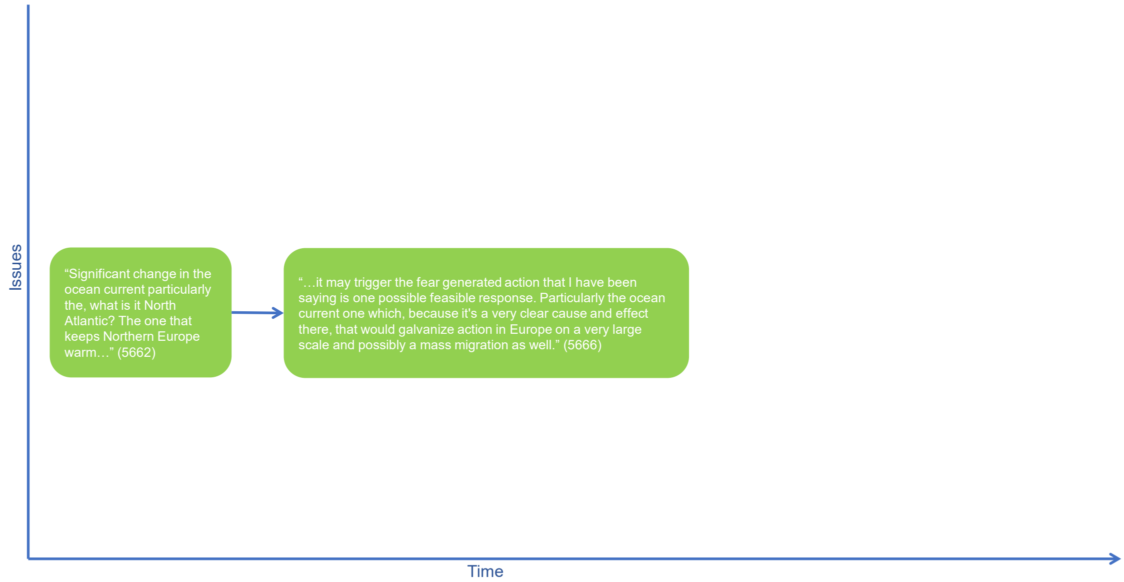
Complexity: Three steps linear, three layers with assumptions
Assumptions:
Issues and options: Regional versus global cooperation
Actors and interests: States interested in regional cooperation rather than global cooperation
Response: Fragmentation of international cooperation
Outcome: Other
Notes:
Coding: Other, fragmentation of international cooperation

Respondent 14 – Other scenario



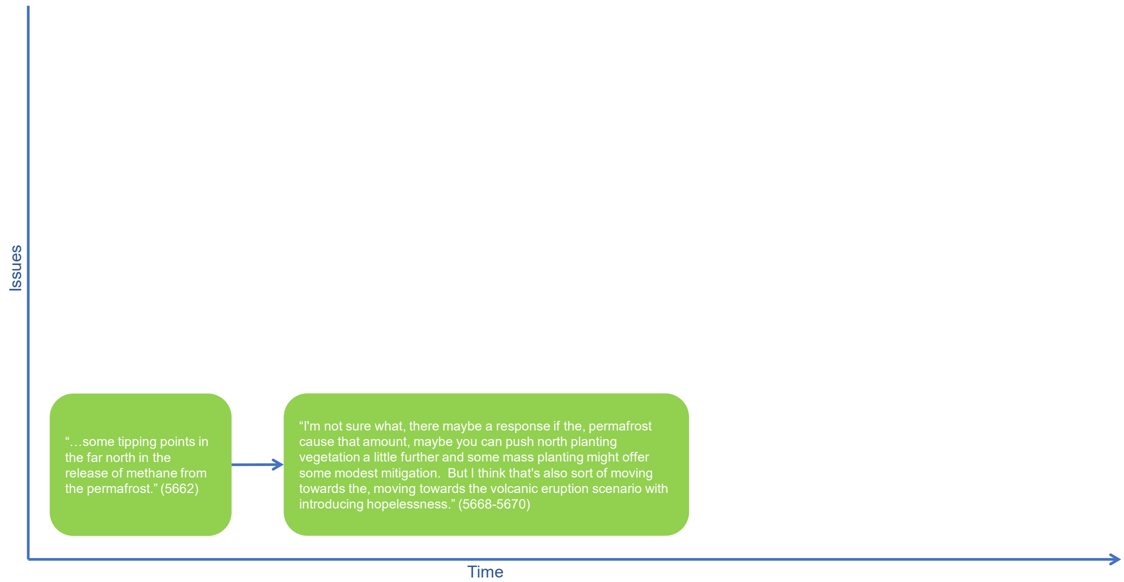
Complexity: Two steps linear, one layer
Assumptions:
Issues and options: Other change, crisis or catastrophe. Massive volcanic eruption affecting climate
Actors and interests: Society may become hopeless
Response:
Outcome: Other
Notes:
Coding: Other, other change, crisis or catastrophe

Respondent 14 – Other scenario



Complexity: Two steps linear, one layer
Assumptions:
Issues and options: Change in North Atlantic ocean current
Actors and interests: Realisation
Response: Impact response
Outcome: Other
Notes:
Coding: Other, impact response,

Respondent 14 – Other scenario



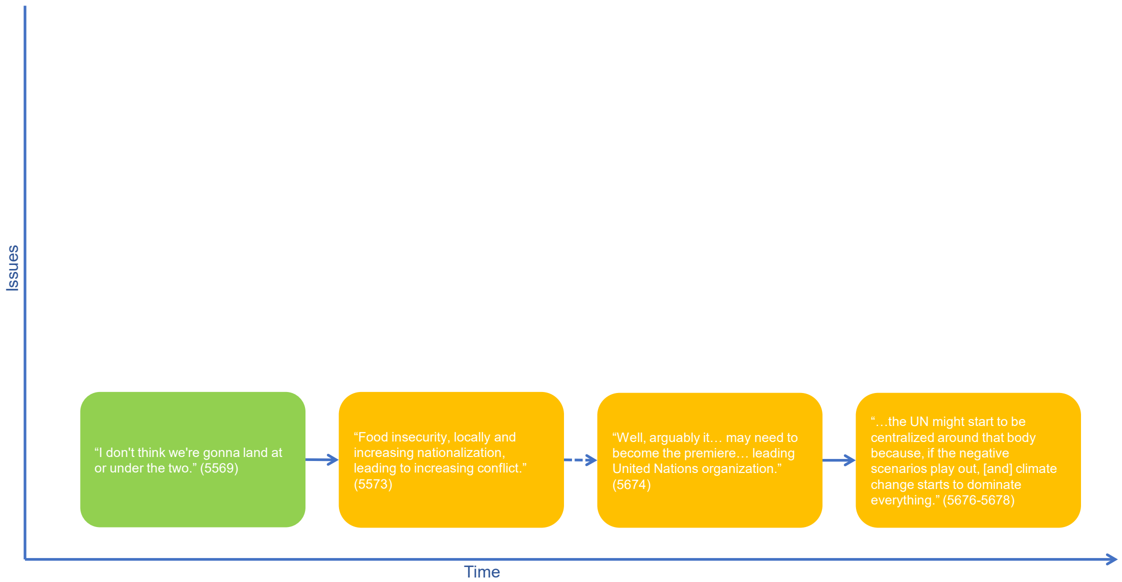
Complexity: Two steps linear, one layer
Assumptions:
Issues and options: Methane release tipping point (Arctic)
Actors and interests: Hopelessness
Response: Impact response
Outcome: Other
Notes:
Coding: Other, impact response

Other scenarios

Respondent 14 – Other scenario

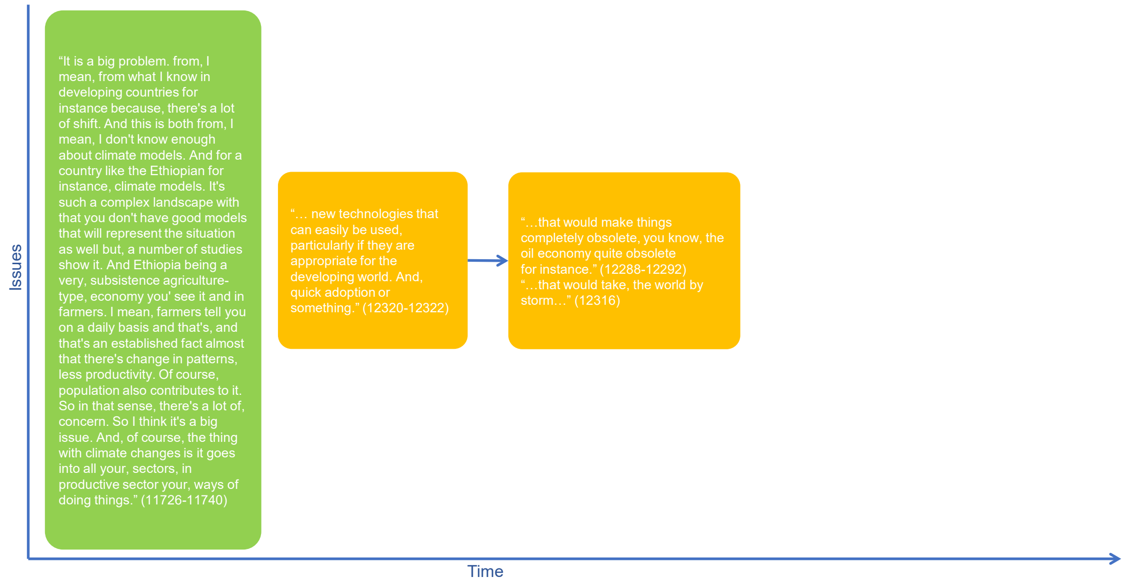
Complexity: Two steps linear, one layer
Assumptions:
Issues and options: Nationalism
Actors and interests: Nationalist leaders
Response: Fragmentation of international cooperation
Outcome: Other,
Notes: UN has trouble delivering its mandate
Coding: Other, fragmentation of international cooperation

Respondent 14 – Other scenario



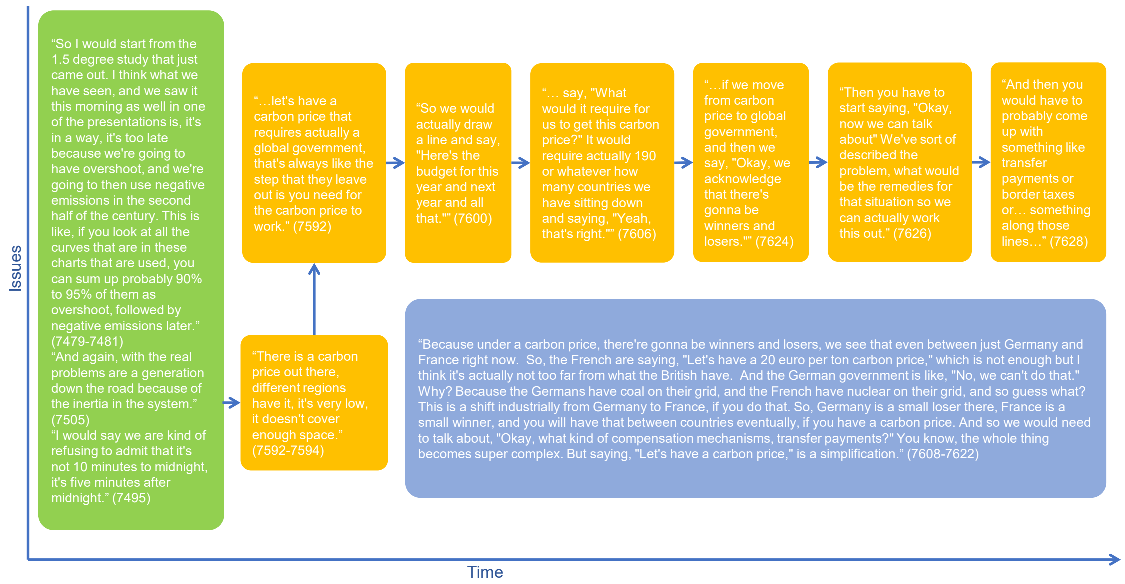
Complexity: Four steps linear, one layer
Assumptions:
Issues and options: Food insecurity, nationalism, conflict
Actors and interests:
Response: Impact response, international regime, international cooperation,
Outcome: Other
Notes: UNFCCC becomes the premier UN organisation
Coding: Other, international regime

