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Defining and understanding transformational adaptation at different spatial scales and sectors, and assessing progress in planning and implementing transformational adaptation approaches at the global level

Technical paper by the secretariat

Summary

This technical paper explores how transformational adaptation is defined and understood across spatial scales and sectors, emphasizing the need for adaptation measures that change the fundamental attributes of natural and human systems in response to climate change and its effects. It summarizes the existing knowledge on the definition and dimensions of, and pathways and potential for, transformational adaptation. It provides practical examples of transformational adaptation, focusing on the importance of broad, systemic shifts rather than incremental changes. The paper also reviews the evidence of the implementation of transformational adaptation by sector and region, including from reports submitted by Parties, and of progress in planning and implementing transformational adaptation approaches at the global level.

Finally, the paper offers a detailed examination of ways of defining and conceptualizing transformational adaptation in the context of climate change. This includes proposals for the dimensions and practical attributes of transformational adaptation and the elements that can contribute to building a common understanding thereof. It underscores the importance of a nuanced, context-specific approach, integrating consideration of diverse perspectives and knowledge systems, to creating robust frameworks for adapting to climate impacts.

Contents

Abbreviations and acronyms

AR	Assessment Report of the Intergovernmental Panel on Climate Change
BTR	biennial transparency report
CIF	Climate Investment Funds
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
DALY*	disability-adjusted life year
GGA*	global goal on adaptation
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
NAP	national adaptation plan
NBS*	nature-based solution(s)
PESTEL	political, economic, social, technological, environmental and legal (analysis)
RKR*	representative key risk
SDG	Sustainable Development Goal
SSP*	shared socioeconomic pathway
TX*	proportion of days with a maximum temperature
UNEP	United Nations Environment Programme
WG I*	Working Group I
WG II*	Working Group II

* Used exclusively in figures.

I. Introduction

A. Mandate and scope

1. CMA 5 requested the secretariat to undertake work to examine how transformational adaptation is defined and understood at different spatial scales and sectors, and how progress in planning and implementing transformational adaptation approaches might be assessed at the global level, for consideration at CMA 6.[1]

2. In addition, CMA 5:

(a) Decided that the United Arab Emirates Framework for Global Climate Resilience should guide and strengthen efforts, including long-term transformational and incremental adaptation, towards reducing vulnerability and enhancing adaptive capacity and resilience, as well as the collective well-being of all people, the protection of livelihoods and economies, and the preservation and regeneration of nature, for current and future generations, in the context of the temperature goal referred to in Article 2 of the Paris Agreement;[2]

(b) Recognized the challenges to implementing transformational adaptation for countries that have significant capacity constraints;[3]

(c) Decided to launch the two-year United Arab Emirates–Belém work programme on indicators for measuring progress achieved towards the targets referred to in paragraphs 9–10 of decision 2/CMA.5 with a view to identifying and, as needed, developing indicators and potential quantified elements for those targets.[4]

3. In response to the mandate referred to in paragraph 1 above, the secretariat held a number of inter-agency exchanges on transformational adaptation, including representatives of United Nations and other intergovernmental organizations. This technical paper has been prepared with a view to informing further deliberations on transformational adaptation, drawing on the above-mentioned inter-agency discussions, relevant literature, including from the IPCC, as well as inputs from the regional collaboration centres.

4. Chapter I.B below provides the background for the following chapters of the paper. Chapter II below provides a summary of the existing literature and views expressed at the exchanges referred to in paragraph 3 above on defining and understanding transformational adaptation across different spatial scales and sectors, and on assessing progress in planning and implementing transformational adaptation approaches at the global level. Chapter III below presents possible elements for building a common understanding of transformational adaptation, while chapter IV below illustrates a possible way forward. Examples of case studies and success stories of transformational adaptation to climate change are provided in the annex.

B. Background

5. Since its adoption, the Paris Agreement has driven near-universal climate action by setting global goals and sending signals regarding the urgency of responding to the climate crisis. While action is proceeding, much more is needed now on all fronts.[5]

6. To strengthen the global response to the threat of climate change in the context of sustainable development and efforts to eradicate poverty, governments need to support system transformations that mainstream climate resilience and low GHG emission

[1] Decision 2/CMA.5, para. 46.
[2] Decision 2/CMA.5, para. 8.
[3] Decision 2/CMA.5, para. 12.
[4] Decision 2/CMA.5, para. 39.
[5] See document FCCC/SB/2023/9, para. 1.

development. Although such transformations generate many opportunities, rapid change can also be disruptive.[6]

7. In the AR5, the IPCC highlights that transformational system change is required to meet the SDGs. Transformation is defined as "a change in the fundamental attributes of natural and human systems. Transformation could reflect strengthened, altered or aligned paradigms, goals, or values towards promoting adaptation for sustainable development, including poverty reduction" (see the box below).[7] The IPCC defines the related concept of transition as "the process of changing from one state or condition to another in a given period of time".[8]

8. Transformation is seen as a pluralistic concept embracing many interpretations, but all focus on the general concept of transformation as entailing fundamental change in systems and society as opposed to change that is minor, marginal or incremental. The term "transformation" applies to adaptation and mitigation and its use can differ with respect to:

(a) How the system undergoing change is conceptualized;[9]

(b) The extent to which the change is continuous or discontinuous and the timescales involved;

(c) The extent to which transformation is guided towards desired goals or emerges without intent;[10]

(d) Whether the use focuses on descriptions of societal processes or includes normative judgment as to which outcomes should or should not occur.[11]

9. The AR6 focuses on five system transitions to a just and climate-resilient future, namely societal,[12] energy, land and ocean ecosystems, urban and infrastructure, and industrial and assesses many of the timescales that shape the context for such transformations, including the present, by 2030[13] and by the mid-century. These system transitions will require transformations in existing social, social-technological and environmental systems and involve shifts in most aspects of society. The concepts of transition and transformation help to facilitate the organization of assessments of near- and longer-term adaptation actions that may prove feasible and effective in achieving climate-related societal goals, as well as sustainable development.

10. History provides many examples of transformation, including in the last 200 years, when human society underwent a rapid and profound transformation, with population and income per capita expanding by an order of magnitude or more. In the last 200 years, changes in technologies and economies of this scale have been embedded alongside political, religious

[6] See document FCCC/SB/2023/9, paras. 3 and 6.

[7] IPCC. 2014. Summary for Policymakers. *In*: CB Field, VR Barros, DJ Dokken, et al. (eds.). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press. Available at https://www.ipcc.ch/report/ar5/wg2/, box SPM.2, p.5.

[8] IPCC. 2022. *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* H Pörtner, D Roberts, M Tignor, et al. (eds.). Cambridge: Cambridge University Press. Available at https://www.ipcc.ch/report/ar6/wg2/, p.2925.

[9] For example, the dimensions of transformational adaptation.

[10] See the definitions of deliberate and societal transformation in the box below.

[11] IPCC. 2022. *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. H Pörtner, D Roberts, M Tignor, et al. (eds.). Cambridge: Cambridge University Press. Available at https://www.ipcc.ch/report/ar6/wg2, section 1.5.1, pp.171–172.

[12] IPCC. 2018. *IPCC Special Report on the Impacts of Global Warming of 1.5 °C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. V Masson-Delmotte, P Zhai, H-O Pörtner, et al. (eds.). Geneva: World Meteorological Organization. Available at https://www.ipcc.ch/sr15/.

[13] As mentioned in decision 2/CMA.5, paras. 9–10.

and social changes. Future transformation may involve similar interlinked social, cultural, economic, environmental, technical and political factors.[14]

11. Many transformations, whether deliberate or without specific intent, have brought with them both positive and negative consequences. For example, shifts in agricultural practices from small-scale subsistence farming to globalized consumer-driven processes have resulted in the benefit of increased nutrition and health for populations and stimulated economic growth, but have also reduced soil quality and natural nutrient levels through artificial pesticides and fertilizers. The long-term climatic and environmental impacts of such a transformation are now being felt, with shifts back towards regenerative agriculture[15] often cited as the next great agricultural transformation.

II. Defining and understanding transformational adaptation at different spatial scales and sectors

A. Defining transformational adaptation

12. In a warming world, incremental adaptation may not always be sufficient to adjust to the negative impacts of climate change, leading to substantial residual risks and, in some cases, the breaching of adaptation limits. Transformational adaptation, involving larger system-wide change, will increasingly be necessary for coping with climate change. In this context, transformational approaches to adaptation will generate new options for adapting to the impacts and risks of climate change by modifying the fundamental attributes of single or multiple systems that focus on future and long-term change and question the effectiveness of existing systems.[16]

13. The box below presents the key terms for defining and understanding transformational adaptation. The evolution of the concepts of transition and transformational adaptation are summarized in paragraphs 14–18 below.

Box 1
Key terms for defining and understanding transformational adaptation

Transformation: a change in the fundamental attributes of natural and human systems. Transformation could reflect strengthened, altered or aligned paradigms,[a] goals or values towards promoting adaptation for sustainable development, including poverty reduction:

- **Deliberate transformation**: a profound shift towards sustainability, envisioned and intended by some societal actors and facilitated by changes in individual and collective values and behaviours and a fairer balance of political, cultural and institutional power in society;[b]
- **Societal (social) transformation**: a change in the fundamental attributes of human systems advanced by societal actors.[c]

Transition: the process of changing from one state or condition to another in a given period of time. Transition can occur in individuals, firms, cities, regions and nations, and be based on incremental or transformational change.

Transformative change: a system-wide change that requires more than technological change through consideration of social and economic factors that, with technology, can bring about rapid change at scale.

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

[14] See the contribution of Working Group II to the AR6, section 1.5.1, p.171.

[15] Regenerative agriculture relates to farming practices aimed at working with nature rather than against it, such as those that promote soil health and biodiversity using cover cropping, crop rotation and minimal tillage based on principles that have existed for centuries.

[16] IPCC. 2019. *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*. H-O Pörtner, DC Roberts, V Masson-Delmotte, et al. (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. Available at https://www.ipcc.ch/srocc/, p.678.

opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

Solution space: the set of biophysical, cultural, socioeconomic and political–institutional dimensions within which opportunities and constraints determine why, how, when and who acts to reduce climate risks. Within these dimensions, there are 'hard' (unsurpassable) and 'soft' (surpassable) limits. The boundaries of the solution space are path dependent, contested and in constant flux (see figure 1).

Adaptation limits: the point at which an actor's objectives (or system needs) cannot be secured from intolerable risks through adaptive actions

- 'Hard' adaptation limit: no adaptive actions are possible to avoid intolerable risks;
- 'Soft' adaptation limit: options may exist but are currently not available to avoid intolerable risks through adaptive action.[d]

Residual risk: the risk related to climate change impacts that remains following adaptation and mitigation efforts. Adaptation actions can redistribute risk and impacts, with increased risk and impacts in some areas or populations, and decreased risk and impacts in others.

Incremental adaptation: adaptation actions that maintains the essence and integrity of a system or process at a given scale:

- In some cases, incremental adaptation can accrue to result in transformational adaptation;
- Incremental adaptation to climate change is understood as an extension of action and behaviour that already reduces the loss or enhances the benefits of natural variations in extreme weather and climate events.[e]

Transformational adaptation: adaptation that changes the fundamental attributes of a system in anticipation of climate change and its impacts. Such adaptation action can:

- Result in significant changes in the structure or function of the system that go beyond adjusting existing practices;
- Be adopted at a large scale, lead to new strategies in a region or resource system, transform places and potentially shift locations;
- Lead to deep and long-term societal changes that influence sustainable development (including values and world views).

Climate-resilient development pathways: trajectories that strengthen sustainable development and efforts to eradicate poverty and reduce inequalities while promoting fair and cross-scalar adaptation to and resilience in a changing climate. They raise the ethics, equity and feasibility aspects of the deep societal transformation needed to drastically reduce emissions to limit global warming (e.g. to well below 2 °C) and achieve desirable futures, a liveable world and well-being for all.

Values and beliefs: fundamental attitudes about what is important, good and right; and strongly held principles or qualities that are intrinsically valuable or desirable and are often enshrined in laws, traditions and religions.

[a] The IPCC does not provide a definition of paradigms. However, some key paradigms for adaptation include incremental and transformational adaptation, resilience, vulnerability and risk reduction, ecosystem-based adaptation, adaptive governance and sustainability.

[b] The contribution of Working Group II to the AR6 seeks to identify the conditions for deliberate transformation that is envisioned and intended by some societal actors (e.g. through narratives such as the green economy). See IPCC. 2022. Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. H Pörtner, D Roberts, M Tignor, et al. (eds.). Cambridge: Cambridge University Press. Available at https://www.ipcc.ch/report/ar6/wg2/.

[c] Societal transformation can occur without explicit intent, in the same way that the industrial revolution and some of the trends shaping modern society could arguably have been generated (see the contribution of Working Group II to the AR6, section 1.1).

[d] The contribution of Working Group II to the AR6, pp.2898.

[e] The contribution of Working Group II to the AR6, pp.2899.

Source: Adapted from the glossary of the contribution of Working Group II to the AR6, pp.2898–2927; Field CB, Barros VR, Mach KJ, et al. 2014. Technical Summary. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Cambridge and New York: Cambridge University Press.

Available at https://www.ipcc.ch/report/ar5/wg2/, box TS.2, pp.39–40; IPCC. 2014. Summary for Policymakers. In: CB Field, VR Barros, DJ Dokken, et al. (eds.). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press. Available at https://www.ipcc.ch/report/ar5/wg2/., box SPM.2, p.5; and the IPCC presentation at the fifth workshop under the Glasgow–Sharm el-Sheikh work programme on the global goal on adaptation, available at https://unfccc.int/documents/627408 p.3.

14. The concept of transformation was used by the IPCC in its Special Report on Global Warming of 1.5 °C[17] to refer to a change in the fundamental attributes of a system. In its Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, the IPCC notes that these systems include value systems; regulatory, legislative, or bureaucratic systems; financial institutions; and technological or biological systems.[18] In the AR6, transformation is defined as a change in the fundamental attributes of natural and human systems. Transformations are often considered to involve changes to underlying values and world views and are facilitated by changes in ideologies, power structures and actions towards the 1.5 °C temperature goal.

15. The terms transformational change (used in this paper) and transformative change are often used interchangeably but can imply different things, depending on the context:

(a) Transformational change refers to large-scale, systemic changes that fundamentally alter existing structures, systems or paradigms. It involves a complete shift from one state to another and often requires overhauling deep-rooted patterns. It also often impacts entire economic, social, political or environmental systems and is seen as necessary for addressing challenges such as climate change, social inequity or global economic restructuring;

(b) Transformative change often entails catalysing significant change from within systems, making them more adaptive, resilient or innovative. The respective change requires more than technological change by considering social and economic factors.