Respondent 16 – Other scenario



Complexity: One step, one layer
Assumptions:
Issues and options: Ease of uptake and scale of uptake.
Actors and interests: Developing countries
Response: Technology, disruption
Outcome: Other
Notes:
Coding: Other, technology

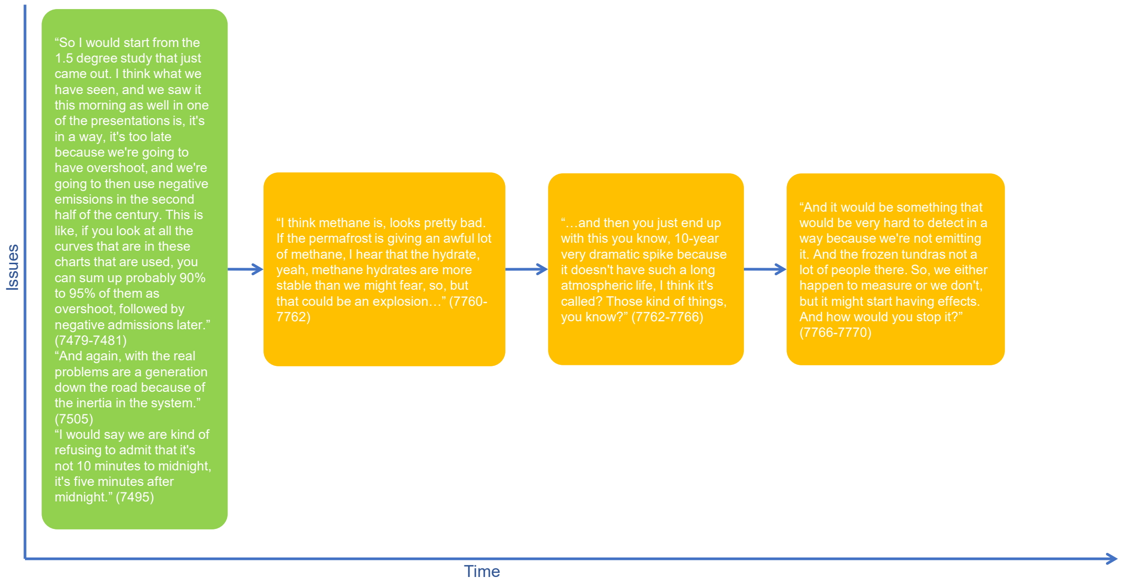
Respondent 17 – Other scenario



Complexity: Seven steps linear, two layers including assumptions
Assumptions:
Issues and options: Linking carbon markets, border taxes, transfer payments
Actors and interests: States
Response: Political will and policy
Outcome: Other
Notes: Carbon price, linked carbon markets
Coding: Other, political will and policy

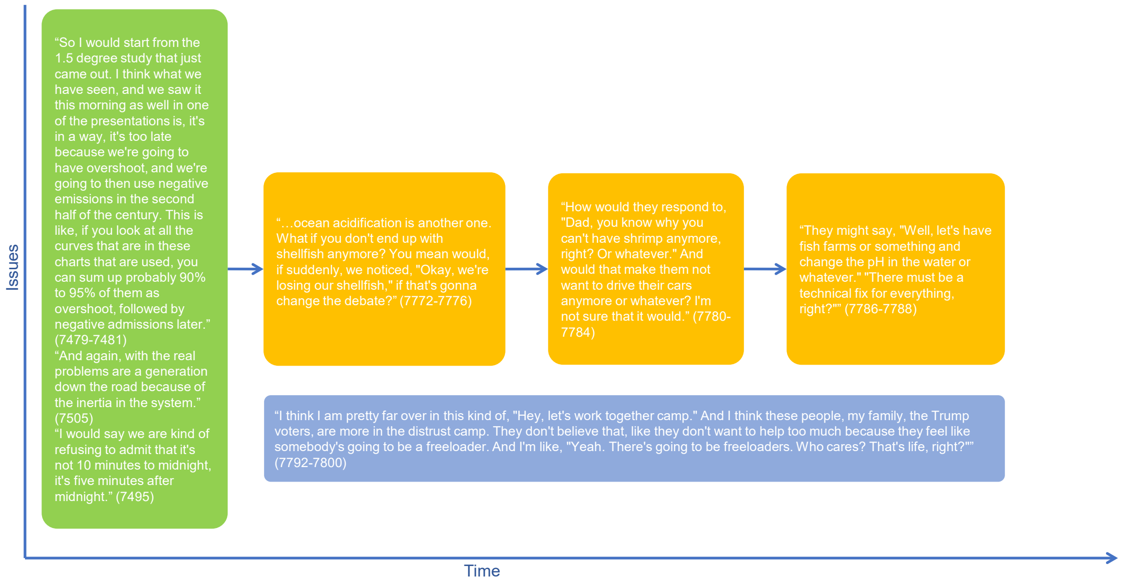
Other scenarios

Respondent 17 – Other scenario



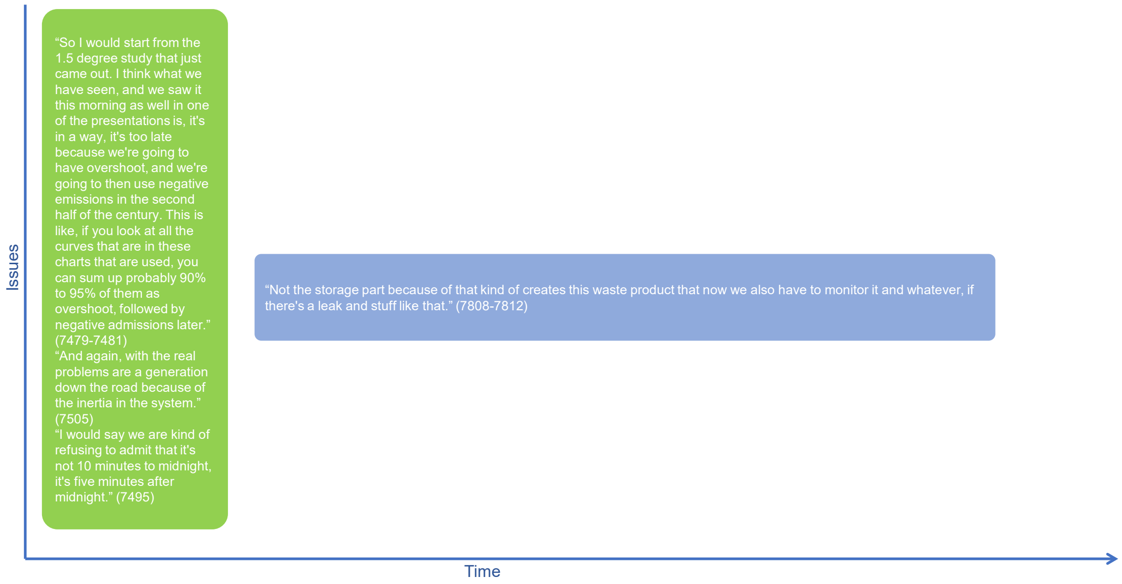
Complexity: Four steps linear, one layer
Assumptions:
Issues and options: Environmental feedback or tipping point. Rapid and massive methane release. How to monitor it? How to stop it?
Actors and interests:
Response:
Outcome: Other
Notes:
Coding: Other, environmental feedback or tipping point

Respondent 17 – Other scenario



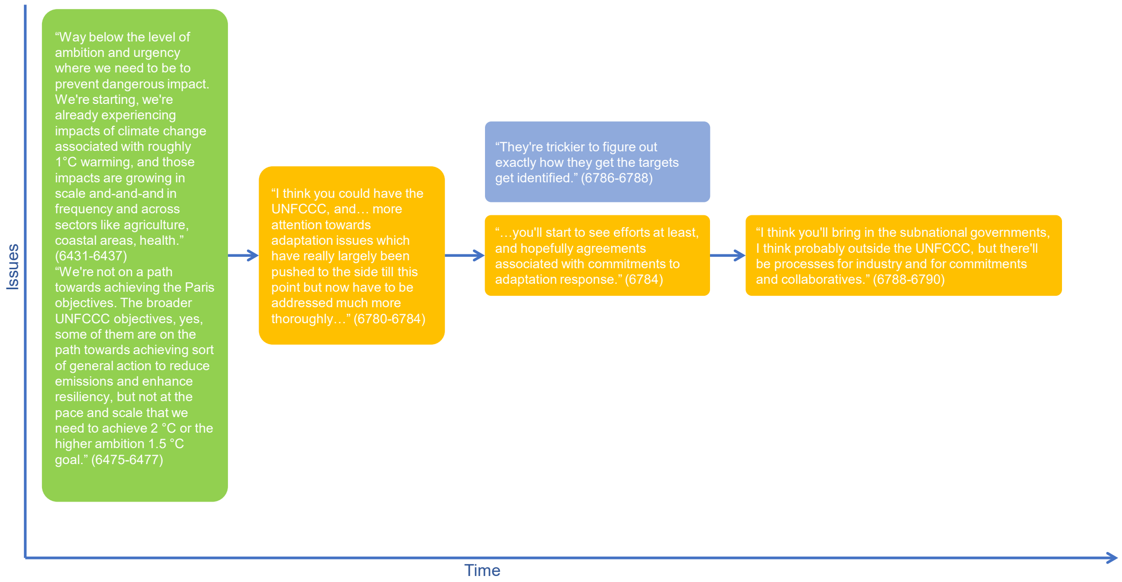
Complexity: Four steps linear, two layers including assumptions
Assumptions:
Issues and options: Impacts of climate change and related physical changes. Technological fixes
Actors and interests: Society
Response: Impact response, technology
Outcome: Other
Notes:
Coding: Other, impact response, technology

Respondent 17 – Other scenario



Complexity: One step, one layers
Assumptions:
Issues and options: Carbon capture and storage. What if it leaks? Risk
Actors and interests:
Response: Technology, carbon capture and storage
Outcome: Other
Notes:
Coding: Other, technology

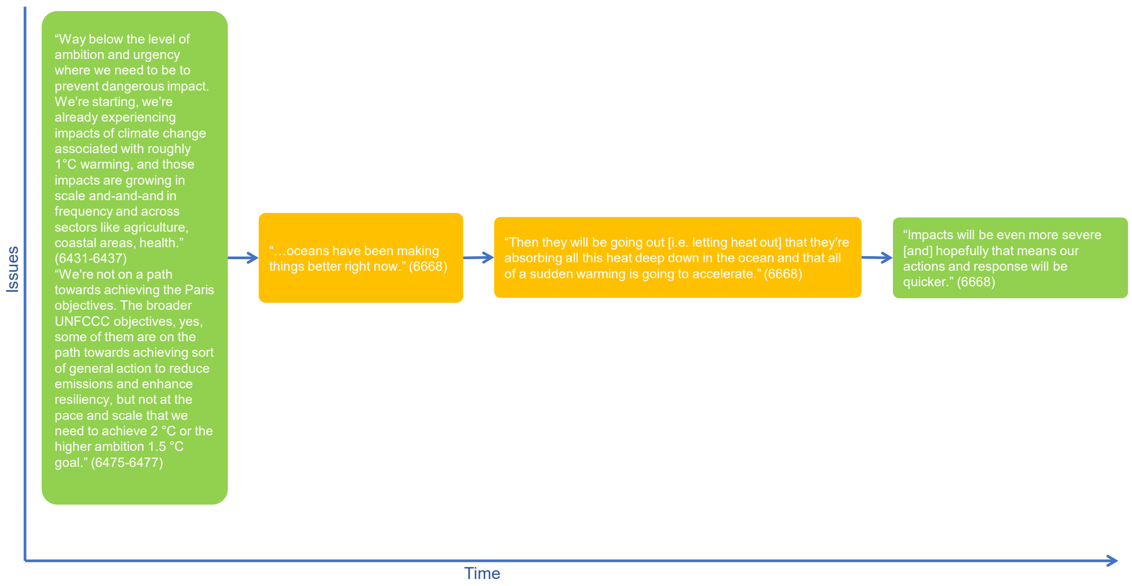
Respondent 18 – Other scenario



Complexity: Four steps linear, two layers including assumptions
Assumptions:
Issues and options:
Actors and interests: States, local government, industry
Response: International regime
Outcome: Other
Notes: Focus on adaptation, engagement of local government and industry
Coding: Other, international regime

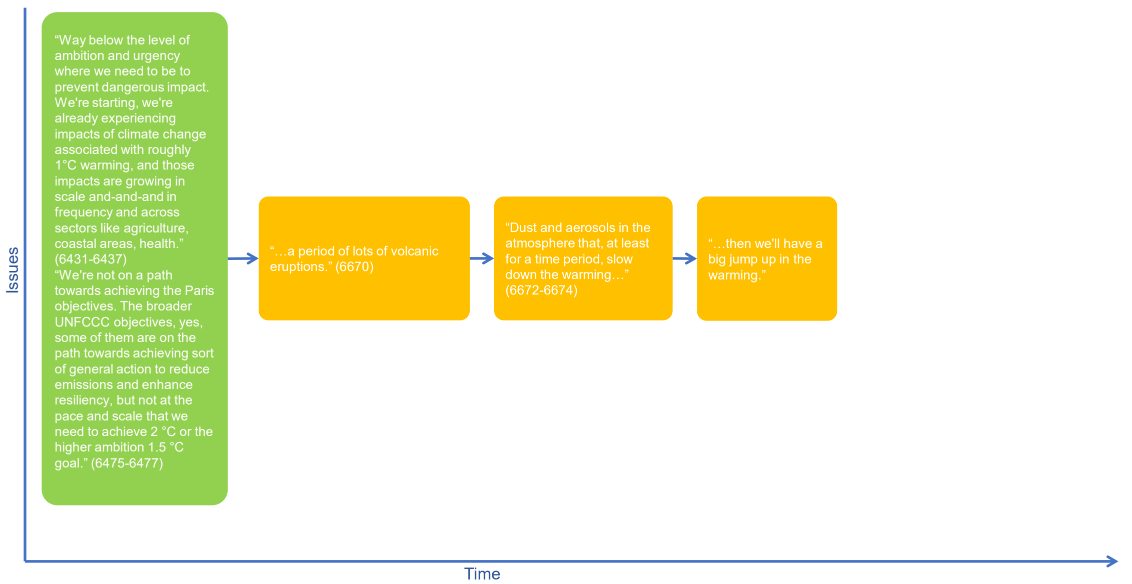
Other scenarios

Respondent 18 – Other scenario



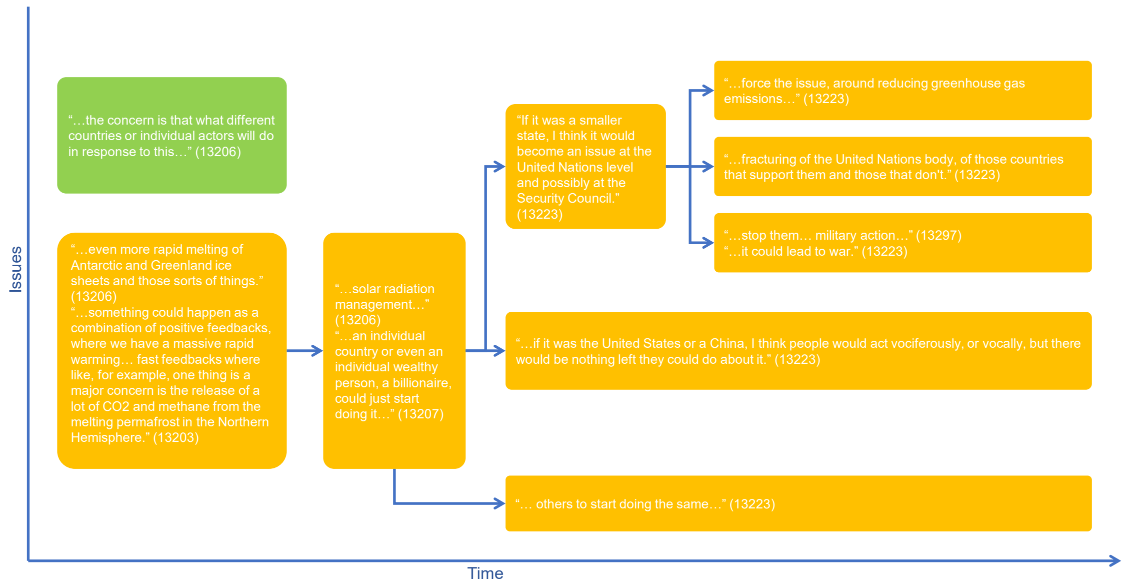
Complexity: Four steps linear, one layer
Assumptions:
Issues and options: Environmental feedback or tipping point. Oceans releasing heat, severe climate change impacts,
Actors and interests:
Response: Impact response
Outcome: Other
Notes:
Coding: Other, environmental feedback or tipping point

Respondent 18 – Other scenario



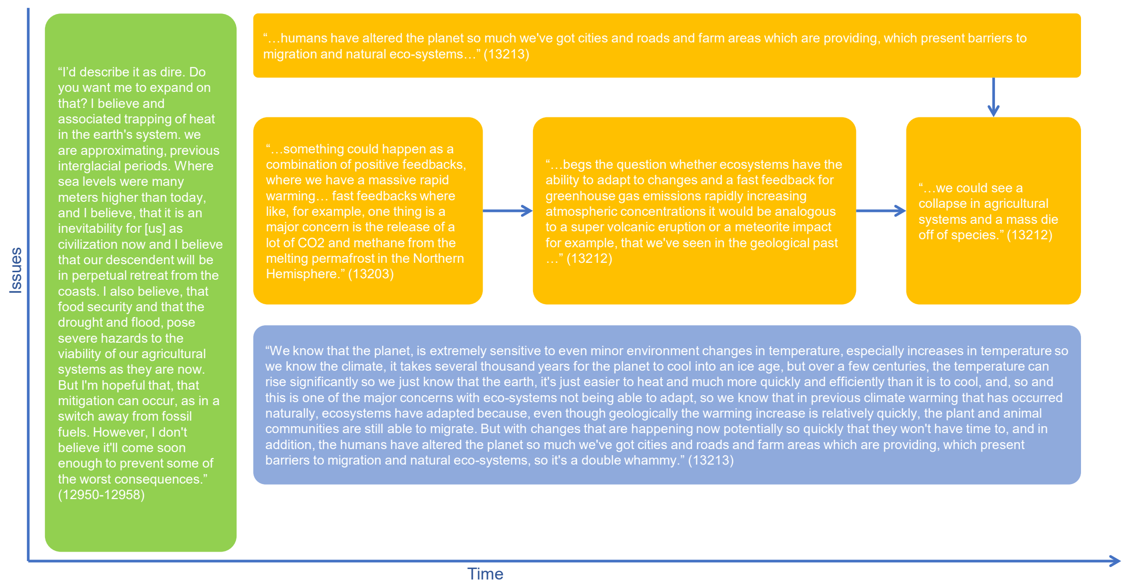
Complexity: Four steps linear, one layer
Assumptions:
Issues and options: Other change, crisis or catastrophe. A period of volcanic eruptions with aerosols slowing down global warming for a time, followed by a big jump in global warming
Actors and interests:
Response:
Outcome: Other
Notes:
Coding: Other, other change, crisis or catastrophe

Respondent 20 – Other scenario



Complexity: Four steps multiple branching, five layers including parallel conditions
Assumptions:
Issues and options: Fast feedback, massive melting of ice sheets, methane or carbon dioxide release from permafrost, option of solar radiation management.
Actors and interests: Individuals, small states, large states, United Nations
Response: Impact response, solar radiation management, geo-political power
Outcome: Other
Notes:
Coding: Other, impact response, solar radiation management

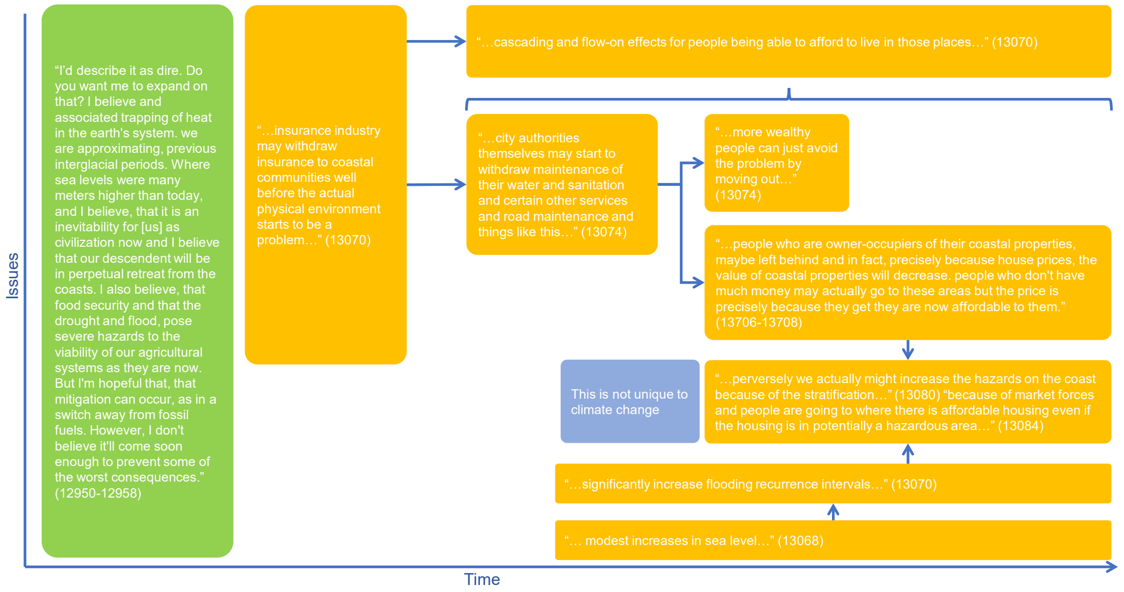
Respondent 20 – Other scenario



Complexity: Three steps linear, three layers with interrelations including assumptions.
Assumptions:
Issues and options: Environmental feedback or tipping point.
Actors and interests: Humans
Response:
Outcome: Other
Notes:
Coding: Other, environmental feedback or tipping point