16. The IPCC first highlighted the concept of transformational adaptation in its Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, in which adaptation measures are referred to as ranging from incremental steps to transformational changes and seen as being on a continuum from incremental to transformational change, with no clear division between them.[19] Transformation is seen as a part of the solution space[20] alongside options such as reducing vulnerability and exposure and increasing resilience for managing risk.

17. In the AR5, the IPCC contrasts transformational adaptation with incremental adaptation and considers it within the context of principles for effective adaptation. It refers to transformational adaptation as adaptation at large scope or scale; as the type of adaptation that occurs once ‘soft’ limits have been breached; or a change that addresses the root causes of vulnerability as well as redressing long-standing inequities.

18. In the AR6, transformational adaptation is referred to as adaptation that changes the fundamental attributes of a social-ecological system in response to climate change and its

[17] IPCC. 2018. *IPCC Special Report on the Impacts of Global Warming of 1.5 °C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. V Masson-Delmotte, P Zhai, H-O Pörtner, et al. (eds.). Geneva: World Meteorological Organization. Available at https://www.ipcc.ch/sr15/ p.559.

[18] IPCC. 2012. Summary for Policymakers. *In*: C Field, V Barros, T Stocker, et al. (eds.). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Special Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press. Available at https://www.ipcc.ch/report/managing-the-risks-of-extreme-events-and-disasters-to-advance-climate-change-adaptation/, box SMP.1, p.5.

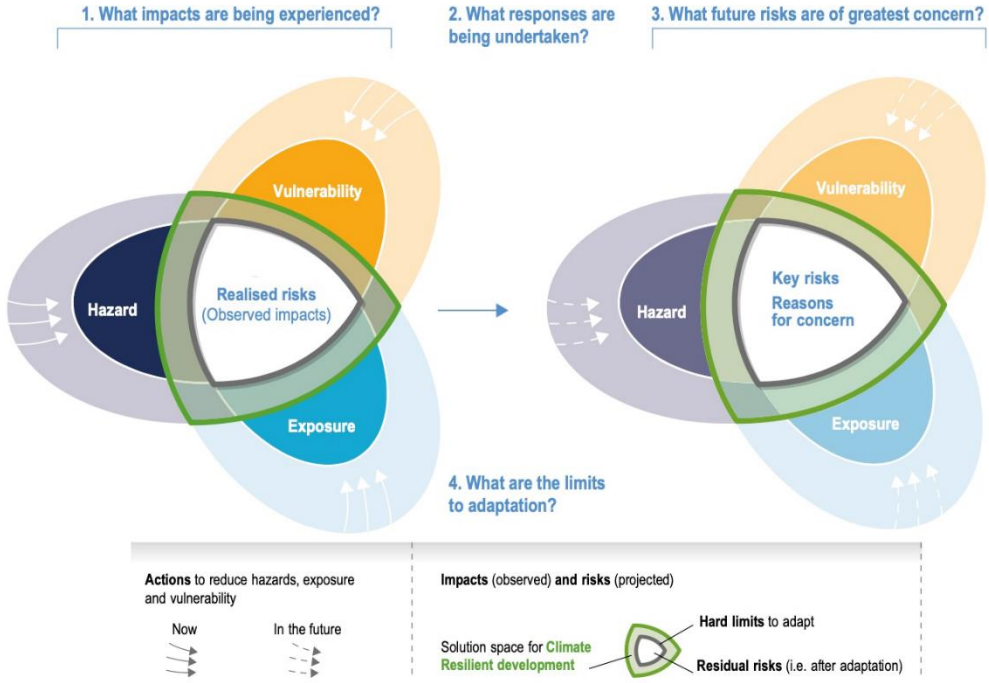
[19] Incremental steps (adaptation) are aimed at improving efficiency within existing technological, governance and value systems, whereas transformation may involve alterations to the fundamental attributes of those systems.

[20] See figure 1 for an illustration of the solution space used by the IPCC in the contribution of Working Group II to the AR6.

effects. Such adaptation action can result in significant changes in the structure or function of the system that go beyond adjusting existing practices; be adopted at a large scale; lead to new strategies in a region or resource system; transform places and potentially shift locations and lead to deep and long-term societal changes that influence sustainable development[21] (see the box above).

19. Figure 1 illustrates the risk framework and highlights the four questions used in the AR6 to assess the extent to which transformational adaptation is currently being implemented (the assessment required to estimate the future risks determined by the IPCC as being of greatest concern). It shows the concept of a solution space, 'soft' and 'hard' adaptation limits, areas of climate-resilient development and residual risks.

Figure 1
Risk framework and questions for assessing representative key risks across sectors and regions



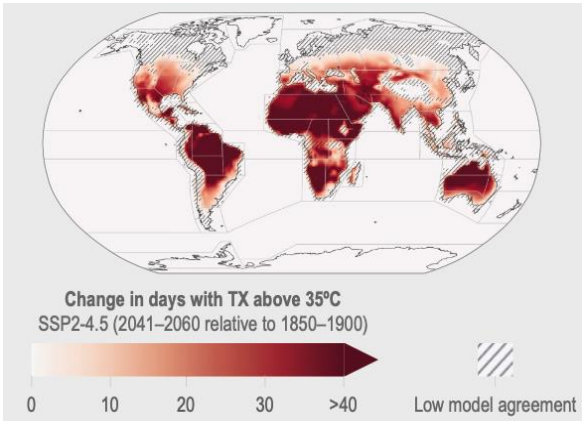
Source: Adapted from the contribution of Working Group II to the AR6, figure 16.1, pp.2419.

20. Figure 2, panel b, illustrates the continuum from incremental to transformational planned adaptation for managing climate-related heat risk to human health (both globally and regionally) due to an increasing number of days with an average temperature exceeding 35 °C (figure 2, panel a). It integrates observed climate impacts, projected risks for 2041–2060 and both incremental and transformational adaptation measures to address these risks. It also presents the corresponding 'soft' limits (to incremental adaptation) and 'hard' limits to adaptation both at the global and regional level for Africa (see original figure for other regions) and highlights the complexity of assessing all these factors for a single climate-related risk.

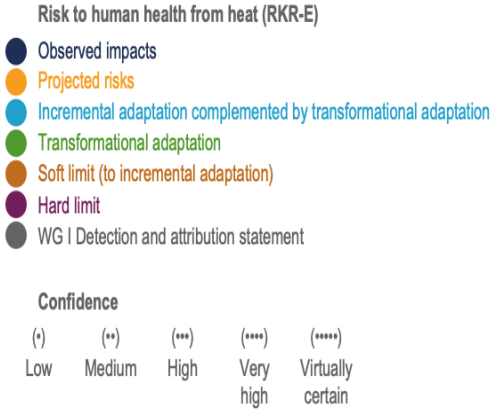
[21] See the IPCC presentation at the fifth workshop under the Glasgow–Sharm el-Sheikh work programme on the global goal on adaptation, available at https://unfccc.int/sites/default/files/resource/FINAL_IPCCContribution_GGA_5thWorkshop_IPCC.pdf, p.3.

Figure 2

Continuum from incremental to transformational planned adaptation for managing heat risk to human health due to changes in days with temperature above 35 °C



b.



Global level

Heat is a significant health risk due to widespread urbanization, demographic changes and increase in hot weather (•••) 323,000 estimated heat-related deaths and 13 million heat-related DALYs in 2019.

Temperature-related mortality expected to increase under medium- and high-heating scenarios even with adaptation. By 2050 (compared to 1961–1991) an excess of 94,000 deaths per year attributable to climate change projected due to heat for medium warming.

Implementation of heat warning systems has reduced relative mortality risk in developed countries (•••), unclear trends in low-middle income countries. Multi-sectoral integrated approach is beneficial, including heat early warning and response systems targeting vulnerable groups (•••).

Longer term urban planning and design, including NBS to reduce urban heat island effects. Improved basic protection for outdoor work, including work rescheduling to cooler times of the day (•••). Some regions with heat stress conditions approaching upper limits of labour productivity (•••).

Thresholds of survivability approached (•••).

Hot extremes (including heat waves) have become more frequent and more intense across most land regions since the 1950s (•••••).

Human-induced climate change is the main driver of these changes (•••).

Every additional 0.5 °C of global warming causes clearly discernible increases in the intensity and frequency of heat waves (•••).

Africa

Climate variability impacting the health of tens of millions of Africans through exposure to extreme heat. Heat extremes (hot days and hot nights) have increased in frequency since 1980 (•••).

Increasing temperatures will cause tens of thousands of additional deaths under moderate and high global warming scenarios, particularly in North, West and Central Africa (•••).

Cooling stations, limited evidence of proactive climate change adaptation in African cities (•••).

Urgent need for improved societal and political transformations to reduce climate change risks for vulnerable groups (••). Deployment considered necessary of NBS with demonstrated health, ecological, economic and social co-benefits.

Morbidity and mortality will escalate with further global warming, placing additional strain on health and economic systems (•••).

Under high warming scenarios annual exceedance of deadly heat thresholds in North, West and Central Africa (•••).

Source: Adapted from the contribution of Working Group II to the AR6, figure 17.6, p.2561.

B. Pathways for transformation

21. The IPCC Special Report on the Ocean and Cryosphere[22], in the context of adaptation pathways, notes the progress in the readiness of societies, institutions and/or individuals in engaging in transformational change and assessing the potential for transformational adaptation.[23] Two pathways – no to moderate and maximum potential response – were used for assessing additional risks, for example for sea level rise, with the maximum potential response pathway including an ambitious combination of both incremental and transformational adaptation.[24] The report notes that transformational adaptation is occurring mainly in coastal zones.

22. In the AR5, the IPCC evaluates the ways in which interlinked human and natural systems can build resilience through adaptation, mitigation and sustainable development. It describes climate-resilient pathways, incremental versus transformational change and limits to adaptation, and considers the co-benefits, synergies and trade-offs among mitigation, adaptation and sustainable development.[25] The concepts of transformation and transformation pathways are used to assess the large-scale societal changes needed to meet GHG emission reduction goals. The contribution of Working Group II to the AR6 focuses on transformational adaptation as one component of climate-resilient development in which adaptation, mitigation and development solutions are pursued together to exploit synergies and reduce trade-offs (figure 3).

23. As illustrated in figure 3, the ultimate aim of climate-resilient development pathways is to support sustainable development for ensuring planetary health and human well-being. Climate-resilient development is both an outcome at a point in space and time, as observed through the achievement of the SDG indicators, as well as a process consisting of actions and social choices made by multiple actors, including governments, industry, the media, civil society and the scientific community. Consequently, transformational adaptation, which is a component of climate-resilient development, includes both an outcome and a process. The development outcomes and processes pertain to political, economic, ecological, sociocultural, technology and community areas.

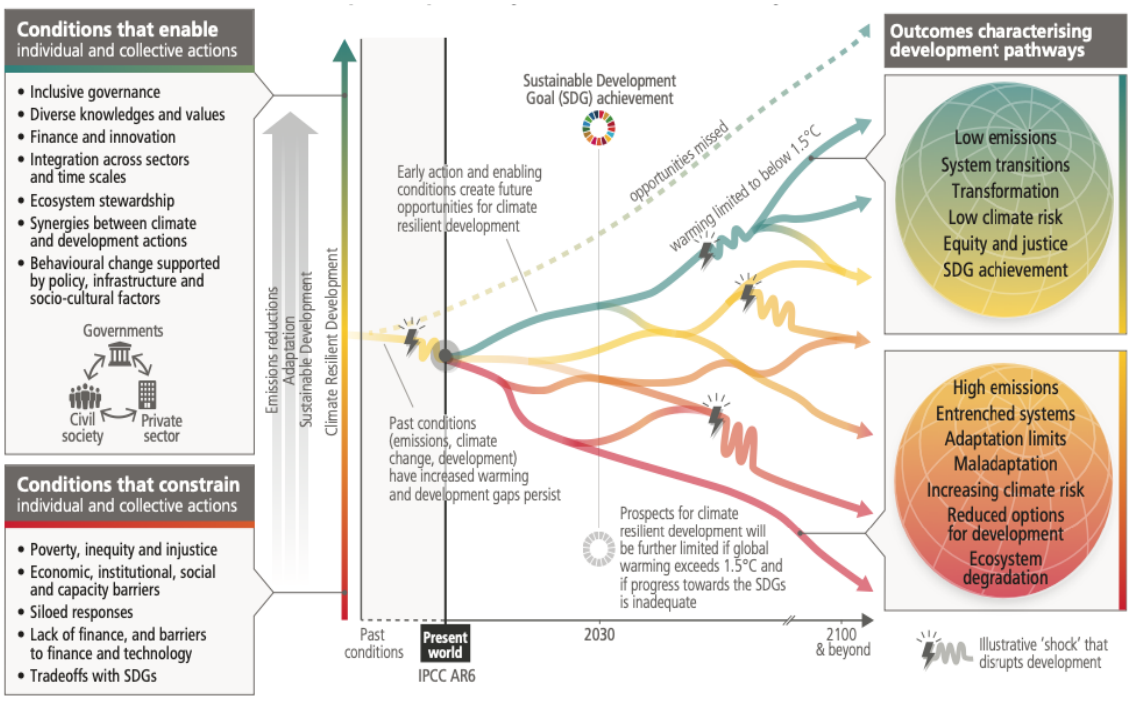
[22] IPCC. 2019. *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*. H-O Pörtner, DC Roberts, V Masson-Delmotte, et al. (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. Available at https://www.ipcc.ch/srocc/.

[23] A series of adaptation choices involving trade-offs between short- and long-term goals and values. These are processes involving deliberation to identify solutions that are meaningful to people in the context of their daily lives and to avoid potential maladaptation.

[24] *IPCC Special Report on the Ocean and Cryosphere* (see footnote 22 above), figure 4.3, p.328.

[25] See the technical summary of the contribution of Working Group II to the AR5, section C-2, pp.87–89, table TS.7, p.86.

Figure 3
Climate-resilient development pathways



Source: IPCC. 2023. Summary for Policymakers. *In*: Core Writing Team, H Lee, and J Romero (eds.). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva: IPCC. Available at https://www.ipcc.ch/report/sixth-assessment-report-cycle/. Figure SPM.6, p.25.

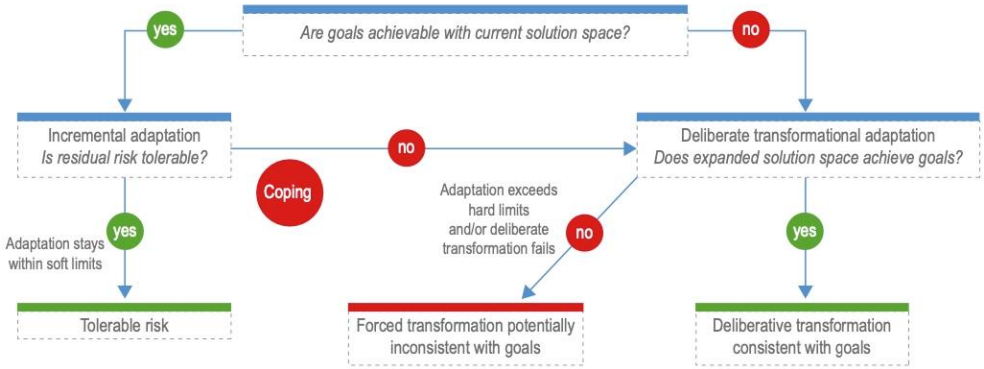
24. The development pathways followed by countries at all stages of economic development impact GHG emissions as well as the scale of mitigation challenges and opportunities and vary across countries and regions. Pathways and opportunities for action are shaped by previous climate action (or inaction) and enabling and constraining conditions (see the left-hand panel in figure 3) and take place in the context of climate risks, adaptation limits and development gaps. The longer efforts to reduce GHG emissions are delayed, the fewer effective adaptation options exist.

25. Pathways may lead to transformation deliberately or through forced action. As figure 4 shows, adaptation actions can achieve goals within the solution space of the existing system or beyond it. In the former case, incremental adaptation may stay within 'soft' adaptation limits and hold risks at tolerable levels that avoid threatening private or social norms. In the latter case, deliberate transformational adaptation is necessary to achieve the goals.

26. Should this approach fail, or if 'hard' adaptation limits are exceeded, the system may nonetheless undergo a type of forced transformation, which results in outcomes that are inconsistent with societal goals.[26] Multiple actors are involved at each stage, and some may find themselves coping with what they regard as intolerable risks that cannot otherwise be avoided. Such coping situations often reveal significant inequities, with tolerable risks for powerful groups and intolerable ones for marginalized groups.

[26] See para. 64(i) below on possible overlaps with loss and damage, for example voluntary relocation of communities.

Figure 4
Alternative pathways to transformation



Source: The contribution of Working Group II to the AR6, figure 1.9, p.173.

C. Dimensions of transformational adaptation

27. Given that the term "transformational" reflects a multidimensional, rather than a one-dimensional, scale integrating different aspects of climate change, the following dimensions are used in the AR6 for assessing the evidence of transformational adaptation: depth of change, namely the degree to which adaptation reflects major shifts;[27] scope or scale of change, namely the degree to which adaptation has been implemented widely (geographic or institutional); speed of change; and limits of change, with evidence that adaptation 'soft' limits are being challenged or overcome (see table 1). For each dimension, as well as for all dimensions taken together ("overall"), the operational descriptors are shown for low, medium and high transformational adaptation potential.[28]

Table 1
Dimensions of transformational adaptation

Dimensions	*Transformational potential of adaptation*		
	Low	*Medium*	*High*
Overall	Adaptation is largely sporadic and consists of small adjustments to 'business as usual'. Coordination and mainstreaming are limited and fragmented	Adaptation is expanding and increasingly coordinated, including wider implementation and multilevel coordination	Adaptation is widespread and implemented at or very near its full potential across multiple dimensions
Depth	Adaptations are largely expansions of existing practices, with minimal change in underlying values, assumptions or norms	Adaptations reflect a shift away from existing practices, norms or structures to some extent	Adaptations reflect entirely new practices involving deep structural reform (e.g. a complete change in mindset and changing institutional or behavioural norms)
Scope	Adaptations are largely localized and fragmented, with	Adaptations affect wider geographic areas, multiple areas	Adaptations are widespread and substantial, involving

[27] Categorized as something new, novel and different from existing norms, practices or structures.

[28] See the contribution of Working Group II to the AR6, supplementary material, table SM16.5, p.16SM-11, for information on operationalizing adaptation typology in the form of key questions and variable categorizations used by the Global Adaptation Mapping Initiative; and table SM16.6, p.16SM-14, for the corresponding operational descriptors for high, medium and low transformational adaptation potential. Examples of adaptation actions coded for all four dimensions as high, medium and low are presented in table SM16.7, p.16SM-15.

Dimensions	*Transformational potential of adaptation*		
	Low	*Medium*	*High*
	limited evidence of coordination or mainstreaming across sectors, jurisdictions or levels of governance	and sectors, or are mainstreamed and coordinated across multiple dimensions	most possible sectors, levels of governance and actors
Speed	Adaptations are implemented slowly (e.g. results are seen after a period of more than five years)	Adaptations are implemented moderately quickly (e.g. results are seen within three to five years)	Change is considered rapid for a given context (e.g. results are seen within one to three years)
Limits	Adaptations may approach but do not exceed or substantively challenge 'soft' limits	Adaptations may overcome some 'soft' limits but do not challenge or approach 'hard' limits	Adaptations exceed many 'soft' limits and approach or challenge 'hard' limits

Source: Adapted from the contribution of Working Group II to the AR6, chap. 16, table 16.1, p.2435. For details on the methodology used for assessing evidence of transformational adaptation, see the contribution of Working Group II to the AR6, supplementary material, chap. 16.1, table 16.6, p.16SM-14.

28. Another framework for assessing the evidence of transformational adaptation has been proposed in the literature on the basis of the review of 80 conceptual papers, encompassing six common characteristics or dimensions of transformational adaptation in ecological, social and social-ecological systems, namely restructuring,[29] path-shifting, innovative, multiscale, system-wide and persistent.[30] The analysis showed that restructuring and path-shifting were the most frequently mentioned dimensions in the description of transformational adaptation, while persistent was the least mentioned dimension.

29. A separate framework was used by the IPCC to assess the potential for transformation[31] of the options mentioned in paragraph 38 below, encompassing the following key aspects for understanding the continuum from incremental to transformational adaptation: change within or across the system; agency (single or heterogeneous); the role of visioning, including explicit normative visions of the future; the type of learning required, from first-order, 'business as usual' learning, to second-order learning (i.e. doing something different under a different paradigm); and the extent to which equity and distributional issues are explicit.[32] Actions are categorized as resulting in no, small, moderate and broad system change.

30. The CIF has also developed a programmatic framework for transformational climate action and evaluation for operationalizing transformational adaptation in a country-driven manner and supports countries in developing investment plans with stakeholders and preparing adaptation plans, such as NAPs, using this framework.

31. The CIF framework contains five dimensions of transformational adaptation (see figure 5), specifying that the actions must:

(a) Be relevant to the context and beneficiaries. Relevance is an action-oriented dimension that illuminates the ongoing, dynamic relationship between desired goals, context

[29] This can refer to either the ecological structure of ecosystems (e.g. species diversity), the social structure of communities (e.g. power dynamics) or the structure of social-ecological interactions (e.g. land uses).

[30] Fedele G, Donatti CI, Harvey CA, et al. 2019. Transformative adaptation to climate change for sustainable social-ecological systems. *Environmental Science & Policy*. 101: pp.116–125. Available at https://www.sciencedirect.com/science/article/pii/S1462901119305337.

[31] See the contribution of Working Group II to the AR6, table 17.3, p.2559.

[32] David Tàbara J, Jäger J, Mangalagiu D, et al. 2019. Defining transformative climate science to address high-end climate change. *Regional Environmental Change*. 19(3): pp.807–818. Available at https://doi.org/10.1007/s10113-018-1288-8.

and opportunity. Change can be assessed for its relevance to or alignment with key goals and processes;

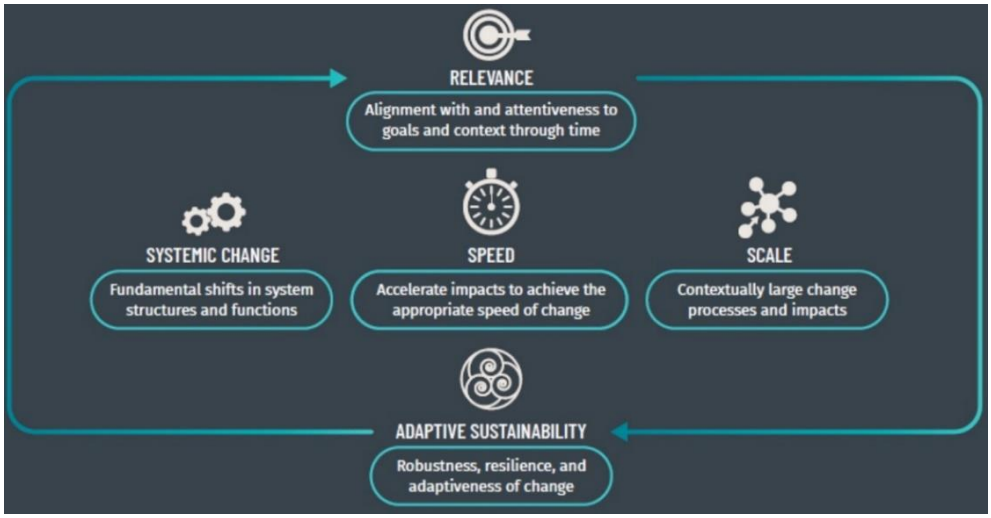
(b) Lead to systemic change, including fundamental shifts in system structures and functions, interrelationships among core elements within and between systems and changing power dynamics;

(c) Accelerate the speed of change to leverage windows of opportunity while ensuring a just transition;

(d) Be scalable[33] along different dimensions (e.g. levels, policies, people, geography, levels of understanding and the public–private continuum);

(e) Be sustainable, involve no backsliding and focus on evolving to integrate multiple stakeholders. This dimension emphasizes the importance of robustness and resilience for sustainability, as well adaptability in the face of change.

Figure 5
Five dimensions of transformational change



Source: Adapted from the CIF presentation at the fifth workshop under the Glasgow–Sharm el-Sheikh work programme on the global goal on adaptation. Available at https://unfccc.int/documents/627410.

32. Three qualitative categories are used to evaluate the transformational change of the dimensions of change mentioned in paragraph 31 above, except for speed of change: early signals (conditions created); interim signals (change happening, outcomes not obvious); and advanced signals (transformation happening).[34]

33. The AR6 stresses that transformational adaptation does not imply adequacy or effectiveness of adaptation (e.g. low transformation may be sufficient for some climate risks, and high transformation may be insufficient to offset others).[35] Nevertheless, the above-mentioned dimensions of transformational adaptation are seen as providing a systematic framework for tracking the progress of transformational adaptation and assessing the state of adaptation-related responses.

D. Examples of transformational adaptation

Examples of transformational adaptation include using Indigenous knowledge as a way of enabling profound change (e.g. livelihood change and/or diversification, implementation of agricultural strategies, water conservation); enabling voluntary relocation of communities; reshaping cities for increased disaster resilience; implementing significant policy changes

[33] Entailing vertical, horizontal and depth scaling.
[34] Societal (social) transformations can be measured by considering the quality of interactions with the most vulnerable groups.
[35] It is important to communicate clearly that transformational adaptation is not always better than incremental adaptation.

that reduce vulnerability and decrease inequality, resulting in a shift in power structures; and shifting how climate adaptation is considered, for example for industrial versus regenerative agricultural strategies (see box 2 and the annex).

Box 2
Examples of transformational adaptation

Promoting decentralized rainwater harvesting in cities to combat water scarcity

In cities facing severe water shortages (e.g. Cape Town, South Africa; Bangalore, India; or São Paulo, Brazil) traditional large-scale water infrastructure such as dams and reservoirs have struggled to meet demand owing to droughts, overpopulation and climate change. In response, some cities are exploring decentralized rainwater harvesting as a transformational adaptation to radically change how water is sourced, stored and distributed.

Structural change: Shifting water supply from a centralized, large-scale infrastructure (e.g. reservoirs, pipelines and groundwater extraction) to a distributed, community-based system. Individual buildings (e.g. homes, offices, schools) are equipped with rainwater collection systems to store water locally, reducing reliance on the central water supply grid.

Functional impact: The function of the water supply system changes. Rather than relying solely on municipal supply for water needs, households and communities become self-sufficient, with their own stored rainwater that can be used for non-potable uses (e.g. gardening, washing) or even purified for drinking. This decentralized system can alleviate pressure on overstressed centralized infrastructure and diversify water sources.

Governance and management: The governance of water resources changes from a top-down, city-managed system to a distributed management approach, where individual citizens and local communities play a direct role in water collection, conservation and distribution. This requires new regulations, incentives and infrastructure investments to ensure widespread adoption of rainwater harvesting systems.

Adopting regenerative agriculture for climate-resilient food production

Conventional agriculture, dominated by monocultures and heavy reliance on chemical inputs, is highly vulnerable to climate change due to soil degradation, loss of biodiversity and the overuse of water. Transformational adaptation in this context involves shifting entire farming systems to regenerative agricultural practices that improve the health of ecosystems, mitigate climate change and enhance the resilience of food production systems.

Structural change: The entire farming system is restructured from monoculture, chemical-intensive practices to a polyculture, ecosystem-based approach. This changes not only the crops grown but also the land-use patterns, soil management and water-use strategies of farms.

Functional impact: Instead of focusing solely on maximizing short-term yields, regenerative agriculture prioritizes long-term sustainability, soil fertility and climate resilience. The function of farms shifts from being purely a production unit to becoming a regenerative part of the local ecosystem, restoring natural processes such as water infiltration, carbon sequestration and biodiversity support.

Role and knowledge of farmers: Farmers move from being ‘input managers’ (applying chemicals to boost yields) to becoming land stewards who work closely with the environment. They rely more on local knowledge and agroecology principles and have a deeper understanding of natural cycles.

Building climate-resilient health systems through green urban design

In response to the rising health impacts of climate change such as heat waves, vector-borne diseases, air pollution and flooding, some cities are adopting green urban planning and infrastructure to mitigate health risks, rather than simply expanding hospitals or clinics to handle rising patient loads.

Structural change: This approach transforms the structure of the health system from being a centralized, hospital-based response system to one that is embedded into the urban environment. Health resilience is no longer just about medical treatment but about how cities are designed, how people live and how community systems are organized.

Functional impact: The function of the health system changes from merely reacting to diseases and health problems (such as treating heatstroke in hospital emergency rooms) to proactively preventing them through urban design that mitigates climate risks. This includes functions such as reducing heat-related mortality through cooler, greener cityscapes or preventing disease outbreaks by managing water and sanitation systems effectively.