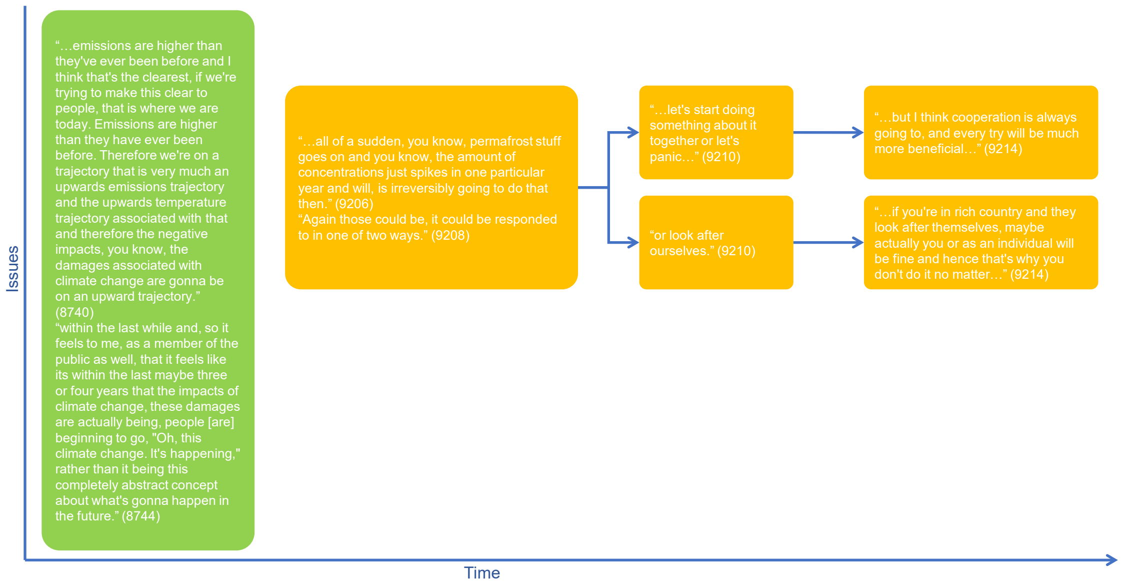
Other scenarios

Respondent 20 – Other scenario



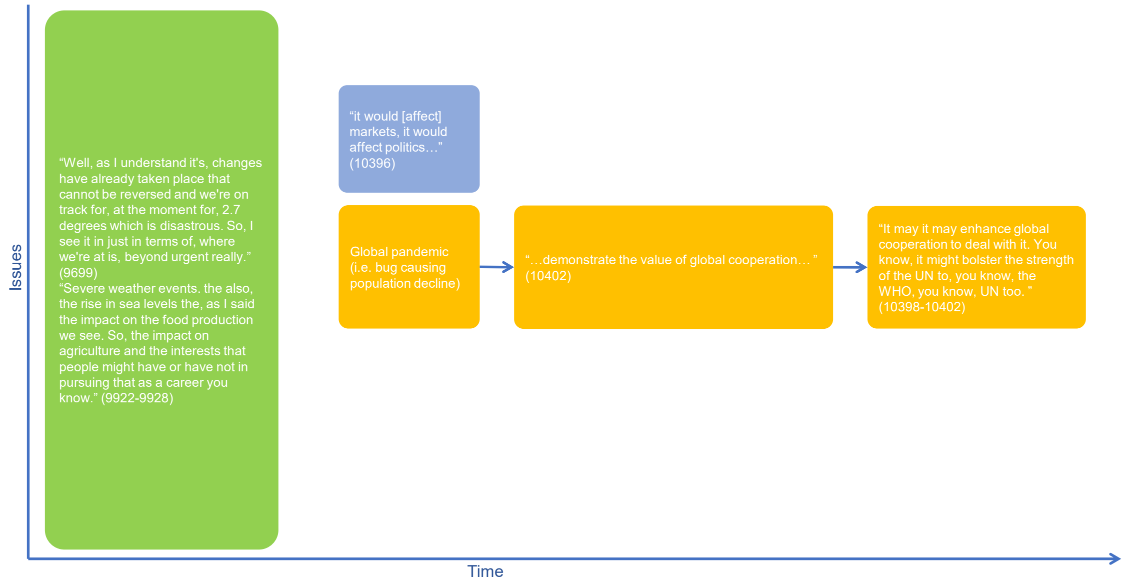
Complexity: Three steps branching, six layers including interrelations and assumptions
Assumptions:
Issues and options: Sea level rise, flooding, affordability of housing, social stratification, market forces
Actors and interests: Insurance industry, coastal communities, city authority maintenance services and budget costs, poor people, rich people
Response: Insurance and public service retreat
Outcome: Other
Notes: Insurance withdraw insurance coverage, cities stop maintaining infrastructure in some areas, poor move into cheap exposed areas
Coding: Other, insurance and public service retreat

Respondent 21 – Other scenario



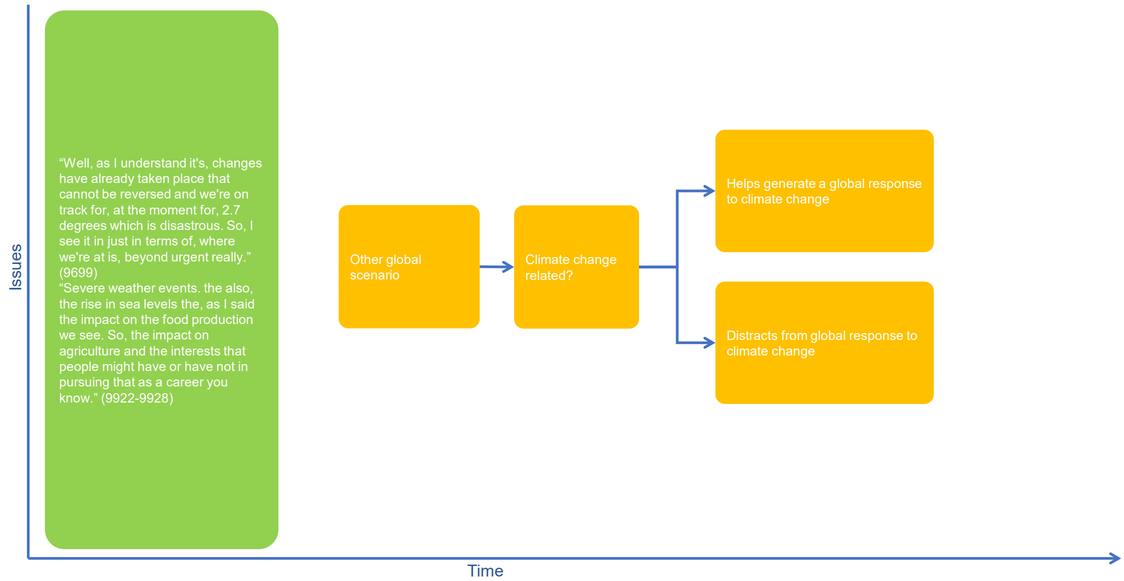
Complexity: Three steps branching, two layers
Assumptions:
Issues and options: Environmental feedback or tipping point. GHGs from the environment, tipping point, methane
Actors and interests: Some states may be fine regardless of having passed a tipping point. Other states may not be fine
Response:
Outcome: Other
Notes: Do something (collaborative intervention) or look after ourselves (defensive intervention)
Coding: Other, environmental feedback or tipping point

Respondent 22 – Other scenario



Complexity: Three steps linear, two layers including assumptions
Assumptions:
Issues and options: Global pandemic and international cooperation
Actors and interests: States and others realise international cooperation can be effective
Response: Other impact response, enlightenment, international cooperation, international regime
Outcome: Other
Notes:
Coding: Other, impact response, enlightenment

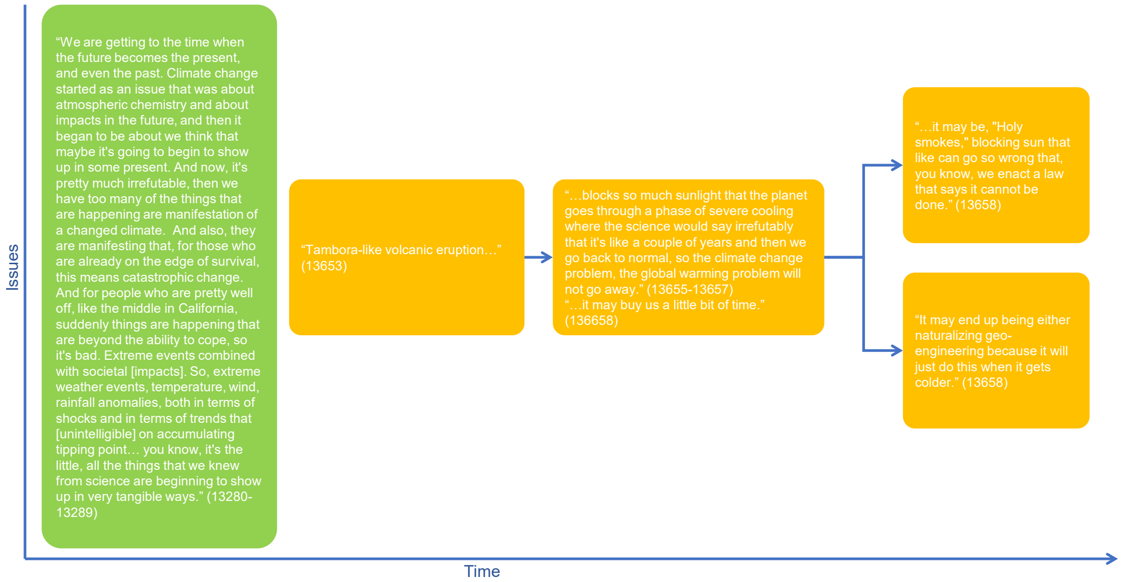
Respondent 22 – Other scenario



Complexity: Three steps branching, two layers
Assumptions:
Issues and options: Other change, crisis or catastrophe. Global issues not related to climate change might distract from the global response to climate change. Other global issues that are related to climate change may encourage a global response climate change
Actors and interests:
Response:
Outcome: Other
Notes:
Coding: Other, other change, crisis or catastrophe

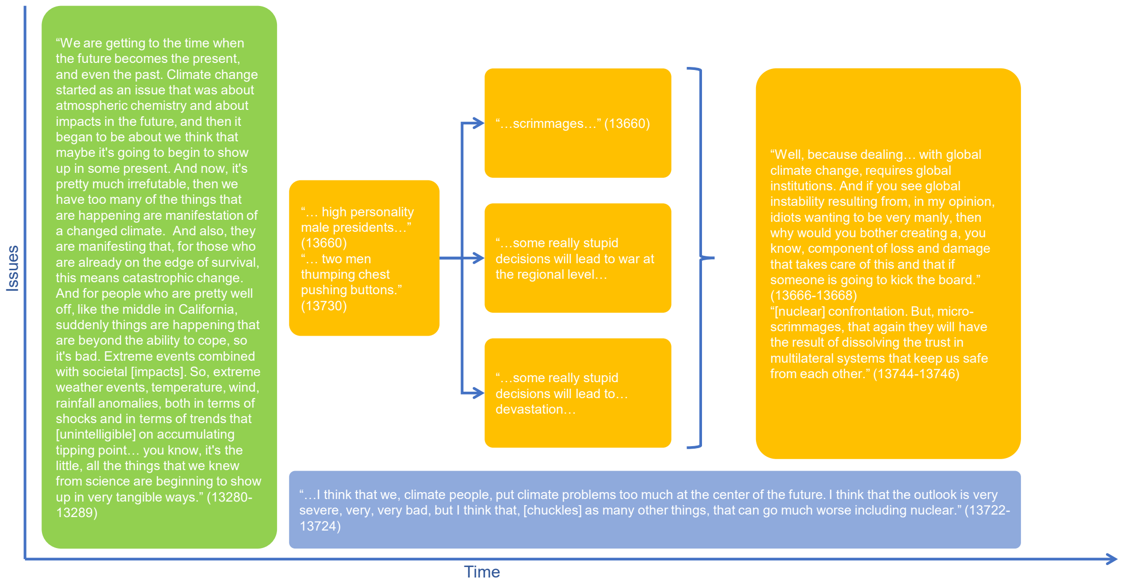
Other scenarios

Respondent 23 – Other scenario



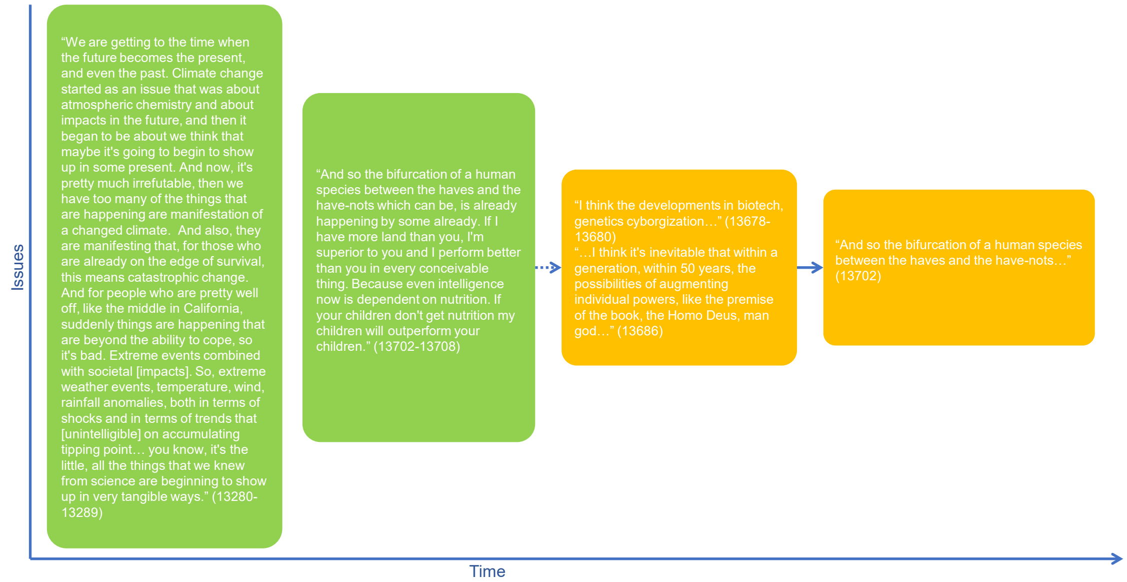
Complexity: Three steps branching, two layers
Assumptions:
Issues and options: A large volcanic eruption block sunlight and cools the world, then when aerosols fall out, temperatures go back up. The event serves as a natural experiment that may either encourage or discourage adoption
Actors and interests:
Response: Impact response, solar radiation management
Outcome: Other
Notes: Natural experiment
Coding: Other, solar radiation management