Collaboration across sectors: Health resilience becomes a shared responsibility across sectors, involving urban planners, environmental scientists and public health officials working together to design cities that protect human health from climate impacts.

Assisting migration of species to new habitats

The American pika, a small mammal native to mountainous regions of North America, is highly vulnerable to rising temperatures. As a warming climate shrinks its alpine habitat, researchers have considered relocating pikas to higher elevations or cooler regions, beyond their traditional range, to ensure their survival.

Structural change: The entire approach to species conservation changes. Instead of maintaining species within their historical ranges through habitat restoration or protection, this method restructures the geographic boundaries of ecosystems. By introducing species into new areas, it alters the composition of both the source and target ecosystems.

Functional impact: The function of conservation shifts from preserving ecosystems in their current form to actively intervening in natural processes to anticipate future changes. This requires a more dynamic and flexible view of ecosystems as ever-evolving systems, rather than static entities to be preserved in their current form.

Ecosystem interaction: Relocating species creates new interspecies relationships, altering predator–prey dynamics, competition and resource use in both the ecosystems the species leave and the ones they enter. This could lead to a restructuring of entire food webs, creating a fundamental change in ecosystem functioning.

Restoring coastal wetlands for storm protection

Structural change: Large-scale restoration of coastal wetlands (e.g. salt marshes) to replace or supplement traditional engineered defences (e.g. sea walls).

Functional impact: Wetlands act as natural buffers, absorbing storm surges and reducing flooding. This can improve coastal resilience by enhancing the ability of an ecosystem to protect human populations while also providing habitats for biodiversity. Wetlands change the natural coastline structure and shift its function from being a natural habitat only to also serving as a critical climate adaptation solution.

Relocating a coastal community

A coastal town facing severe risks from rising sea levels and increased storm surges might engage in transformational adaptation by relocating the entire community to a safer inland location. This is a more radical shift compared with traditional adaptation measures such as building higher sea walls or improving flood defences, which are aimed at maintaining the community in its current location.

Structural change: The community's geographic location changes, which alters the layout of homes, infrastructure and public services.

Functional impact: The economic activities of the town may shift as industries tied to the coast (e.g. fishing or tourism) may need to be replaced by new livelihoods more suitable to an inland setting.

Community identity: Moving a whole town fundamentally reshapes its cultural and social connections, changing the way the community interacts with its environment.

Promoting land-tenure reform to address climate vulnerability and inequality

In many parts of the world, marginalized communities, including Indigenous Peoples and smallholder farmers, often lack secure rights to the land they live on and cultivate. This insecurity makes them vulnerable to climate change because they have limited control over land-use decisions, are often displaced by 'land grabs' and cannot invest in long-term, climate-resilient agricultural practices.

Transformational adaptation through land-tenure reform involves creating and enforcing policies that give these communities legal ownership or secure access to their land.

Structural change: Land-tenure reform changes the fundamental structure of who owns and controls natural resources, shifting it from governments, corporations or other powerful groups to local, marginalized communities. This restructuring is crucial for long-term climate adaptation, as communities can now manage and protect their lands with climate resilience in mind.

Functional impact: The function of land use and governance is transformed from being top-down and extractive to being community-driven and sustainable. The focus shifts from short-term profit-making through resource exploitation to long-term environmental stewardship and climate resilience.

Power shift: This policy reform results in a significant shift in power dynamics, giving control over resources to communities that have been historically disenfranchised. It also allows them to participate more actively in national and global discussions on climate adaptation, reducing inequality and increasing their influence in policymaking.

Reintroducing cultural fire practices to manage wildfire risk

To address the growing threat of wildfires, some regions in Australia have abandoned conventional wildfire suppression practices and instead embraced traditional Aboriginal fire management. This involves setting small, controlled fires in cooler seasons, which reduces fuel loads and minimizes the intensity of wildfires later in the dry season.

Structural change: The entire land management approach shifts from a reactive firefighting strategy to a proactive, cyclical practice of landscape management. This changes the relationship between people, the environment and fire.

Functional impact: The role of fire is redefined from a hazard to a tool for ecological balance, drawing on thousands of years of Indigenous knowledge. Fire is no longer merely something to be suppressed but is understood as part of the land's natural rhythm.

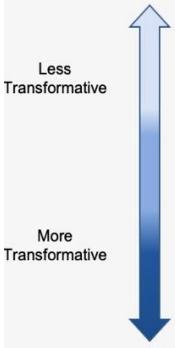
Governance and knowledge systems: Indigenous leaders take on a key role in managing fire practices, requiring the integration of local knowledge into regional and national fire management policies. This represents a shift in power dynamics, where Indigenous communities are central to decision-making processes.

E. Potential for transformational adaptation or maladaptation

34. Figure 6 shows several adaptation options for the health sector, including their potential for transformational adaptation and their benefits or disadvantages for marginalized groups, including exclusion.[36] Early warning systems tend to be incremental rather than transformational because they enable people to maintain or protect existing systems. At the other end of the continuum, climate-resilient health-care systems are leading to increased transformation. None of the options were seen by the IPCC to be consistently beneficial for vulnerable or marginalized groups (see also para. 36 below).

[36] See table 17.3 of the contribution of Working Group II to the AR6 for all 24 adaptation options analysed.

Figure 6
Potential for transformation of several adaptation options in the health sector



Adaptation	Benefits to marginalized groups	Dis-benefits or exclusion of marginalised groups
Early-warning systems (*high confidence*)	Help with planning and pre-emptive identification of vulnerable groups	People of higher socio-economic status tend to receive warnings, while marginalized groups may be excluded
Infrastructure for health (high confidence)	Improvements to water infrastructure reduce displacement and improve mental health outcomes	Development of sanitary water infrastructure in Germany offered less benefit in areas with higher income inequality
Climate-resilient health care systems (*medium confidence*)	Universal health coverage can be highly beneficial, especially to lower income people when needed for climate-related health outcomes	Facilities in poor communities are often poorly sited and can lack capacity to support people during climate-related extreme events

Source: IPCC presentation at the fifth workshop under the Glasgow–Sharm el-Sheikh work programme on the global goal on adaptation. Available at: https://unfccc.int/documents/627408

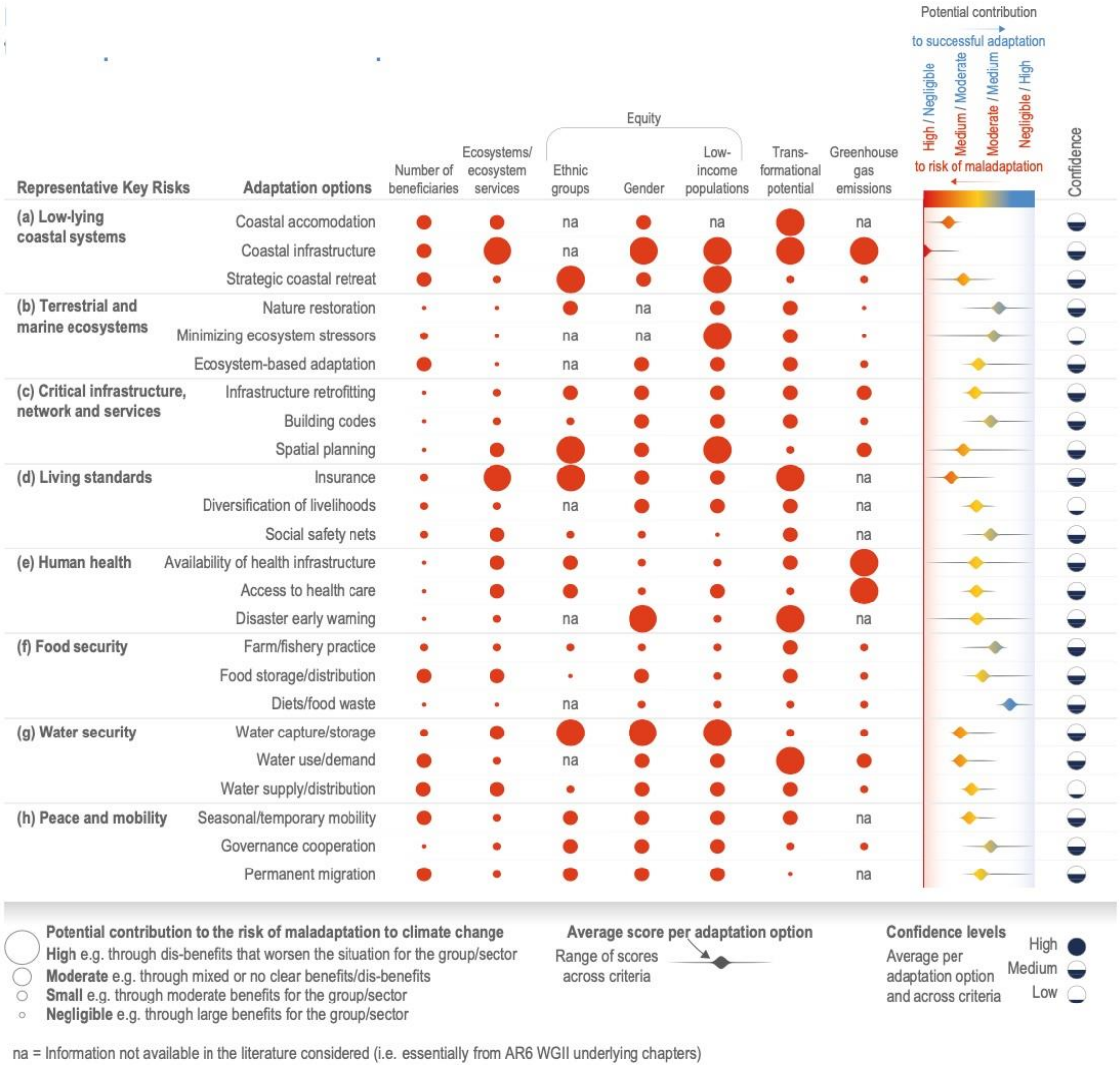
35. Although transformational adaptation could be considered a better adaptation approach, in some cases it can result in maladaptation. Figure 7 ranks the potential contribution of several adaptation options to successful adaptation and the related risk of maladaptation and illustrates where they are placed on the continuum of incremental to transformational adaptation. The adaptation options selected were identified as relevant to eight representative key risks[37] and mapped onto the adaptation–maladaptation continuum.

36. Figure 7 shows, for example, that for the representative key risks associated with low-lying coastal systems, the transformational adaptation potential of the option of strategic coastal retreat has the lowest risk of maladaptation, while the other options of coastal accommodation and costal infrastructure have moderate to high risks. Other options with a high transformational potential for maladaptation include insurance (with representative key risks associated with living standards), disaster early warning (with representative key risks associated with human health) and water use/demand (with representative key risks associated with water security). For representative key risks associated with food security, the option of changing diets and/or addressing food waste has a negligible transformational potential for maladaptation, as well as the highest potential for successful adaptation among all the options presented in the figure.[38] The option of permanent migration (with representative key risks associated with peace and mobility) also has a negligible transformational potential for maladaptation.

37. The IPCC estimated the transformational potential of the adaptation options listed in figure 7 using expert judgment. The extent to which adaptation actions have the potential to lead to systemic change was evaluated[39] on the basis of the dimensions referred to in paragraph 31 above. The criteria applied were non-risk-focused actions that generated positive outcomes as a systemic change based on the recognition that risk-focused actions are (mostly) no longer feasible. This could entail discrete actions, such as livelihood diversification, as well as processes that foster systemic rethinking and reconfiguration.[40]

[37] See chap. 16 of the contribution of Working Group II to the AR6 for further details.
[38] The contribution of Working Group II to the AR6, supplementary material, table SM17.20, pp.36–39, provides evidence from across regional and thematic chapters on incremental and transformational adaptation, as well as on observed and projected loss and damage (current and future risks, and adaptation limits).
[39] Categorized as broad, moderate, small and no systemic change.
[40] See the contribution of Working Group II to the AR6, supplementary material, table SM17.2, p.17SM-5.

Figure 7
Potential contribution of 24 adaptation-related options to successful adaptation and maladaptation



Source: The contribution of Working Group II to the AR6, figure 17.11., p.2604.

38. Successful transformational adaptation, while multifaceted and challenging, depends on the availability of appropriate enabling environments, including experiential and niche learning, alignment of transformational change objectives with strategic priorities (of governments or other actors), strong bottom-up governance grounded in local contexts, long-term programme support and appropriate financing.[41]

F. Assessing progress in planning and implementing transformational adaptation approaches at the global level

39. According to the IPCC, progress in adaptation planning and implementation has been observed across all sectors and regions, generating multiple benefits. However, this progress is unevenly distributed, with observed adaptation gaps. Many initiatives prioritize immediate and near-term climate risk reduction, which reduces the opportunity for transformational adaptation.[42] While transformational adaptation is increasingly being considered in theory and planning, implementation is only beginning to gain attention.

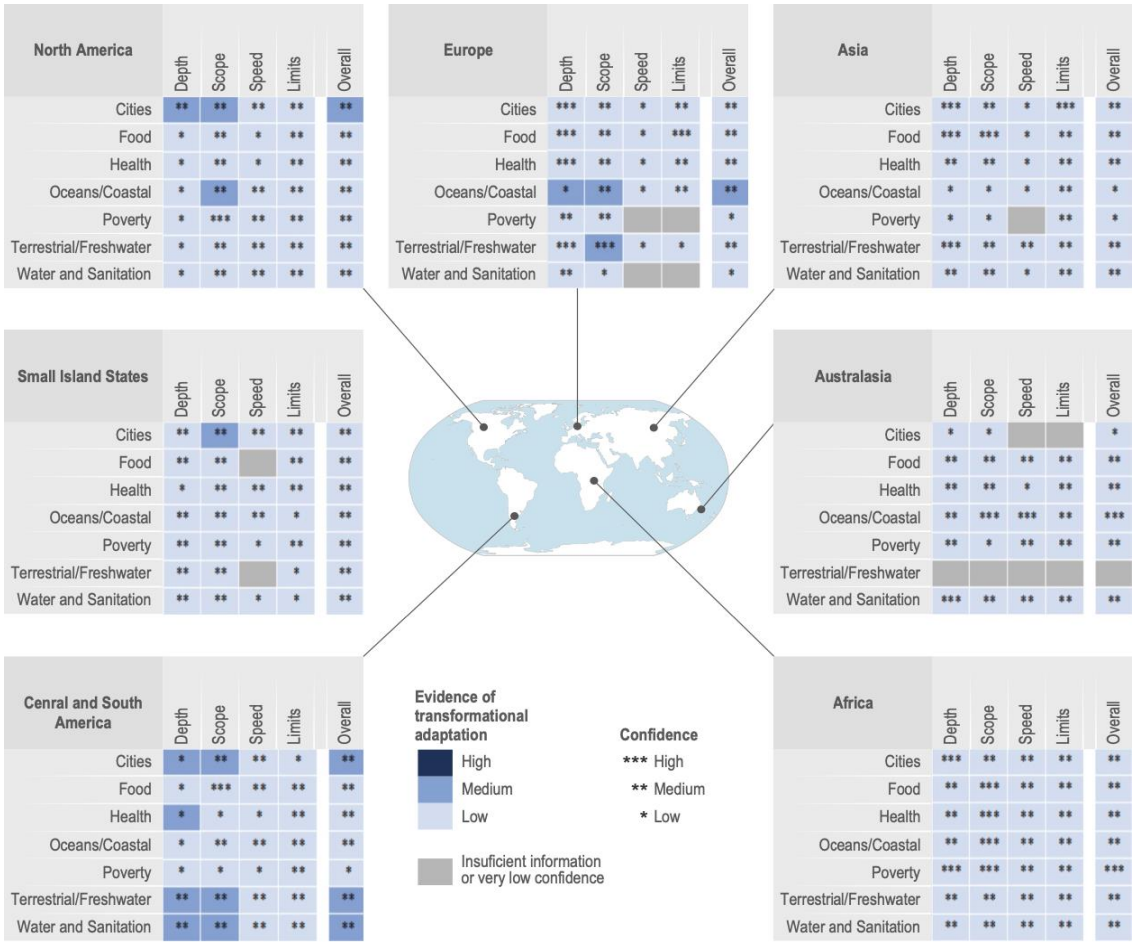
[41] See the contribution of Working Group II to the AR6, section 17.2.2.4, p.2558.
[42] See the Summary for Policymakers in the contribution of Working Group II to the AR6, p.20.

1. Evidence of implementation of transformational adaptation by sector and region

40. The IPCC provides an evaluation of the evidence of assessing transformational adaptation in terms of depth, scope, speed of change and ability to challenge adaptation limits based on adaptation responses reported in the scientific literature (see para. 27 above and table 1). Information from the Global Adaptation Mapping Initiative[43] was used to develop a database of scientific literature related to reporting on adaptation-related responses to climate change in human systems.

41. The Global Adaptation Mapping Initiative conducted a systematic review of the literature from 2013 to 2019 using machine learning and 1,682 articles were deemed eligible for inclusion in the database and coded to extract information on adaptation. The review focused on articles reporting on documented and implemented adaptation actions with the potential to directly reduce risk and excluded a large section of the literature focusing on the processes of adaptation-related decision-making and governance, such as adaptation planning and vulnerability assessment. Each article was assigned to one or more sector and region and an overall score of low, medium or high was assigned to each of the four dimensions of transformational adaptation (depth, scope, speed, limits). The aggregate score reflects a conceptual average of the overall state of evidence of transformational adaptation within a region or sector.[44]

Figure 8
Evidence of transformational adaptation by sector and region



Source: The contribution of Working Group II to the AR6, figure 16.6, p.2436.

Note: "Cities" relates to cities, settlements and key infrastructure; "Food" relates to food, fibre and other ecosystem products; "Health" relates to health, well-being and the changing structure of

[43] https://globaladaptation.github.io.

[44] Although there may be a small number of highly transformational adaptation examples in a particular region or sector, if the overall profile of adaptations across all regions or sectors was low, then the aggregate score was low.

communities; “Oceans/Coastal” relates to oceans and coastal ecosystems and their services; “Poverty” relates to poverty, livelihoods and sustainable development; “Terrestrial/Freshwater” relates to terrestrial and freshwater ecosystems; and “Water and Sanitation” relates to water, including sanitation.

42. Figure 8 shows that the overall transformational nature of adaptation across most regions and sectors is low (light blue). The evidence also demonstrates that:

(a) Adaptations tend to involve minor modifications to usual practices taken to address extreme weather conditions[45] and are frequently focused on a single sector or small geographic area. No documented adaptation responses were determined as having high evidence of transformational adaptation (dark blue). For food, fibre and other ecosystem products, and poverty, livelihoods and sustainable development, there were no documented adaptations determined as having medium evidence of transformational adaptation (blue);

(b) Adaptations implemented by individuals or households are generally small in scope, unless they are widely adopted (e.g. by farmers across a region) or address numerous aspects of life.[46] Adaptation actions implemented at the individual or household level were frequently categorized as high speed (e.g. changes in the timing or type of crop planting produces results within a single year);

(c) National policies are more likely to be broad in scope, although they frequently focus on a single sector and are therefore still limited.

43. The speed of change is rarely noted explicitly in the literature, but the average speed documented is slow. Adaptation efforts frequently encounter either ‘soft’ or ‘hard’ limits, with limited evidence to suggest that ‘soft’ limits are being challenged or overcome (e.g. strategic efforts by Indigenous Peoples to overcome governance and institutional barriers were determined as medium in terms of addressing limits to adaptation).

44. Few documented adaptation responses are simultaneously widespread, rapid and novel. Some examples exist, such as voluntary relocations of villages or the creation of new multi-stakeholder resource governance systems, but these are rare. In general, adaptations that are broad in scope tend to be slow, suggesting that achieving a high level of transformation in all four dimensions (depth, scope, speed and limits) may be particularly challenging or even involve trade-offs. For example, for the voluntary relocation of a village to high ground and for the population to build a new life (high depth of change), it could take 10 years to implement a relocation plan (low speed of change). Nevertheless, this could be seen as transformational adaptation.

45. The contribution of Working Group II to the AR6 also shows in which systems and regions transformational adaptation is increasingly required and considered once incremental adjustments have been exhausted in the context of ‘soft’ and ‘hard’ limits to adaptation. For example, options for transformational adaptation for managing climate-related risks to health at the global level include longer-term urban planning and design, including nature-based solutions to reduce urban heat island effects and improved basic protection for outdoor workers, including rescheduling work to cooler times of the day.[47]

46. Reports submitted by Parties, including adaptation communications, BTRs, NAPs, national communications and nationally determined contributions, are essential for assessing progress in planning and implementing transformational adaptation at the global level. To this end, the secretariat conducted an analysis during the first global stocktake under the Paris Agreement, revealing that less than one third of Parties currently provide information on such efforts in their reports. Specifically:

[45] For example, changing crop varieties or the timing of crop planting to address floods or droughts, implementing new types of irrigation, pursuing supplementary livelihoods and building elevated homes.

[46] Such adaptations could also be considered to result in a high depth of change if they were novel and to be implemented at high speed if they were broadly adopted by numerous individuals across a region and were supported by government or non-government policies that enabled widespread adoption across a large geographic area or affected numerous sectors or aspects of life (e.g. not only crop yield but also water availability).

[47] See the contribution of Working Group II to the AR6, figure 17.6, p.2561.

(a) A total of 28 per cent of Parties described their planned transformational adaptation measures in key sectors such as agriculture, fisheries, forestry, terrestrial ecosystems, disaster risk management and urban areas;

(b) In total, 22 per cent of Parties are aiming to strengthen transformational adaptation planning and implementation or enhance the transformational capacity of social and economic systems;

(c) A total of 11 per cent of Parties acknowledged that implementing transformational adaptation requires a combination of technological innovations, institutional reforms, diverse funding sources, and behavioural and cultural shifts within the multilevel governance system;

(d) A total of 10 per cent of Parties emphasized the importance of fostering gender-sensitive and gender-inclusive approaches, as well as increasing gender equality in planning for transformational adaptation;

(e) In total, 5 per cent of Parties highlighted the need for a deeper understanding of fairness and just transitions in planning and implementing transformational adaptation, with some noting a lack of sufficient international support necessary for the just transformation of adaptation priority sectors.

2. Shaping future adaptation to global and local needs

47. Assessing progress in transformational adaptation requires much more than assessing which future climate risks are of greatest concern (figure 1), the corresponding potential for transformational adaptation or maladaptation of various adaptation options and the evidence of transformational adaptation (see paras. 35–39 above). Such an assessment needs to consider the future of adaptation measures in general and integrate explicit normative visions (the desired future of transformational adaptation) as well as subjective judgment on transformational futures to reorient policy strategies at various scales of action.

48. In this context, the secretariat carried out a ‘horizon scanning’ exercise using artificial intelligence, consisting of an analysis of PESTEL factors of transformational adaptation and an analysis of future trends. The findings of the analysis can be summarized as follows:

(a) Political: international agreements will continue to shape adaptation efforts; instability, adjustments in leadership and priorities may undermine adaptation and influence funding and support for transformations;

(b) Economic: economic possibilities of transformational adaptation will be facilitated through new markets and innovations; increased premiums will be implemented in the insurance market. Key uncertainties: the economic feasibility of large-scale adaptations and the degree to which climate change will disrupt traditional economic systems;

(c) Social: public awareness and perception of climate change risks will be enhanced, influencing the social acceptance of transformational policies; more sustainable lifestyle changes will occur. Key uncertainties: social willingness and capacity to adapt to the changes required to combat climate change and the potential for social unrest owing to climate inequities;

(d) Technological: emerging technologies will support adaptation and enhance existing capacities; big data and forecasting will have an increased role in decision-making;

(e) Environmental: there will be more frequent and intense climate impacts on biodiversity and ecosystems;

(f) Legal: national legislation and international treaties will mandate adaptation; there could be legal disputes over adaptation obligations and an evolving body of case law; new projects will incorporate compliance with environmental regulations. Key uncertainties: developing and enforcing legal frameworks that effectively facilitate transformational climate adaptation.

49. Table 2 shows future trends for 12 selected adaptation options analysed in terms of impact, likelihood, time frame, maturity and priority. On the basis of their signal, the future trends could be summarized as follows:

(a) Weak signal: greater focus on highly localized climate adaptation strategies; innovative financing mechanisms; rise in the use of artificial intelligence and big data;

(b) Emerging trend: for example, integration of Indigenous knowledge into adaptation planning; increased interest in regenerative agriculture; and emphasis on urban green infrastructure to enhance the climate resilience of cities;

(c) Maturing trend: mainstreaming climate-proofing in infrastructure development.

Table 2
Future trends for adaptation options

Options	*Impact*	*Likelihood*	*Time frame*	*Maturity*	*Priority*
Community-driven climate-resilience planning	High	Likely	2023–2030	Emerging	High
Green infrastructure in urban areas	Very high	Very likely	2023–2034	Emerging	Very high
Adaptive water resource management	High	Likely	2023–2030	Emerging	High
Climate-proofing infrastructure	Very high	Likely	2023–2037	Maturing	Very high
Migration as an adaptation strategy	High	Likely	2023–2034	Emerging	High
Disaster-resilient agriculture	High	Likely	2023–2030	Emerging	High
Investment in climate-resilience metrics	High	Likely	2023–2030	Emerging	High
Nature-based coastal defence strategies	High	Likely	2023–2030	Emerging	High
Climate-induced innovation in insurance	High	Likely	2023–2030	Emerging	High
Urban heat island mitigation measures	High	Likely	2023–2030	Emerging	High
Cross-sectoral climate education programmes	High	Likely	2023–2030	Emerging	High

Note: The information in this table is based on the PESTEL analysis carried out by the secretariat.

50. These findings show, for example, that at the global level green infrastructure in urban areas and climate-proofing infrastructure are seen as high-priority adaptation options over the next decade. Cross-referencing these findings with the data presented in figure 7 would suggest that a focus on building codes and retrofitting infrastructure may have a greater potential for transformation than spatial planning (figure 9).

51. While the 'horizon scanning' exercise was conducted at the global level, it would also be beneficial to conduct such an exercise at the regional level to capture significant differences between regions.

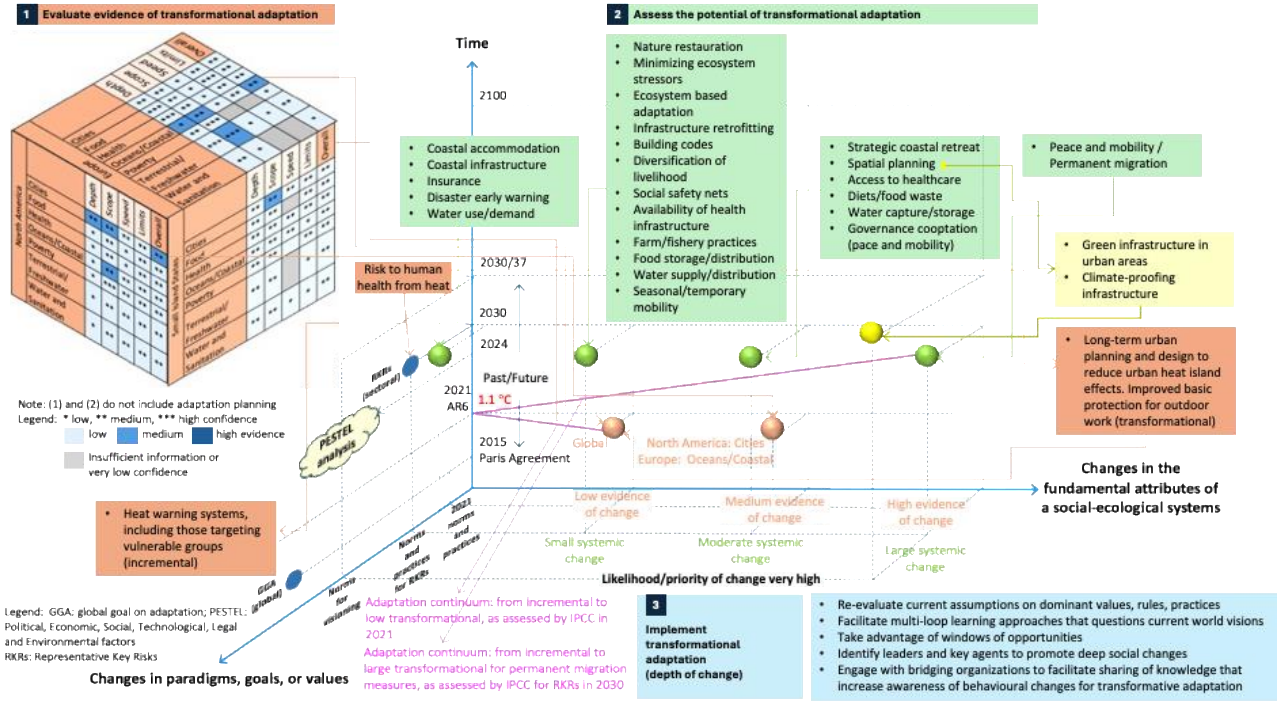
52. Figure 9 illustrates current findings on evidence of and potential for transformational adaptation, as well as on operationalizing it (on the basis of two dimensions only, namely depth and limits of change; see table 3 for further details). A three-dimensional graphic was used to capture the respective change over time, as well as the fact that the change evolves in tandem with the change in the context (e.g. norms and practices), even while the ultimate goal (i.e. the global goal on adaptation under the Paris Agreement) remains constant.