Respondent 23 – Other scenario



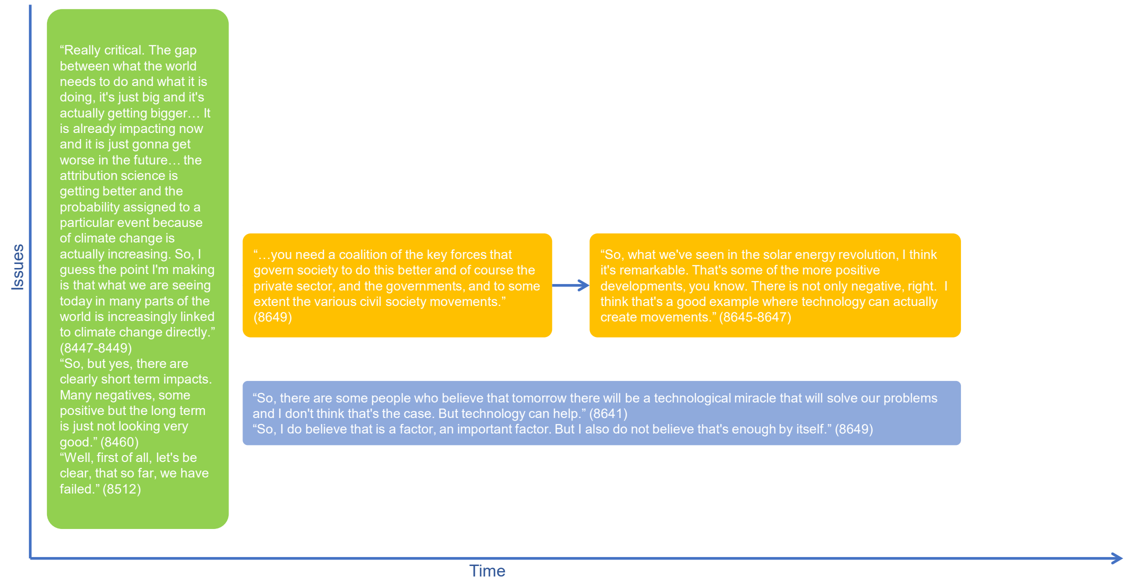
Complexity: Three steps branching and merging, four layers including assumptions
Assumptions: Climate change specialists put too much emphasis on climate change problems compared to other problems including war
Issues and options: Other change, crisis or catastrophe. War at different scales
Actors and interests: Macho political leaders, society
Response: Conflict
Outcome: Other
Notes: Reduced international cooperation, loss of trust in multilateral systems
Coding: Other, other change, crisis or catastrophe

Respondent 23 – Other scenario



Complexity: Three steps linear, one layer
Assumptions:
Issues and options: Biotechnological advance and application to people
Actors and interests: Wealthy and poor
Response: Technology, inequality
Outcome: Other
Notes:
Coding: Other, technology

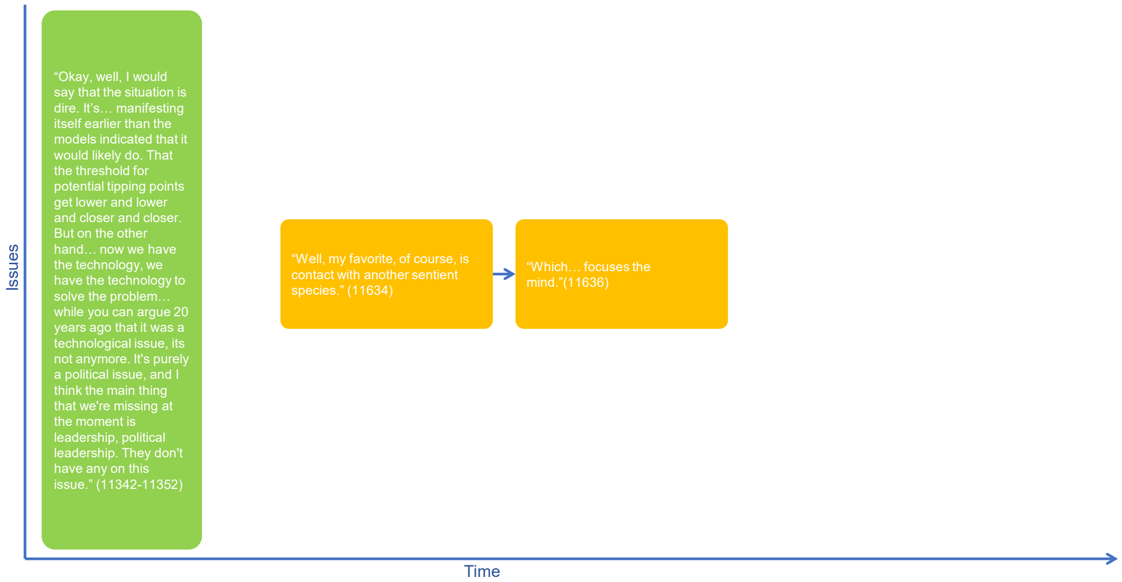
Respondent 24 – Other scenario



Complexity: Two steps linear, two layers
Assumptions:
Issues and options: Technologies meeting the needs of different actors and groups
Actors and interests: Government, business and civil society
Response: Technology, social change, geo-political power (coalition)
Outcome: Other
Notes: Coalition of governments, business and civil society
Coding: Other, technology

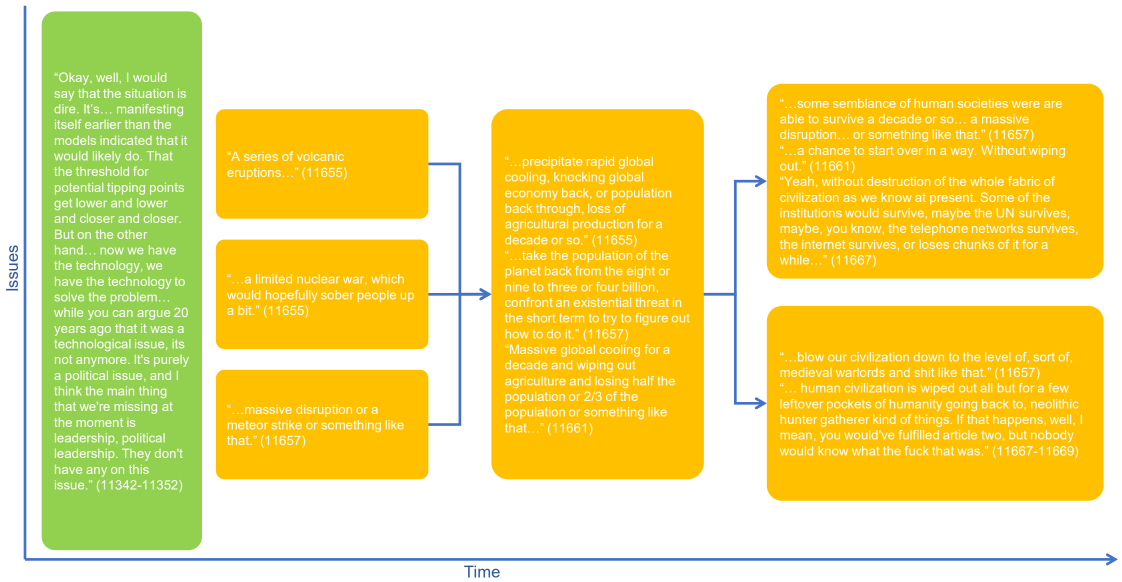
Other scenarios

Respondent 25 – Other scenario



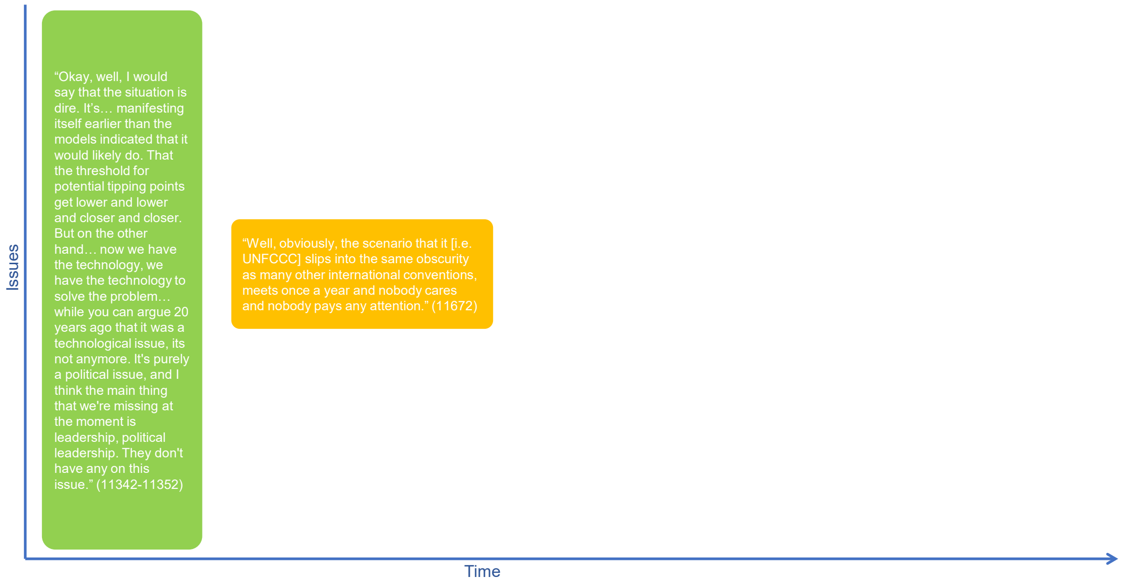
Complexity: Two steps, one layer
Assumptions:
Issues and options: Contact with another sentient species
Actors and interests:
Response: Enlightenment
Outcome: Other
Notes:
Coding: Other, enlightenment

Respondent 25 – Other scenario



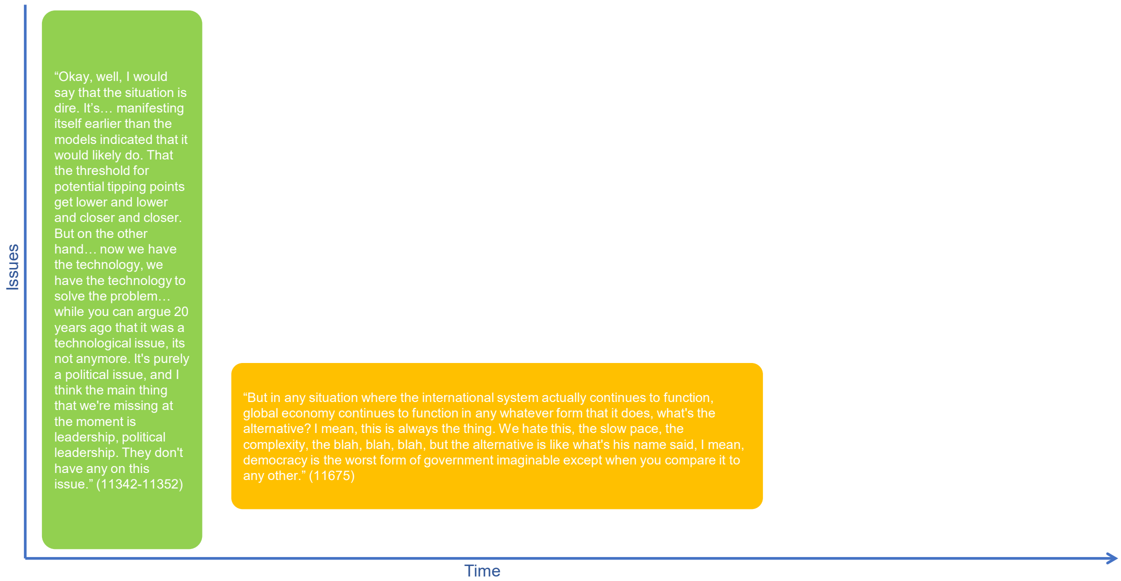
Complexity: Three step, three layers
Assumptions:
Issues and options: Other change, crisis or catastrophe. Volcanic eruption, limited nuclear war, meteor strike
Actors and interests:
Response:
Outcome: Other, global cooling, reduced agricultural production, institutional and civilisation disruption
Notes:
Coding: Other, other change, crisis or catastrophe