53. Figure 9 indicates that, at the global level, the evidence of transformational adaptation measures is low (represented by brown spheres). For certain regions and sectors (e.g. North America, Cities; and Europe, Oceans/Coastal) the evidence of transformational adaptation measures is moderate (medium). The pink lines in the figure represent the potential adaptation continuum, showing that incremental action can lead to transformational outcomes. The brown boxes also illustrate transformational and incremental adaptation measures for addressing heat risk to human health (see figure 2 for further details, including on 'soft' and 'hard' limits to adaptation).

54. While some adaptation measures (illustrated in the green boxes in the figure) show a moderate potential for transformational adaptation (depth and limits of change), most measures have a small or insignificant potential for such change (represented by green spheres). The yellow sphere represents the options identified through the PESTEL analysis of political, economic, social, technological, legal and environmental factors, with a very high priority of change. The light blue box illustrates some of the implementation measures that could affect the depth of transformational adaptation.

Figure 9

Summary of findings presented in chapter II of this document on transformational adaptation



Source: UNFCCC secretariat. Includes elements of figure 16.6, p.2436, of the contribution of Working Group II to the AR6 (figure 8 in this document).

55. Changes in the fundamental attributes of a system that characterize transformational adaptation are estimated against norms and practices that are changing over time. This could alter the position of a given adaptation option on the adaptation continuum over time. Furthermore, incremental or transformational adaptation options that are feasible and effective today will become constrained and less effective with increasing global warming.[48]

56. Global warming of above 1.5 °C will result in limited freshwater resources, with potential 'hard' adaptation limits for small island developing States and for regions reliant on glacier and snow melt. In addition, ecosystems such as some warm-water coral reefs, coastal wetlands, rainforests and polar and mountain ecosystems will have reached or surpassed 'hard' adaptation limits, rendering adaptation efforts ineffective. This highlights the urgency of evaluating the effectiveness of transformational adaptation, especially under potential temperature overshoot scenarios, as well as the need for innovative transformational adaptation options.

III. Unpacking current definitions and dimensions for building a common understanding of transformational adaptation

A. Definition and dimensions of transformational adaptation

57. While some experts referred to in paragraph 3 above are of the view that a prescriptive definition of transformational adaptation is still needed, the definition introduced in the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation has remained virtually unchanged in subsequent IPCC reports published to date. Arguably, a common understanding of transformational adaptation need not entail a prescriptive definition beyond that provided by the IPCC (see the box above).

58. Some transformational adaptation approaches and actions have been practically implemented, even without being specifically labelled as transformational. For some, transformational adaptation can be defined through specific experience or contexts, while others define it in terms of process, outcomes or impacts on risks. Context specificity is key when discussing transformational adaptation, as is the need to incorporate the experience and perspectives of adaptation practitioners, which are sometimes not fully captured in the ARs.

59. Some other experts noted the importance of questioning the paradigms underlying transformational adaptation, which may be biased towards knowledge and practices from the developed world, potentially excluding those from the developing world, such as Indigenous knowledge systems rooted in entirely different approaches. Challenging dominant paradigms would redefine transformational adaptation as a dynamic, power-laden concept grounded in sociocultural practices. It would transversally connect spatial, temporal, historical and epistemological (theory of knowledge) scales. This approach would require flexible tools and methodologies, allowing for the combination of diverse knowledge resources.

60. Transformational adaptation could involve specific aspects in relation to transboundary climate risk, which occurs when the effects of climate change in one area create a risk to people in another. These risks can occur within a single or multiple countries, with potential regional repercussions, especially for countries sharing a border. In addition, such risks involve international consequences if climate change disrupts human migration, trade, financial flows or access to natural resources shared between two or more countries. CMA 5 recognized that climate change impacts are often transboundary in nature and may involve complex, cascading risks that require knowledge-sharing and international cooperation for addressing them.[49] These aspects could be considered under the dimension of adaptive sustainability of transformational adaptation.

61. The concept of transformational adaptation frequently functions as a 'boundary concept', allowing different communities to share the concept while maintaining their unique interpretations of it, all of which are within the framework provided by the IPCC. However,

[48] See the Summary for Policymakers of the Synthesis Report of the AR6, section B.4, p.19.
[49] Decision 1/CMA.5, para. 52.

this flexibility raises important questions about what qualifies as transformational, what should be transformed, and how and by whom these changes should be enacted (only the first question is considered within the scope of this paper).[50]

62. A common understanding of the definition and possible dimensions of transformational adaptation would reduce the conceptual ambiguity that arises from the use of similar terms (albeit with different meanings) across relatively discrete theoretical and disciplinary literature. Such differences are magnified when used across a wide variety of scales, sectors and geographical regions. An operational definition built on this common understanding would help in assessing progress in planning and implementing transformational adaptation, including at the global level.

63. Table 3 provides a mapping of the elements of the IPCC definition of transformational adaptation and the possible dimensions of transformational adaptation for assessing the evidence of, estimating the potential for, and operationalizing or implementing transformational adaptation measures. It should be noted that:

(a) Taken together, the possible dimensions presented are specific to transformational adaptation. For example, while an incremental adaptation measure could be implemented at high speed, it may not lead to the deep changes required by transformational adaptation. In addition, some dimensions may apply to a particular stage in the adaptation cycle (e.g. planning, implementation, monitoring, evaluation and learning);

(b) The dimensions relating to depth of deliberate change and limits to change are core to transformational adaptation. The other dimensions, relating to scope/scale and speed of deliberate change, can be viewed as complementary. For example, an adaptation measure with a high depth of change, which challenges but does not overcome adaptation limits, would still be transformational at a medium level (see the operational descriptors in table 1). Similarly, an adaptation measure with a high depth of deliberate change and low scope or low speed (a gradual change) would also be transformational (see figure 10);

(c) In general, there are strong relationships and interactions across the dimensions. For example, early changes at a large-scale implemented through large-scale investment can catalyse deep systemic changes that enable additional subsequent scaling (the speed of action often needs to be slow enough to enable depth and scope of transformation).[51] The speed of change could be affected by the alignment of systemic changes, scaling pathways and shifts in other related social, economic and environmental systems, demonstrating that there can be a dynamic interplay between depth of change, speed and scaling (scope);

(d) The operational descriptors used in table 1 for each dimension would indicate when incremental adaptation becomes transformational (at a low level). The dimensions and operational descriptors could, to some extent, be level- and case-specific, and could also be considered as part of an operational definition of transformational adaptation;

(e) The activities included in table 1 are components of the adaptation cycle: assessing evidence of transformational adaptation is a component of adaptation monitoring, evaluation and learning; estimating transformational potential is a component of planning for adaptation; and operationalizing transformational adaptation is a component of implementing adaptation measures. While none of these activities could be considered as a component of assessing impacts, vulnerabilities and risks, the dimension on challenging and overcoming 'soft' limits to adaptation would require such an assessment to be conducted;

(f) The definition of transformational adaptation does not refer to specific paradigms, goals, values or speed of change. Nevertheless, such references are included in

[50] Lidskog R and Sundqvist G. 2022. Lost in transformation: The Paris Agreement, the IPCC and the quest for national transformative change. *Frontiers in Climate*. 4. Available at https://www.frontiersin.org/journals/climate/articles/10.3389/fclim.2022.906054/full.

[51] For an example of a trade-off between speed and depth of transformation, see UNEP. 2024. *People-centric Ecosystem-based Adaptation: A Case Study from Sudan*. UNEP. Available at https://www.unep.org/resources/case-study/people-centric-ecosystem-based-adaptation-case-study-sudan.

the definitions of transformation and transformative change respectively (see the box above and figure 3) and are used in table 3. For example, at the global level, the work under the United Arab Emirates Framework for Global Climate Resilience is aimed at guiding and strengthening efforts, including long-term transformational and incremental adaptation to support the achievement of the global goal on adaptation;

(g) The definition of transformational adaptation and the related concepts of transformation and transition qualify the outcome of the adaptation measure. Assessing whether a transformation is "good" is an activity related to monitoring, evaluation and learning from the respective adaptation measure;

(h) For deliberate transformations, the shift towards sustainability is facilitated by changes in individual and collective values and behaviours and a fairer balance of political, cultural and institutional power in society (see the box above). The definition of transformational adaptation refers to values and world views. Other terms are also used in the IPCC reports and relevant literature, such as norms, including cultures, ideologies and beliefs, structures and power relationships, frameworks, logic and assumptions underlying a system, behaviours, rules and perspectives;

(i) The dimensions of transformational adaptation should provide clarity on potential overlaps with concepts such as loss and damage and climate-resilient development. For example, with regard to the dimension on limits to adaptation, the operational descriptor used in table 1 for high transformational potential was "Adaptations exceed many 'soft' limits and approach or challenge 'hard' limits" (expanding the adaptation space beyond 'soft' limits but before 'hard' limits are reached). This indicates, for example, that the option of forced relocation due to sea level rise pertains more closely to loss and damage than to transformational adaptation. In general, the distinction between transformational adaptation and loss and damage should be further considered. The pre-emptive adaptation, contingent arrangements and loss acceptance framework, which entails the consideration of pre-emptive adaptation or risk reduction, contingent arrangements and loss acceptance, could be used to consider adaptive responses that include loss acceptance, where this is most appropriate.[52] The time of relocation – before or after the climate impact – should also be considered.

64. An operational definition of transformational adaptation, which includes the above-mentioned clarifications in this chapter, would allow for a constantly shifting baseline to be used and for visioning exercises and 'horizon scanning' on transformation pathways to be conducted with a view to adjusting goals and targets at all levels and reviewing the potential contribution of adaptation-related options to successful adaptation or maladaptation. This could indicate when a move from incremental towards transformational adaptation is not desirable. Furthermore, a degree of 'constructive ambiguity' in the definition of transformational adaptation is understandable and is arguably indicative of the deeply contested nature and extent of the transformations deemed necessary to limit the temperature increase to 1.5 °C above pre-industrial levels.

65. This paper proposes depth of deliberate change, limits of change, scope/scale of deliberate change, speed of change, and adaptive sustainability as the fundamental dimensions of transformational adaptation, and relevance as a dimension specific to monitoring, evaluation and learning and/or implementation of transformational adaptation, as follows:

(a) Depth of deliberate change refers to the extent to which a change reflects something new, novel and different from existing norms and practices. A change with limited depth merely adheres to current practices, with no significant difference to the underlying values, assumptions and norms. In contrast, an in-depth change may involve a radical transformation of practices by altering the fundamental values, logic and assumptions underlying the system. This could entail deep structural reform, a complete change in mindset among governments or populations, radical changes in public perceptions or values, and a change in institutional or behavioural norms;

[52] See https://arxiv.org/abs/2004.06144.

(b) Limits of change relates to how the adaptation measure challenges ‘soft’ limits to adaptation that result from the interaction of adaptation constraints (presented in table 3) and speed of change;

(c) Scope of deliberate change refers to the scale of change. A small scope might refer to local initiatives or activities confined to neighbourhoods, communities, groups or projects. In contrast, a broad scope encompasses large-scale and system-wide changes that could affect an entire organization, country, large region or large population. The development of networks, inter-organizational coordination and social relations are more likely to facilitate changes of greater scope;

(d) Speed of change refers to the period of time within which changes occur. Slow or incremental change typically involves small, gradual adjustments made in a series of steps. Conversely, faster change may entail sudden shifts in views, perceptions, attitudes and norms;

(e) Adaptive sustainability refers to a transformational change that is robust, resilient and lasting, as well as to the necessary adaptability of populations, systems and change processes to respond to evolving contexts and the dynamic interplay between social, economic and environmental factors. It emphasizes the need to ensure that populations, systems and change processes have the capacity to respond effectively to changing circumstances and evolving needs over time;

(f) Relevance is an action-oriented dimension that highlights the ongoing dynamic relationship between desired goals, context and opportunity. At the systems level, change can be assessed for its relevance to or alignment with key goals (signalling “where we need to go”) and processes (signalling “who needs to be involved”).