Respondent 25 – Other scenario



Complexity: One step, one layer
Assumptions:
Issues and options:
Actors and interests:
Response: Failure of international cooperation
Outcome: Other
Notes: UNFCCC becomes irrelevant (slips into obscurity)
Coding: Other, failure of international cooperation on climate change

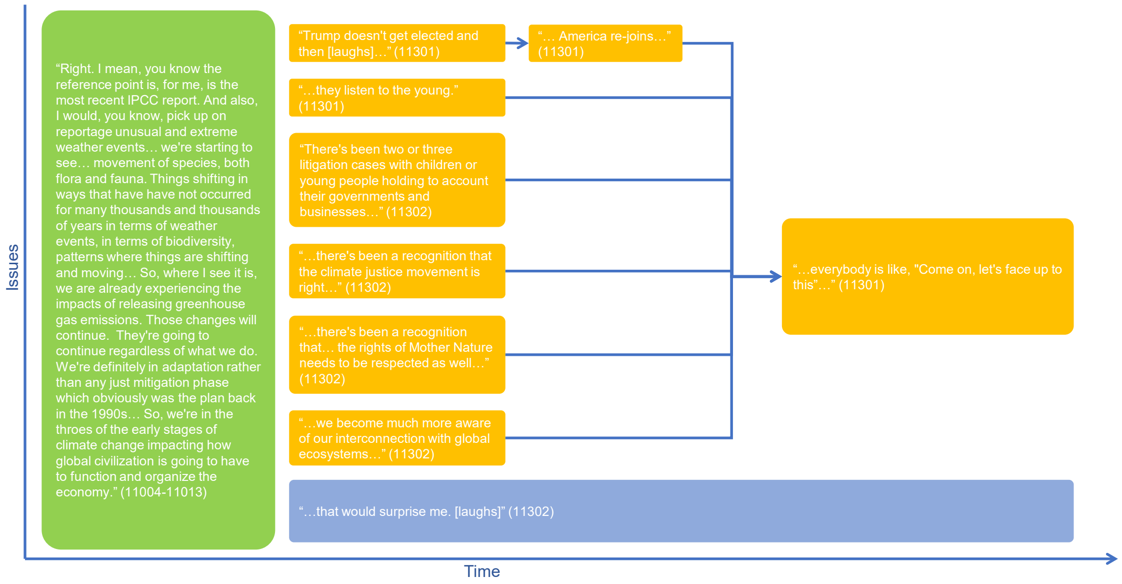
Respondent 25 – Other scenario



Complexity: One step, one layer
Assumptions:
Issues and options:
Actors and interests:
Response: International regime
Outcome: Other
Notes:
Coding: Other, international regime

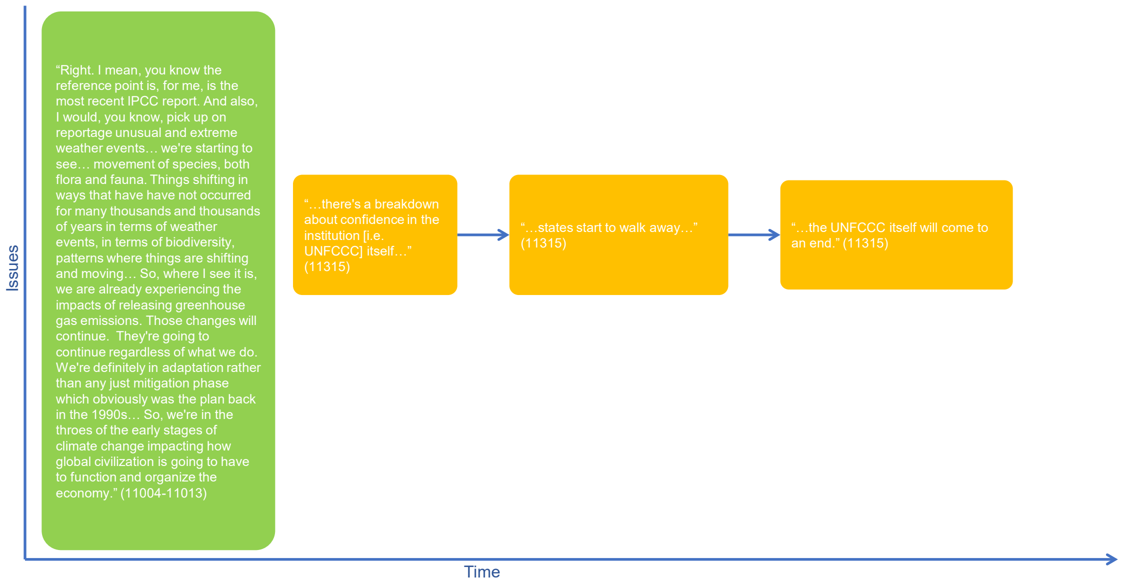
Other scenarios

Respondent 26 – Other scenario



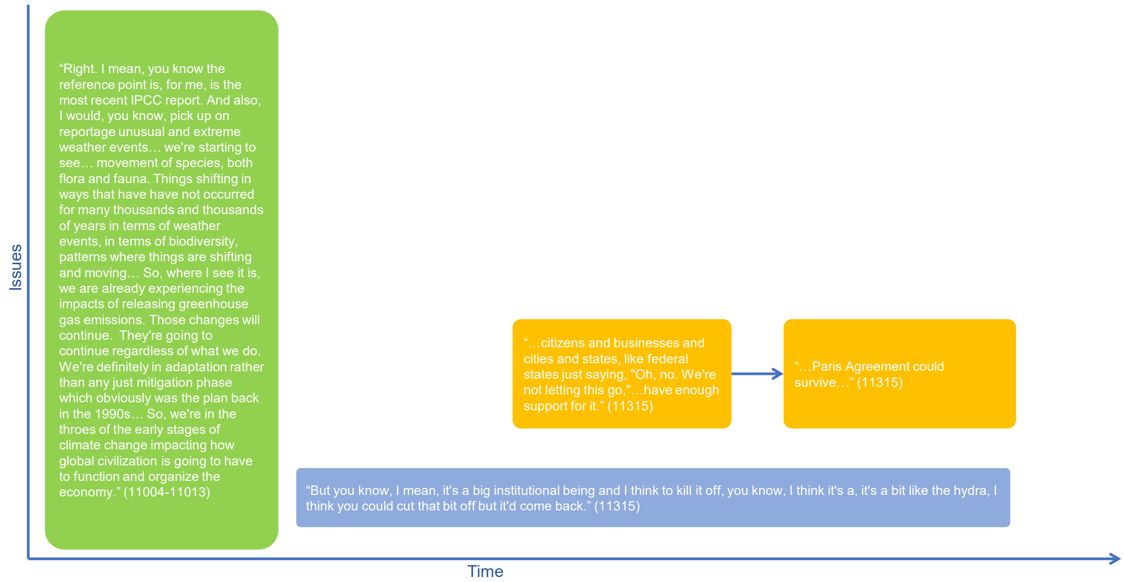
Complexity: Three steps merging, seven layers, options with assumptions.
Assumptions:
Issues and options:
Actors and interests:
Response: Social change
Outcome: Other
Notes: Youth activism, legal pressure, political movement, environmental rights, awareness
Coding: Other, social change

Respondent 26 – Other scenario



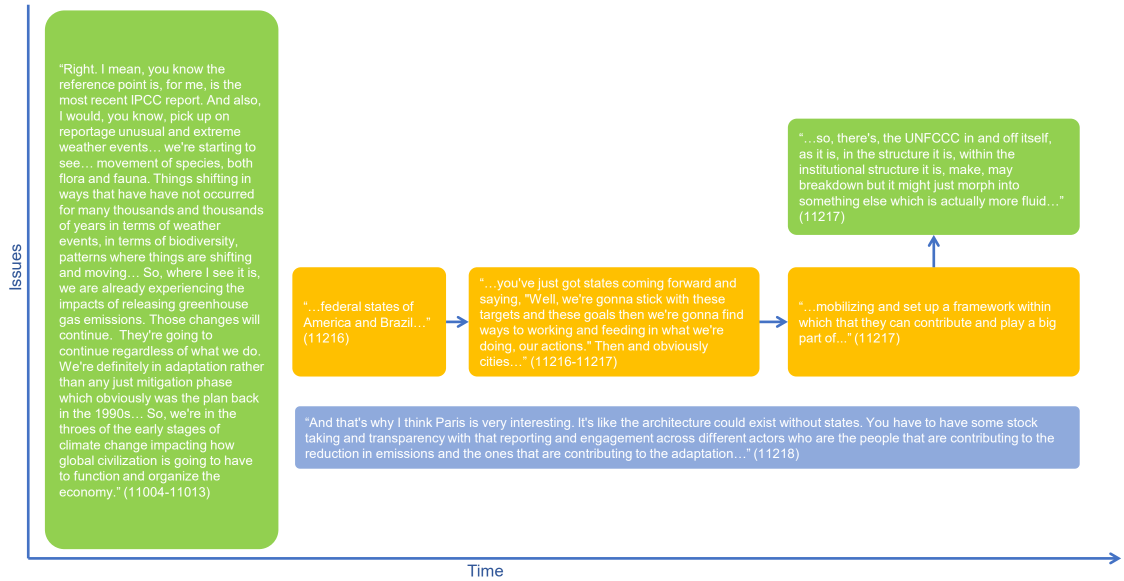
Complexity: Three steps linear, three layers including assumptions
Assumptions: Climate agreements are like the hydra
Issues and options: Participation and compliance with international climate change agreements.
Actors and interests: States not interested in the UNFCCC
Response: Withdrawal, failure of international cooperation
Outcome: Other,
Notes: Withdrawal, UNFCCC fails
Coding: Other, Withdrawal, failure of international cooperation on climate change

Respondent 26 – Other scenario



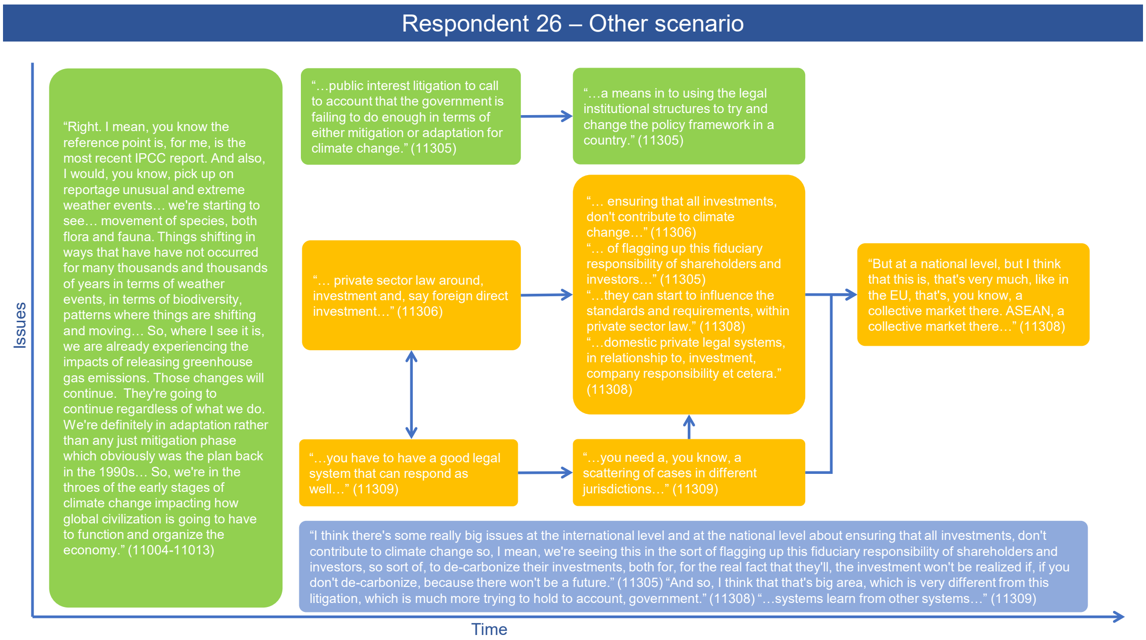
Complexity: Two steps linear, two layers including assumptions
Assumptions: Climate agreements are like the hydra
Issues and options: Participation and compliance with international climate change agreements.
Actors and interests: Sub-national actors are interested in continuation of the Paris Agreement
Response: International cooperation
Outcome: Other
Notes:
Coding: Other, international cooperation