Table 3

Mapping the definition and possible dimensions of transformational adaptation for assessing the evidence of, estimating the potential for, and operationalizing and implementing transformational adaptation measures

	Definition	*Dimensions*	*Elements to be assessed for evidence of transformational adaptation*	*Elements to be assessed for estimating transformational potential*[a]	*Operationalizing and implementing transformational adaptation (transformational change for climate action)*
Transformational adaptation	Adaptation that changes the fundamental attributes of a social-ecological system in response to climate change and its effects. Such adaptation action can result in the following outcomes				
	Significant changes in the structure or function of the system that go beyond adjusting existing practices New strategies in a region or resource system	Depth of deliberate change in the fundamental attributes of natural and human systems: the degree to which adaptations reflect major shifts (new, novel and different paradigms, goals or values that represent a change from existing practices and alter the frameworks, values, logic and assumptions underlying the system)	• Deep structural reforms • Complete change of mindset among governments or populations • Radical shifts in public perceptions or values • Changing institutional or behavioural norms • Path-shifting • Restructuring of socioecological systems • Innovative approaches • Deep changes in individual and collective values and behaviours • A fairer balance of political, cultural and institutional power in society	• Systems change, or change within a single system only • Shifts away from existing practices, such as the adoption of new agricultural techniques that moderately alter farming norms • Deep structural reforms, such as integrating climate resilience into all facets of urban planning • Integration of the role of explicit normative visions of the future and subjective judgment on transformational futures in reorienting policy strategies at various scales of action. This entails acknowledging a range of meanings and motives and ensuring a participatory co-production process	• Depth of change: • Re-evaluating current assumptions on dominant values, rules and practices to promote new adaptation options • Facilitating multi-loop learning approaches that question current world visions and create opportunities for alternative adaptation • Taking advantage of windows of opportunity such as extreme climate hazards, political reform and new technologies to redirect development pathways • Identifying leaders and key agents to promote deep social changes that lead to transformational adaptation, as well as power dynamics that might prevent its implementation • Engaging with bridging organizations to facilitate knowledge-sharing that increases awareness of behavioural changes for transformational adaptation
		Limits of change (challenging the limits to	Constraints that make it harder to plan and implement adaptation action include: economic: existing livelihoods, economic structures and economic mobility; social/cultural: social norms, identity, place attachment, beliefs, world views, values, awareness, education, social justice and social support; human capacity: individual, organizational and		

Definition	*Dimensions*	*Elements to be assessed for evidence of transformational adaptation*	*Elements to be assessed for estimating transformational potential*[a]	*Operationalizing and implementing transformational adaptation (transformational change for climate action)*
	adaptation that result from the interaction of adaptation constraints and speed of change)	societal capabilities to set and achieve adaptation objectives over time, including training, education and skills development; governance, institutions and policy: existing laws, regulations, procedural requirements, governance scope, effectiveness, institutional arrangements, adaptive capacity and absorption capacity; financial: lack of financial resources; information/awareness/technology: lack of awareness or access to information or technology; physical: presence of physical barriers; and biological: temperature, precipitation, ocean salinity, acidity and intensity and frequency of extreme events, including storms, droughts and wind		
Deep and long-term societal changes that influence sustainable development (including values and world views)		• Persistent changes: • Ecological: hard to reverse (without human input) • Social: persistent (over several generations) • Social-ecological: future-oriented and long term but not necessarily irreversible	• The extent to which equity and distributional issues are explicit (i.e. strongly considered, including in relation to both intra- and intergenerational equity)	• Adaptive sustainability (robustness, resilience and adaptiveness of change): • Investing in research and experimentation on new adaptation options, including transformational adaptation • Learning through long-term monitoring and evaluation, including impact evaluation, to avoid ineffective adaptation • Institutionalizing new practices and regulatory frameworks • Securing political and funding support for long-term actions
Adoption at a large scale, transforming places and potentially shifting locations	Scope/scale of deliberate change (geographic or institutional)	• System-wide change: • Ecological: in large areas of ecosystems or landscapes • Social: widespread among societies and geographies • Social-ecological: large-scale or systemic • Multiscale change: • Ecological: at multiple trophic[b] levels and spatial scales • Social: across jurisdictional and societal levels • Social-ecological: at multiple system scales (spatial, governance, sectors) • A small scope refers to local initiatives or activities restricted to	• Decision-making process: a single or heterogeneous agent in charge of assessment. A complex perspective and heterogeneous agent are important for assessing options and innovative solutions and potential cooperation mechanisms required for systems transformation	• Scale of change relating to levels, policies, people, geography, levels of understanding and the public–private continuum: • Scaling up from the individual household, community or subsector level over time as decisions, practices or technologies become widespread • Scaling down from the national level, for example through large-scale nationally determined contributions to the regional and local level and through investments in change

	Definition	*Dimensions*	*Elements to be assessed for evidence of transformational adaptation*	*Elements to be assessed for estimating transformational potential*[a]	*Operationalizing and implementing transformational adaptation (transformational change for climate action)*
			particular neighbourhoods, communities, groups or projects • A broad scope refers to large-scale and system-wide changes that might involve an entire organization, country, large region or large population		
Transformational change	A system-wide change that requires more than technological change by considering social and economic factors that, together with technology, can bring about rapid change at scale	Speed of deliberate change	• A slow or incremental change might include small changes made in incremental steps, or a series of small shifts • A faster change might involve rapid changes or what might be called 'transformational' changes in terms of relatively sudden shifts in views, perceptions, attitudes and norms (a disruptive attribute of transformational adaptation)		• Speed of change: • Accelerating impacts to achieve the appropriate speed of change while ensuring a just transition • Typically affected by alignment of systemic changes, scaling pathways and shifts in other related social, economic and environmental systems
Transformation	A change in the fundamental attributes of natural and human systems. Transformation could reflect strengthened, altered or aligned paradigms, goals or values towards promoting adaptation for sustainable development, including poverty reduction				• Relevance highlights the ongoing dynamic relationship between desired goals, context and opportunities. At the systems level, change can be assessed for its relevance to or alignment with key goals (signalling "where we need to go") and processes (signalling "who needs to be involved")

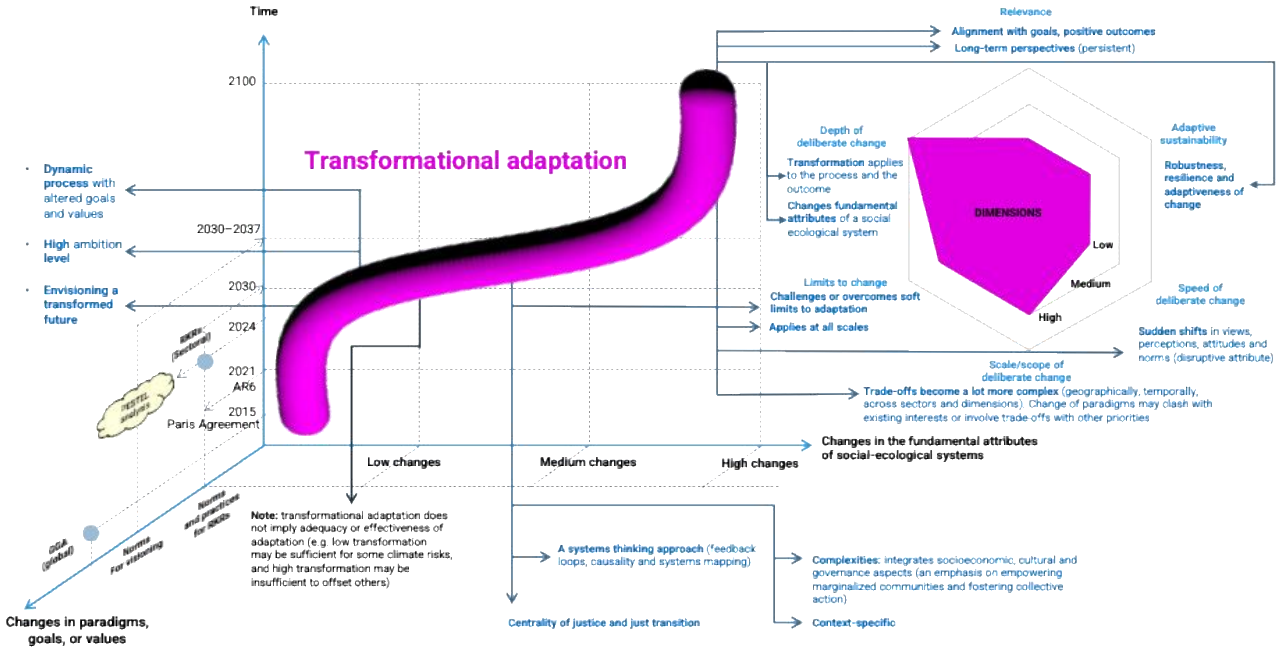
[a] See paras. 11 and 64(h) and the box above.

[b] An organism can occupy multiple trophic levels in an ecosystem. This typically occurs when an organism is an omnivore, meaning it consumes both plants and animals.

B. Practical attributes of transformational adaptation

66. Figure 10 illustrates some practical attributes that distinguish transformational adaptation from incremental adaptation. It depicts the dimensions of a transformational adaptation measure (in dark blue text), while the practical attributes of transformational adaptation (in blue text) are positioned close to the relevant dimension or along the axis representing the changes in the paradigms, goals or values. General attributes are grouped beneath the diagram. The curve in the diagram represents the temporal evolution of the transformational adaptation process, highlighting that changes occur along all three axes (changes in fundamental attributes of socioecological systems, changes in paradigms, goals or values and time).

Figure 10
Practical attributes of transformational adaptation



Note: The practical attributes (in dark blue text) are positioned close to the dimension of transformational adaptation (in light blue text) or the axis of the figure to which they are related.

67. Further considerations regarding the practical attributes of transformational adaptation include the following:

(a) Transformation entails changing the fundamental attributes of a social-ecological system, which includes altering goals or values through a dynamic process. It is therefore important to periodically revisit adaptation measures, as the form of an adaptation cycle is more similar to a spiral, rather than a circle. It is crucial to reassess all goals, paradigms and values and to bear in mind that a potential indicator for a dimension that can be relevant and useful for one phase (now) may not necessarily be appropriate for another phase (future);

(b) Transformational adaptation typically entails actions that have a higher level of ambition. One way of conceptualizing ambition levels is viewing them as a spectrum, staring with survival (basic needs are safeguarded); stabilization (the impacts of climate change are offset); the SDGs (which are attained and sustained in the long term, even in the presence of climate change); and transformation (the transformational aspirations of countries towards attaining scaled-up levels of sustainability and resilience are achieved, even in a world changed by climate);

(c) Assessing whether a transformation is “good” in the context of transformational adaptation involves evaluating the extent to which the transformation has achieved its intended goals and generated positive outcomes. While there is no ‘one size fits

all' approach to measuring the success of a transformation, key considerations include alignment with goals, positive outcomes, long-term sustainability, equity and social justice, and monitoring and evaluation;

(d) Envisioning the characteristics of the transformed future is the essential starting point of transformational adaptation. The future should be perceived as aspirational and desirable by society to ensure buy-in and ownership. Goals that help people envision a future significantly different from the present can be a key difference between decision-making processes that pursue transformational adaptation as opposed to incremental change;

(e) Transformation can apply to the process and the outcome of transformational adaptation of social-ecological systems. The process involves fundamental changes in such systems,[53] while the outcome refers to the changes that occur because of these transformations;

(f) Disruption is considered to be an attribute of transformational adaptation. Transformation goes beyond the normal or usual response, and beyond current (political and economic) 'business as usual' scenarios and can involve a drastic change in attitudes or mindsets. Leveraging windows of opportunity and disruptions to mindsets and of social-ecological systems could help to advance towards a deeper level of transformation;

(g) Adopting long-term perspectives implies that an indicator for an outcome in the short term may be very different from an indicator for the same outcome over a longer period. It also implies that deep changes resulting from transformational adaptation should be persistent;

(h) Transformational adaptation can take place at all scales, at the ground, national and global level, including for individual projects, investments and decisions, and its attributes differ on the basis of the level of implementation. At the community level, it involves empowering local communities. Municipal planning plays a key role in local adaptation efforts. National policies must prioritize the needs of communities, and regional approaches should address vulnerability and build resilience, as outlined in adaptation communications, NAPs and nationally determined contributions. At the global level, transformational adaptation requires mobilizing resources and involving relevant actors in decision-making processes (e.g. the global goal on adaptation and the global stocktake). Trade-offs across levels should be considered and addressed;

(i) Transformation entails challenging and overcoming 'soft' limits to adaptation, including those related to economic, social and cultural factors, human capacity, governance, institutions and policy, information, awareness and technology, and financial, physical and biological constraints. This underscores the importance of enabling environments for successful transformational adaptation;

(j) Trade-offs become increasingly complex geographically, temporally and across sectors and dimensions in relation to transformation and scaling up adaptation action. For example, achieving transboundary benefits may require some countries to sacrifice individual national benefits for larger collective gains. In humanitarian contexts, policies that promote long-term peace, stability or open markets could facilitate transformational adaptation. Interventions such as supplemental feeding or access to health care could be transformational by providing nutrition that reduces long-term stunting and minimizes the vulnerability of children to future hazards. These aspects have yet to be fully assessed by the IPCC, pending publication of relevant scientific literature;

(k) The complexities[54] of transformational adaptation require a comprehensive approach that integrates socioeconomic, cultural and governance dimensions, with an emphasis on empowering marginalized communities and fostering collective action;

(l) Including the largest possible number of stakeholders and all levels of governance in the visioning and policy-setting agenda is crucial for successful

[53] For example, the adaptation planning process itself (i.e. the development of NAPs) can be conceptualized as transformational, as it includes a mindset shift around incorporating climate risks in planning.

[54] In some cases, however, transformational adaptation can be a simple solution.

transformational adaptation, as the absence of broad ownership can amplify barriers to transformation;

(m) A 'systems thinking' approach could help in understanding the interconnections among the dimensions of transformational adaptation and their emerging properties. This approach incorporates concepts such as feedback loops, causality and systems mapping to navigate the multifaceted challenges posed by transformational adaptation;[55]

(n) Central to transformational adaptation are principles of justice (distributive and procedural and a recognition of justice) that ensure a fair allocation of resources, inclusive decision-making processes and respect for diverse values and perspectives. Applying the principles of justice and ensuring just transition are essential to prevent an expectation that any loss incurred in the transition towards the aspirational future does not outweigh the benefits of that future.

68. An important question to consider is the extent to which contemporary global systems are transformable to enable a desired and positive vision of the future to be achieved, even in an impending climate crisis. The findings presented in this paper on the potential for future transformational adaptation, which are based on previous experience of transformational adaptation, provide an initial answer to this question, but further work is needed.

69. Effective implementation of transformational adaptation involves addressing various barriers and leveraging numerous values and principles. These include, for example, intrinsic, instrumental and relational values specific to nature-based solutions, as well as the incorporation of 'systems thinking' to understand interconnected phenomena and plan for sustainable development. Barriers that need to be overcome include vested interests, economic lock-ins, institutional path dependencies and prevalent social practices, cultures, norms and belief systems.

70. Given that the concept of transformational adaptation is complex and evolving, it should not become a requirement for providing adaptation finance to developing countries, which are struggling to implement incremental adaptation measures and have significant capacity constraints (see para. 2 above). The concept may be more useful when applied from a backward-looking perspective by assessing what worked and was considered transformational in a given project.

71. A collective understanding of the principles guiding transformational adaptation is beneficial, such as equity and equality being fundamental to the success of transformational adaptation to ensure a transition where benefits are fairly distributed, particularly among vulnerable populations. These principles can be operationalized through a possible multilateral development bank process.

72. The AR6 highlights that the post-AR5 focus on transformational adaptation and resilience present in the literature suggests that institutions that enable system transitions towards climate-resilient development are secure enough to facilitate a wide range of voices and legitimate enough to change goals or processes over time, without reducing confidence in their efficacy.[56] How this finding applies to transformational adaptation may require further consideration as the concept develops and is better understood.

C. Connecting transformational adaptation with specific targets

73. Linking transformational adaptation with specific targets could support countries and relevant agencies in implementing adaptation efforts on the ground. This would help to embed transformational thinking in the next generation of NAPs and enable effective tracking

[55] Caldecott J (ed.). 2021. Adaptation and the Paris Agreement. In: Surviving Climate Chaos: by Strengthening Communities and Ecosystems. Cambridge: Cambridge University Press. pp.3–24. Available at https://www.cambridge.org/core/books/surviving-climate-chaos/adaptation-and-the-paris-agreement/8055EC5996AA348BADAFA2CF8ADA4A14. Adaptation and the Paris Agreement (Chapter 1) - Surviving Climate Chaos Surviving Climate Chaos - September 2021

[56] See the contribution of Working Group II to the AR6, section 18.4.2.3, p.2709.

of progress. It could also bridge the work undertaken on transformational adaptation and on indicators under the United Arab Emirates–Belém work programme.

74. Indicators for transformational adaptation should reflect progress both in terms of the process and its outcome. Such indicators could, for example:

(a) Evaluate the depth, scope, speed and limits of adaptation actions to effectively measure their transformational potential (e.g. low, medium, high);

(b) Measure the extent to which diverse stakeholder groups, including marginalized populations, are involved in the decision-making process and assess the role of Indigenous knowledge in transformational adaptation;[57]

(c) Explore the need for capacity-building for transformational adaptation and the type of learning required, from first-order ('business as usual') to second-order (transformational);

(d) Track actions for creating enabling environments for transformational adaptation, such as policies revised or introduced to support transformational adaptation, the level of inter-agency coordination and the establishment of robust monitoring and evaluation systems;

(e) Analyse how change is envisioned within or across the system and the level of participation in decision-making (single or heterogeneous decision-making agent);

(f) Identify how equity and distributional concerns are addressed in decisions, alongside visioning for future transformations.

75. While there is still limited understanding of what transformational adaptation looks like in practice, it is important to consider indicators that can provide advance warning of potential pushback against transformational efforts. Such indicators could include resistance to change, lack of awareness and understanding, political and institutional barriers, social and cultural factors, and lack of resources and capacity. Monitoring these indicators can help to anticipate challenges and inform strategies to overcome potential pushback.

76. Depending on the specific context and goals of the assessment of the level of transformational adaptation, a hierarchy or weighting of indicators associated with different criteria or indicators of transformation could be used. Different methods exist for assigning a weight to indicators, and the choice of method should be based on the specific requirements and preferences of the assessment or decision-making process. However, trade-offs should be considered, given that prioritizing the wrong indicators could result in a barrier to transformational adaptation.[58]

77. Separate indicators exclusively for just transition may not be needed, as the principles of just transition are often integrated into broader indicators and criteria for transformational adaptation. These indicators may encompass aspects such as equitable distribution of benefits and burdens, inclusive decision-making, protection of workers' rights, and addressing historical injustices.

78. Some dimensions of transformational adaptation can be estimated using both inductive and deductive approaches, aligning responses of adaptation practitioners at interviews with indicators from published studies. For example, the innovative approaches referred to in table 3 were defined by the introduction of new elements such as species, practices, technologies and policies and assessed from different perspectives, including regional and sectoral innovation. This dual approach ensures that transformational characteristics are both theoretically sound and practically relevant.

[57] See the summary of the fifth workshop under the Glasgow–Sharm el-Sheikh work programme on the global goal on adaptation (with the theme of the workshop selected in accordance with decision 3/CMA.4, para. 20(e) and (g)), available at https://unfccc.int/documents/627908.

[58] Holler J, Bernier Q, Roberts J, et al. 2020. Transformational Adaptation in Least Developed Countries: Does Expanded Stakeholder Participation Make a Difference? Sustainability. 12: pp.1657.

D. Implementing transformational adaptation

79. Building a common understanding on transformational adaptation can help policymakers and implementers create opportunities to catalyse it. Such opportunities include identifying key actors that can help spread new practices (e.g. bridging organizations or local leaders) and restructure systems; creating safe spaces to question current dominant values, structures, power relationships and knowledge systems (e.g. through learning and re-evaluation workshops) that help to shift away from current development pathways; and fostering partnerships and polycentric governance structures (e.g. commodity chains, mixed management committees) that connect multiple spatial and jurisdictional scales.

80. Transformational adaptation would involve, for example, anticipating changes by planning transformational adaptation; redirecting changes by assisting autonomous transformational adaptation; and recovering from changes from implementing forced transformational adaptation as a result of climate change. Table 3 presents further details on actions that could be taken to support the implementation of transformational adaptation, grouped by its suggested dimensions.

IV. Possible way forward

81. The concept of transformational adaptation is complex, context-specific and encompasses an evolutionary process. Much therefore remains to be done to improve understanding of the concept, particularly benefits and trade-offs in a wide variety of regional and sectoral contexts, with a view to informing climate-related strategies, decision-making and actions, for example:

(a) Systematically documenting and sharing ongoing efforts, success stories and experience related to transformational adaptation to improve current insights and practices;

(b) Conducting ‘horizon scanning’ exercises at the regional level to capture significant differences, challenges and the potential related to transformational adaptation for each region;

(c) Identifying transformational adaptation approaches for each target under the United Arab Emirates Framework for Global Climate Resilience and for different sectors and regions with the aim of providing an optimal spectrum of transformational and incremental adaptation action for different sectors and regions;

(d) Using the work on indicators under the United Arab Emirates–Belém work programme as an opportunity to formulate meaningful indicators specific to transformational adaptation, considering the possible dimensions presented in table 3. Many improvements to current insights and practices could be made by documenting and sharing ongoing efforts and experience.

82. Collaborative efforts are crucial and more collective thinking could be encouraged. Currently, other entities, such as the IPCC and multilateral development banks, are working on adaptation indicators and should be involved and remain engaged in any efforts to advance the discussion on dimensions and attributes for transformational adaptation.

83. Special attention should be given to bringing in missing elements from current transformation adaptation efforts. This can create an opportunity to integrate missing sectors into the solution space. More research is also needed on the role of technology and innovation and on connecting the adaptation discourse with specific targets, alongside fostering a shared understanding of transformational adaptation.

84. The IPCC findings on transformational adaptation, in particular regarding evidence and potential, could guide priority areas and future work. Adaptation-related reports submitted by Parties, such as adaptation communications, BTRs and NAPs, can complement these findings. Critical areas such as infrastructure development offer opportunities to ‘leapfrog’ into more resilient and sustainable urbanization practices.

85. Transformational adaptation acknowledges the interconnectedness of adaptation and mitigation strategies and is aimed at enhancing climate resilience while reducing GHG

emissions. Harmonizing how this concept is understood and applied across adaptation and mitigation efforts, including reporting requirements, is essential (e.g. by harmonizing relevant reporting requirements).

Annex

Examples of case studies and success stories of transformational adaptation to climate change

1. Transformational adaptation to climate change is a relatively new concept, and there are ongoing efforts to understand and implement it. While there may not be a wide range of well-documented success stories specifically focused on transformational adaptation, there are examples in the literature that highlight the potential and effectiveness of transformational approaches, including:

(a) *The role of adaptive capacity in incremental and transformative adaptation in three large U.S. urban water systems*.[1] Urban water systems need to serve an increasing number of people under a changing climate. Studies of systems facing extreme events such as drought can clarify the nature of adaptive capacity and whether it might support incremental or transformational adaptation to climate change. Comparative case studies of three major metropolitan water systems in the United States were conducted to understand how actions taken in response to drought affected adaptive capacity and whether the adaptive capacity observed in these systems fosters the preconditions needed for transformational adaptation;

(b) *Adapting to Climate Change – Three Success Stories*.[2] This study highlights various examples from around the world where communities, households and governments have taken measures to reduce their exposure and vulnerability to weather shocks and climate change. It emphasizes that investing in successful adaptation strategies can help to reduce the economic costs of climate change;

(c) *Transformational adaptation to climate change for sustainable social-ecological systems*.[3] This article acknowledges that certain coping or incremental adaptation strategies may not be sufficient or sustainable in the long term to address climate change. It emphasizes the need for fundamental changes in social-ecological systems to address the root causes of vulnerability. While the article does not provide specific success stories, it highlights the characteristics of transformational adaptation and the importance of addressing vulnerability;

(d) *Towards more sustainable responses to natural hazards and climate change challenges via transformative adaptation*.[4] This paper reviews the literature on transformational climate change adaptation and refers to a unique set of cases from 20 countries, predominantly in the Global South. While the paper does not provide detailed success stories, it suggests measures through which transformational adaptation can be further deployed to tackle climate challenges;

(e) *Adapting cities for transformative climate resilience: lessons from the field*.[5] This editorial highlights the need for cities to move beyond protecting the status quo towards social transformation in the face of climate change. It emphasizes the importance of

[1] Dilling L, Daly ME, Travis WR, et al. 2023. The role of adaptive capacity in incremental and transformative adaptation in three large U.S. urban water systems. *Global Environmental Change*. 79: pp.102649. Available at https://www.sciencedirect.com/science/article/pii/S0959378023000158.

[2] Pugacheva E and Mrkaic M. 2018. *Adapting to Climate Change—Three Success Stories*. Available at https://www.imf.org/en/Blogs/Articles/2018/03/20/adapting-to-climate-change-three-success-stories.

[3] Fedele G, Donatti CI, Harvey CA, et al. 2019. Transformative adaptation to climate change for sustainable social-ecological systems. *Environmental Science & Policy*. 101: pp.116–125. Available at https://www.sciencedirect.com/science/article/pii/S1462901119305337.

[4] Filho WL, Salvia AL, Balogun A-L, et al. 2023. Towards more sustainable responses to natural hazards and climate change challenges via transformative adaptation. *Cities*. 141: pp.104525. Available at https://www.sciencedirect.com/science/article/pii/S0264275123003372.

[5] Daniere A and Archer D. 2023. Editorial: Adapting cities for transformative climate resilience: lessons from the field. *Frontiers in Sustainable Cities*. 5. Available at https://www.frontiersin.org/journals/sustainable-cities/articles/10.3389/frsc.2023.1211125/full.

rethinking resilience planning and policy and provides insights into how different stakeholders and their networks can engage in transformational resilience at the urban level;

(f) *Water in Circular Economy and Resilience: The Case of Chennai, India*.[6] This case study illustrates the example of a large-scale reconfiguration of the urban water cycle prompted by drought and flooding, which were triggered by reaching 'soft' adaptation limits. It addresses aspects such as multilevel policy support for water reuse, and system-wide action that incorporates domestic water supply, wastewater and industrial water supply. The initiative involved significant stakeholder engagement and changes in tariff structures to ensure that appropriate incentives were established. Based on the case study the dimensions of transformational adaptation can categorized as follows:

(i) Depth of change: the transformation occurs at the city level, involving large-scale physical reconfiguration. However, further insights are needed regarding the extent of shifts in mindsets and norms;

(ii) Medium scope/scale of change: the changes are city-wide and replicable. Wastewater reuse is becoming normalized and replicated globally as a 'new' source of water (e.g. in Singapore). Similarly, aquifer recharge is another approach to water cycle management that is being expanded at a large scale;

(iii) Speed of change: drought cycles have prompted thinking for quite some time, indicating that the transformational process extends beyond a five-year time frame. Nevertheless, for the scale of changes related to infrastructure and technology and securing financing and implementation, the pace of transformation is relatively quick;

(g) *Characteristics of Transformational Adaptation in Climate–Land–Society Interactions*.[7] This paper considers the characteristics of transformational adaptation and development in the context of profound changes in land and climate. It contains four case studies: managing storm water run-off related to the conversion of rural land to urban land in Indonesia; using a basket of interventions to manage the social impacts of flooding in Nepal; combining a national glacier protection law with water rights management in Argentina; and community-based relocation in response to permafrost thaw and coastal erosion in Alaska, United States;

(h) Lessons learned from several case studies conducted by UNEP, such as on Xalapa, Mexico,[8] which highlights the elements necessary for establishing a transformational financing scheme, including the dependencies between the large depth and scope of transformation and political influence on the speed of transformation; and policy briefs on lessons learned from Lesotho,[9] Madagascar[10] and the United Republic of Tanzania[11] that offer

[6] *Water in Circular Economy and Resilience (WICER): The Case of Chennai, India*. Available at https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/737251622708324921/Water-in-Circular-Economy-and-Resilience-WICER-The-Case-of-Chennai-India.

[7] Warner K, Zommers Z, Wreford A, et al. 2019. Characteristics of Transformational Adaptation in Climate-Land-Society Interactions. *Sustainability*. 11(2): pp.356. Available at https://www.mdpi.com/2071-1050/11/2/356.

[8] UNEP. 2024. *A Decade of Ecosystem-based Adaptation: Lessons from the United Nations Environment Programme*. UNEP. Available at https://www.unep.org/resources/policy-and-strategy/decade-ecosystem-based-adaptation-lessons-united-nations-environment.

[9] UNEP. 2022. *Lessons Learned: Building Climate Resilience in Lesotho with Early Warning Systems*. UNEP. Available at http://www.decadeonrestoration.org/publications/lessons-learned-building-climate-resilience-lesotho-early-warning-systems.

[10] UNEP. 2022. *Lessons Learned: Ecosystem-based Adaptation and an Integrated Resilient Rice Model in Madagascar*. UNEP. Available at https://www.unep.org/resources/publication/lessons-learned-ecosystem-based-adaptation-and-integrated-resilient-rice.

[11] UNEP. 2022. *Climate Adaptation in Tanzania with Ecosystem Restoration & Flood Defence Infrastructure - UNEP Lessons in Climate Change Adaptation*. UNEP. Available at https://wedocs.unep.org/xmlui/handle/20.500.11822/40369.

insights into potential examples of transformation, including in terms of sustainability and replicability, and on gender inclusivity as an enabler of transformation in the Gambia;[12]

(i) The NAP task force *Policy brief on progress, good practices and lessons learned: challenges and opportunities in the application of traditional knowledge, knowledge of Indigenous Peoples and local knowledge systems in adaptation*,[13] which highlights the importance of traditional and Indigenous Peoples' knowledge and local knowledge systems in providing insights into and solutions for transformational adaptation measures. The shift towards long-term transformational adaptation, systems change and holistic approaches can facilitate the integration of scientific and technological innovations with traditional and Indigenous knowledge. This includes the application of alternative value systems such as the rights of nature and the deep interconnection between humanity and the natural environment.

2. These examples demonstrate the potential for transformational adaptation to address the challenges posed by climate change. However, it is important to note that transformational adaptation is context-specific and requires interdisciplinary approaches, stakeholder engagement and long-term planning. Further research and case studies are needed to better understand and document successful transformational adaptation efforts.

[12] UNEP. 2024. *A Decade of Ecosystem-based Adaptation: Lessons from the United Nations Environment Programme*. UNEP. Available at https://www.unep.org/resources/policy-and-strategy/decade-ecosystem-based-adaptation-lessons-united-nations-environment.

[13] Available at: https://unfccc.int/documents/640913.