Respondent 26 – Other scenario



Complexity: Three steps linear, three layers with interrelations including assumptions
Assumptions: Paris Agreement architecture could exist without states.
Issues and options:
Actors and interests: Subnational administrative units could adopt targets and goals from the Paris Agreement and NDCs.
Response: International cooperation,
Outcome: Other
Notes: Create a framework for sub-national administrative units to participate and comply with the UNFCCC
Coding: Other, international cooperation

Other scenarios



Complexity: Three steps merging, four layers with interrelations including parallel conditions and assumptions
Assumptions:
Issues and options: Legal options, public interest litigation, private sector law, quality of the legal system. Legal cases in different jurisdictions.
Actors and interests: Shareholders, business, courts
Response: Legal response
Outcome: Other
Notes: Legal (ensure all investments don't contribute to climate change), international cooperation (collective markets and legal requirements)
Coding: Other, legal response

Appendix T: Timeliness and scale of responses

Table T-1: Cynical and non-responses and implications for the timeliness and scale of global responses to climate change.

Trigger or driver:	Contribution to the global response	Timeliness of global response	Scale of global response
Cynical response	Some actors push their own interests increasing GHG emissions.	Due to the deliberate negative contributions to the global response, other actors need to act quicker on mitigation and removals if climate change and its impacts are to be limited.	Other actors need to increase the scale of mitigation and removals if climate change and its impacts are to be limited
Non-response	Actors contribute GHG emissions or contribute to adaptation, mitigation or removals without considering climate change.	Negative contributions mean other actors need to act quicker on adaptation, mitigation and removals if climate change and its impacts are to be limited. Positive contributions help improve the timeliness of the global response.	Negative contributions mean other actors need to do more on adaptation, mitigation and removals if climate change and its impacts are to be limited. Positive contributions help improve the scale of the global response.

Table T-2: Impact and risk responses and implications for the timeliness and scale of global responses to climate change.

Response trigger/driver	Contribution to the global response	Timeliness of global response	Scale of global response
Risk response	Actors mitigate and remove GHGs based on the risk of climate change impacts on human systems.	Climate change hazards generating impacts being experienced are locked in, and some further climate change risks may also be locked in.	Adaptation and improvements in climate resilience (i.e. reduced exposure and vulnerability) can limit impacts on human systems. There will likely be a need for removals but at a smaller scale due to timely mitigation.
Impact response	Actors mitigate and remove GHGs when there are climate change impacts on human systems.	The hazards generating the impacts being experienced are locked in, as is further climate change and related physical hazards due to the lag in climate and related changes which come after GHGs have accumulated in the atmosphere.	Adaptation and improvements in climate resilience can limit impacts on human systems but will need to be scaled up to address future locked in hazards. There will need to be large scale removals due to a lack of timely mitigation.

Timeliness and scale of responses

Table T-3: Response triggers and drivers and implications for the timeliness and scale of global responses to climate change.

Response trigger/driver	Contribution to the global response	Timeliness of global response	Scale of global response
Cost benefit response	Actors mitigate and remove GHGs based on an assessment of costs and benefits, and because of discounting rates applied, immediate impacts and costs of climate action are more strongly weighted in decisions than risks in the future.	Cost benefit approaches are more likely to respond to impacts than risk of unprecedented hazards (see impact response)	Decisions to act on climate change depend on cost benefit analyses and only those actions with a positive net present value taking into account the social cost of carbon, are acted upon. Most likely, only a subset of what needs to be done to limit climate change will actually be done and the scale is unlikely to be adequate until a cost benefit analysis supports large scale removals of GHGs.
Enlightened response	There is urgency and ambition, in part due to climate change considerations but possibly due to other considerations. As such, enlightened responses are likely the be leading responses.	Enlightened responses may come ahead of impacts being realised, and as such make timely contributions to the global response, although any impacts already experienced will likely be locked in already.	The scale of an enlightened responses depends on the extent to which awareness creates change, including the breadth of actors that are enlightened.
Cooperation response (variation of enlightened response)	States decide to cooperate on climate change because they have seen the benefits of international cooperation addressing other challenges	The timing of the responses is not due to any particular climate impact or risk, but rather has arisen due to unrelated experiences (e.g. pandemic and international response)	The scale of the global response is dependent on the ambition of states cooperating on climate change.
Emergency risk response	There is urgency and ambition in the response to risks.	An emergency response to climate change and related hazards could help ensure timely adaptation and mitigation efforts. However, it could be that the risks generating the emergency response are already locked in unless there are GHG removals.	Resilience is essential to limit impacts of climate change on actors and their interests. Mitigation efforts can limit long term climate changes and impacts but will have limited influence on the identified emergency risks. GHG removals at massive scales will be required to lower atmospheric GHG concentrations and may be adequate to limit the emergency risk. Other geoengineering interventions might be necessary to address the emergency risk.
Emergency impact response	There is urgency and ambition in the response to current impacts.	The range of hazards generating the emergency response are already locked in and is part of the new normal for the foreseeable future.	Adaptation efforts will be essential to limit the vulnerability and exposure of actors and their interests. Mitigation efforts can limit long term changes but will have no impact on the emergency. GHG removals at massive scales will be required to lower atmospheric GHG concentrations but the influence of this intervention will take time. Other geoengineering interventions might be necessary to address the emergency.

Table T-4: Response attitudes and implications for the timeliness and scale of global responses to climate change.

Response attitude	Contribution to the global response	Timeliness of global response	Scale of global response
Defensive	Local and domestic adaptation to the extent that is possible given available resources, but little or no mitigation or GHG removals.	Efforts to improve resilience may be enhanced but mitigation and GHG removals will not even be initiated, due to the belief other actors will emit GHGs.	Difficult to achieve mitigation or GHG removals at scale as defensive attitudes lead to each actor acting in isolation on their own interests. Adaptation may be achieved at scale if the actor has sufficient resources.
Cooperative	Cooperation is by its nature limited to common interests, which in most cases are a subset of the problem. So, cooperation can lead to positive contributions, cooperation alone is unlikely to resolve the climate change problem.	Waiting for an agreement to cooperate can delay timely interventions or innovation.	Non-participation, non-compliance can limit the scale of cooperative interventions and initiatives.
Competitive	Can be positive or negative depending on the incentives (including prices, taxes, subsidies, regulations and laws) and the actions being incentivised.	Competitive attitudes can lead to timely actions for example when actors believe "the early bird gets the worm". Competitive attitudes can lead to a situation where actors wait for options to be more viable, e.g. "the second mouse gets the cheese."	With the right incentives, competition can scale up interventions, especially technology and practices including business models.
Technological	Can be positive or negative depending on the characteristics of technologies developed and deployed.	The development of technologies can help ensure there are new technological options for addressing climate change in the future, when they may be especially needed.	Can lead to the creation of technological options that might be scaled up for example through competition. Can also lead to support of existing or close to market options that already exist, helping these options scale up. Technologies require inputs to production and related wastes, all of which could be problematic at scale, depending on the characteristics of inputs and wastes.

Appendix U: Catastrophic climate change

The extent to which climate change is catastrophic threat is important (Section 3.2.2). From Section 12.3.5, catastrophic climate change is anticipated to have the characteristics of an endurable catastrophe; one where the worst case scenario involves climate change reducing civilisation down to the level of “medieval warlords” or even the level of “Neolithic hunter gatherer” (Section 11.8). It was noted that “If that happens, well, I mean, you would've fulfilled Article Two, but nobody would know what the fuck that was.” (Section 11.8). As such, development restarts from a very low base and ecosystems can adapt naturally (Figure U-1).

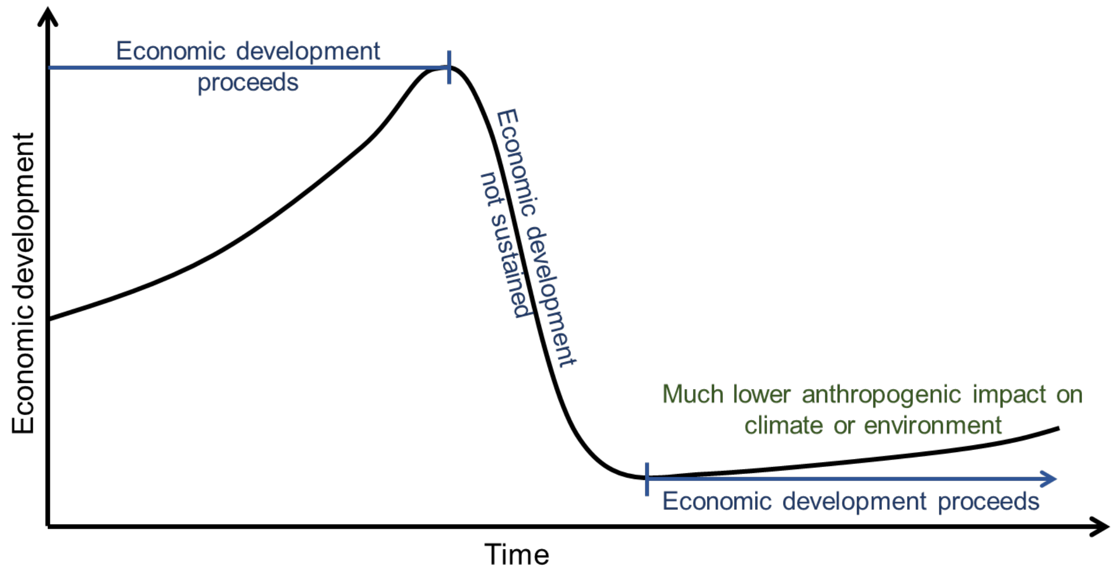


Figure U-1: Economic development success-failure-success scenario, where success after failure starts from a very low base.

The possibility of catastrophic climate change has important implications for understanding the characteristics of the climate change problem. According to Carse “There are at least two kinds of games. One could be called finite, the other infinite. A finite game is played for the purpose of winning, an infinite game for the purpose of continuing the play.” (Carse 1986, p. 3). Ironically the “backcasting” and “reverse stress test” methods used in this study to collect information gives the impression that the climate change problem has the properties of a finite game where “winning” or “success” is fulfilling the UNFCCC objective. However, the UNFCCC objective itself is about “continuing the play”, for example ecosystems being able to adapt naturally, food production not being threatened and economic development being able to proceed in a sustainable manner. For some states, such as low-lying small island developing states, “continuing the play” and staying in the game may not be possible with further climate change and sea level rise. As such, the climate change problem has the characteristics of an infinite game and success is staying in the game.

Appendix V: Effective responses and serendipity

Table V-1: Effective responses, including preconditions, that could conceivably fulfil the UNFCCC objective.

Response	Preconditions for effectively fulfilling the UNFCCC objective
Responses relying on ambition	Responses with high or very high ambition leading to leadership, enlightenment or emergency action on the climate change problem. These scenarios rely on actors taking action and forming effective coalitions to address climate change.
Emergency response	Emergency responses involve very high ambition and urgency. Emergency responses could be considered an extreme end of the spectrum of enlightened responses, consisting of “involuntary enlightenment” (Beck 2006) where climate change impacts and risks force awareness and change.
to impacts	Emergency responses to impacts need climate change and related impacts to be reversible or at least able to be stabilised rapidly. However, given the lags in climate change and related impacts, this may or may not be possible. Furthermore, an emergency response will require technologies and practices capable of limiting climate change and related impacts.
to risks	Emergency responses to climate change and related risks need climate change and related risks to be reversible (i.e. lock-in of risks to be avoidable). A high degree of serendipity is also required, in the form of an unambiguous future climate risk signal that is able to generate an emergency response.
Enlightened response	Enlightened responses include an awareness of impacts and risks to human and managed systems as well as other considerations for example ethical or justice related. Some level of serendipity is likely, and this could include some other factor influencing people to response to climate change (e.g. responding to some other international crisis such as a pandemic and then pushing for international cooperation on climate change).
Leadership response	Acting with high to very high motivation based on concerns based on climate science climate risks or other considerations. Leadership responses from social, political and business actors can help create the preconditions for effective responses for example helping generate and guide social change, create political will and policies, or invest in technologies and practices when most other actors don’t.
Responses relying on serendipity	Responses with high, medium, low, zero or even negative ambition, but through very good or even blind luck manage to fulfil the UNFCCC objective. These scenarios could include much lower than expected climate sensitivity, or the prices of climate resilient low emissions technologies and practices falling much quicker than expected.
Very lucky cost benefit based response	Cost benefit based responses are based cost benefit analyses and as such, discount medium to long term climate change impacts and risks to low values, unless a very low social discount rate is used. A high degree of serendipity is required in the form of either: A. climate resilient low emissions technologies and practices being available at lower cost much quicker than expected, making responding cost effective using a standard discount rate and a given social cost of carbon (depending on the level of ambition); or B. Climate sensitivity is much lower than expected hence the scale of climate change and related impacts is much lower than anticipated, allowing time for technological and changes in practices to become available following established learning curves.
Blind luck non-response	It is conceivable that non-responses could still result in an effective global response to climate change, but this would be through blind luck and an extremely high degree of serendipity rather than anything else. Such serendipity could be in the form of either: 1. climate resilient low emissions technologies and practices being available at lower cost much quicker than expected, making responding cost effective using a standard discount rate; or 2. Climate sensitivity is much lower than expected hence the scale of climate change and related impacts is much lower than anticipated.
Failed cynical response	It is conceivable that if cynical responses fail, and there is a large amount of blind luck, then the global response to climate change could fulfil the UNFCCC objective assuming either climate resilient low emissions technologies and practices become cheaper much quicker than expected or climate sensitivity is much lower than expected.

Appendix W: Revisiting success and failure

From Section 5.2.2.3, all respondents indicated the global response to climate change is failing to fulfil the UNFCCC objective. This is consistent with the IPCC's 1.5 Degree Report (IPCC 2018) which indicated that ecosystems, such as warm-water corals, are having difficulty adapting naturally. However, from the sample of possible futures, it is possible that failure conditions could be followed by success conditions (Section 6.2.4) akin to an overshoot scenarios where global warming temporarily exceeds desirable levels from the IPCC's 1.5 Degree Report (Section 2.2.4). However, some things, such as ecosystems, may be lost (Section 9.3.7) and success would mean "remaining ecosystems are able to adapt naturally" (Figure W-1). In this scenario, some ecosystems from the time when the UNFCCC was agreed, or even the time this study was written, will be lost.

Figure W-1 presents a scenario where at least one of the success criteria fails, followed by a situation that fulfils the UNFCCC objective of atmospheric concentrations being stabilised at a level that allows: economic development to proceed in a sustainable manner; food production not to be threatened; and, ecosystems to adapt naturally. Stabilisation of atmospheric concentrations of GHGs depends on mitigation and GHG removals as well as serendipity in the form of not having any unexpected GHG emissions from natural sources such as volcanic eruptions, and not passing any thresholds or tipping points generating environmental feedbacks in the carbon cycle. Of the other success criteria, economic development proceeding in a sustainable manner and food production not being threatened could conceivably be achieved through adaptation using technologies, practices and policies to reduce vulnerability and exposure to climate change and related hazards. If adaptation is relied upon to limit climate change and related impacts and risks to human and managed systems, rather than mitigation and removals, then the global response will very likely fail to allow ecosystems to adapt naturally.

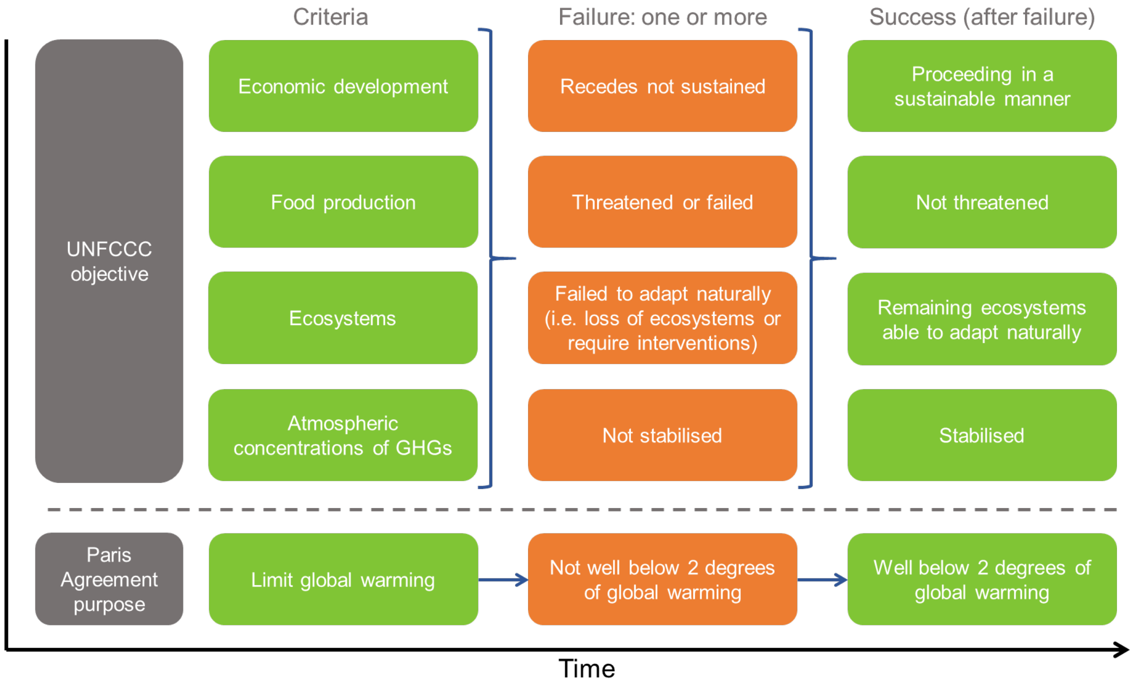


Figure W-1: Schematic scenario showing failure followed by success achieving the UNFCCC objective and Paris Agreement purpose.

Appendix X: Preconditions and the role of serendipity

Table X-1: Preconditions and the role of serendipity.

Tier 1 preconditions	The role of serendipity
Climate change related	
Scale of climate change can be addressed by technologies and practices	The scale of climate change and related impacts depends upon climate sensitivity, atmospheric concentrations of greenhouse gases and other climate forcers. In a high serendipity scenario, climate sensitivity would be lower than anticipated. The concentration of greenhouse gases in the atmosphere depends upon anthropogenic greenhouse gas emissions was well as the balance of GHG absorption and releases by the ecosystems and the rest of the environment through unmanaged processes. In a low serendipity scenario, there could be increased releases, or even net releases, of GHG from the environment into the atmosphere through unmanaged processes.
Climate change and related impacts are reversible or can be quickly stabilised	Given that many scenarios include overshoot with GHG removals from the atmosphere used to eventually stabilise atmospheric concentrations of GHGs, in a low serendipity scenario a threshold could be passed where feedback mechanism kicks in causing the release of GHGs from the environment, or cascade effects creating impacts that are irreversible. In a high serendipity scenario, such tipping points and thresholds are not breached.
Response related	
The global response (i.e. transformation) is timely and at scale	In a high serendipity scenario, climate resilient low emissions technologies and practices quickly become cheaper, or easier to apply, than expected, and are applied at scale much earlier than expected.
Contingencies are available for addressing extreme climate change or other scenarios	In a high serendipity scenario, technologies and practices that can be applied in case of extreme climate change or other scenario, are available with little extra investment or research, but in a low serendipity, a lot of investment in research and development would be required, and still contingencies are inadequate.
Other scenario related	
Other things (e.g. events or dynamics) don't negatively influence at scale, climate or the global response to climate change	The global response to climate change is not the only thing that can influence climate change and related impacts, and furthermore, other things might also influence the global response to climate change. In a low serendipity scenario, other things could happen, such as manmade or natural catastrophes including war, an economic depression, large volcanic eruptions, or even cosmic events that would profoundly affect climate or the global response to climate change.

Appendix Y: Playing the infinite game

Any group wanting to stay in the game, and act on climate change, has the risk that other actors may undermine their contributions to the global response to climate change. Hence climate change is characterised and collective action problem. As such, any strategy related to climate change needs to be aware of possible actions by other actors under a range of scenarios. While the IPCC generally assumes economic decision making, it is possible that with a strong enough climate stress signal, there could be enlightened or emergency responses which focus more on what needs to be done and how to do this for least cost, rather than choosing a subset of actions required using cost benefit criteria. Alternatively, investments in technologies may help bring down the cost of climate resilient low carbon options, making them ever more commercially viable with increased market share.

This study provides a sample of possible futures against which actors can assess their contributions to the global response and how enhance the influence of climate actions, including through the formation of coalitions domestically and internationally. Possible futures also include other scenarios that could affect climate or the global response to climate change, as well as the possibility of catastrophic climate changes constituting an existential threat.

Given that climate change may be an existential threat, it is tempting to think that all efforts should be made to limit climate change and its impacts. However, climate change is not the only existential threat. This raises the question of how much effort and resources to put into guarding against climate change and other risks while also acknowledging there are other problems that need to be addressed including development aspirations?

With regards to considering climate change in relation to other existential threats, the “ever-after” provides a frame to help assess relative threat. Many children’s stories end with words “happily ever after” indicating the reader need not concern themselves with whatever happened next because “it’s all good”[21]. In this case, the ever after refers to what happens beyond the planning horizon. The planning horizon could be the time when discounting for time reduces all costs to something close to zero, or alternatively an arbitrary point in time could be used, for example 2100 which is a common reference point in climate studies. How to respond to risks that might be relatively low in the planning horizon, but inevitable sometime in the ever after, is an important question.

The ever after can be divided into the “near ever after”, “middle ever after”, and “long ever after”. In the case of climate change, the impacts in the “near ever after” are very large and inevitable, for example involving sea level rise, as well as other reasons for concern. As such, the chances of severe climate change related disruption and changes are inevitable in the near ever after

[21] It’s all good is a common New Zealand expression used to indicate there is nothing to worry about, or there is no point worrying.

without a combination of mitigation now, GHG removals soon and progressive adaptation as required. This is not true of other existential risks such as a meteorite strike, for which there is a chance of the event happening, but it is not necessarily inevitable in the near ever after. With regards to the medium ever after, climate change impacts and risks are inevitable without preventative measures, and the chances of things like meteorite strikes get much higher. In the long ever after, things such as a meteorite strike become inevitable without preventative measures.

With regards to priority, it would seem sensible to put more effort into existential risks that are inevitable in the near ever after, while putting some effort into prevention measures related to other existential risks, in case of breakthrough cost effective technologies and practices, that can be applied to limit an existential risk.

Climate change is a collective action problem where effective global responses allow people and related institutions to stay in the game. Global responses to climate change involve balancing risks, opportunities, actions and institutions while also acknowledging serendipity is going to play a role in whether the we stay in the game. At least leadership can help improve the odds of staying in the game.