Chapter 1

Chapter 1 INTRODUCING THE NEXUS[1]

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Note

The Nexus Assessment chapters share a common thread of case studies highlighting Indigenous Peoples' and local communities' (IPLC) food systems. **Chapters 1** to **4**, **5.1** to **5.5** and **6** include one or more of these case studies. The case studies are presented in boxes and are distinguished by *box titles in italicized font*. Lessons learned from the common case studies are presented in **Chapter 7**, online **Suplementary material 7.1**.

Disclaimer on maps

The designations employed and the presentation of material on the maps used in the present report do not imply the expression of any opinion whatsoever on the part of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. These maps have been prepared or used for the sole purpose of facilitating the assessment of the broad biogeographical areas represented therein.

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Chapter **1**

INTRODUCING THE NEXUS

EXECUTIVE SUMMARY

The Nexus Assessment evaluates how biodiversity, water, food, health and climate change influence each other (decision IPBES 8/1) {1.1.1}. It aims to disentangle the complex interlinkages among these five elements, and the socio-ecological systems and actors involved. It focuses on understanding the challenges and opportunities associated with addressing these interlinkages in an integrated manner as a whole system. The assessment aims to inform key policy-relevant questions about past, present and possible future trends in these multi-scale interlinkages among the five nexus elements, with a focus on biodiversity and nature's contributions to people {1.1.3}. The assessment also appraises a diverse range of effective and integrated response options for all actors. These response options emerge from institutions and governance systems, with some options being most efficiently driven by specific actors within a nexus element and others requiring collaborative and coordinated action across multiple elements and actors. These response options are designed to address specific objectives, challenges or opportunities in the governance, financing and management of the interlinkages among nexus elements and accelerate transitions towards just and sustainable futures {1.3, 1.5.2}.

Addressing challenges in biodiversity, water systems, food systems, human health and climate change in isolation can create unintended trade-offs, hindering progress in other areas {1.1.1, 1.1.2}. Siloed policies, i.e., those that treat nexus elements in isolation, can lead to unintended consequences and trade-offs among the elements. Such policies often result in disjointed approaches, including creating gaps and loopholes that allow harmful practices to continue, conflicting objectives and inefficient use of resources. They also tend to maintain the *status quo* by focusing on the immediate symptoms of environmental challenges, rather than addressing their root causes and interlinkages. A nexus approach recognizes challenges within each element are interconnected with other elements across multiple spatial and temporal scales. By improving understanding of these interconnections and identifying opportunities for collaboration across sectors and scales, the findings of the Nexus Assessment will contribute to synergistic and holistic management and governance {1.1.4}.

Despite increasing evidence of the benefits of nexus approaches for integrated decision-making, five key challenges have limited its uptake in policy and practice: navigating social-ecological complexity; fragmented, sectoral and siloed decision-making; neglecting multiple and diverse values; inadequate and inappropriate scaling of actions; and insufficient, inaccessible and unpredictable finance {1.1.2}. Solving for these challenges involves: (a) embracing the complexity of nexus interactions through consideration of the interdependencies, dynamics, fluxes and feedback loops between different nexus elements; (b) fostering governance that engages different actors across the nexus elements to achieve policy change and meet international and domestic goals and objectives, including with response options that promote synergies and manage for trade-offs; (c) recognizing pluralistic values and knowledge systems of actors, including Indigenous Peoples and local communities, to effectively navigate potential conflicts, build trust and mobilize collective action; (d) overcoming mismatches across temporal and spatial scales and identifying the key processes and enabling conditions to scale up holistic solutions; and (e) redesigning financial systems and mechanisms for implementing nexus approaches {1.1.2}. New tools, approaches and indicators that enable understanding and monitoring of the interlinkages between nexus elements and assist in decision-making and meeting governance goals are thus increasingly important {1.1.2.4, 1.3.4}.

The conceptualization of the nexus developed within the assessment can be mapped to the IPBES conceptual framework {1.2.3}. Nexus elements interact in complex ways and can be conceptualized as interweaving threads that run through the different components of the IPBES conceptual framework. While biodiversity is clearly associated with the nature component and climate change with the direct drivers component of the IPBES conceptual framework, all five nexus elements can be mapped onto all other components. For example, nature's contributions to people includes food provisioning, regulation of water quality and climate, and physical and psychological experiences. All elements are also related to good quality of life in terms of health and well-being, including food and water security. The complexity of the nexus approach means that elements are not always easily separated into single components of the IPBES conceptual framework. For example, elements can act as negative drivers (e.g., food production on biodiversity and water) or support positive benefits in other nexus elements (e.g., biodiversity and water to food, or food to health) depending on context.

The Nexus Assessment includes attention to different world views, values and knowledge systems {1.2.2}. Comprehending the nexus of biodiversity, water, food, health and climate change involves considering perspectives and values across different societies and cultures. Indigenous Peoples' world views often offer a distinct perspective on the relationships between nature and people, shaped by their unique values and life experiences. These perspectives frequently highlight essential principles such as balance, complementarity, harmony, reciprocity, respect, interpersonal relationships, kinship and spirituality {1.2.2}. Context-specific Indigenous and local knowledge is inherently linked to specific regions and territories and can provide critical perspectives on sustainable management across nexus elements {1.2.2} **(Box 1.5)**. The assessment places significant emphasis on the pivotal role of Indigenous and local knowledge in shaping the core concepts of the nexus, confirming that embracing the capacity of all knowledge systems is essential to effectively inform decision-making on complex nexus interactions.

The Nexus Assessment takes an actor-oriented approach to identify gaps and needs for actors and stakeholders {1.3.3}. A diverse variety of actors are increasingly visible and vocal in decision-making across nexus elements, at scales ranging from local to global. Putting actors, including the public and other stakeholders and rightsholders, at the center of nexus approaches helps target appropriate scales of action as well as identifying significant challenges to more integrated and transformative actions and policies. Disparities and inequalities across these scales pose a complex challenge for good governance and management decisions. Competing interests among actors as well as institutional, behavioural and economic barriers can create continued pressures to operate in silos. Bringing together knowledge and interests of multiple actors, nexus governance approaches can promote cross-sectoral and cross-scale collaboration around integrated and effective response options {1.3.4}.

Nexus governance approaches can help address problems across temporal, jurisdictional and spatial scales {1.3}. As a holistic strategy, nexus governance places a high emphasis on actor collaboration across complex systems. Nexus governance involves integrative, holistic and transdisciplinary framing of problems and solutions; inclusive approaches to support actor engagement; normative considerations of equity and justice, alongside accountability; enhanced mechanisms and processes for collaboration and coordination across scales and sectors; and adaptive, reflexive and experimental approaches to learn from what works and to scale these solutions *(well established)* {1.3.4, 4.5.4}. Improved outcomes from this approach include cross-sector, multifunctional and multilevel governance systems; identification and recognition of integrated and synergistic response options; opportunities to include multiple actors, values and knowledges in integration and innovation across scales; and appropriate metrics and models to measure and monitor governance performance over time *(established but incomplete)* {1.3.4}.

The assessment's focus on the interlinkages among nexus elements supports informed, evidence-based decision-making in global policy and elsewhere *(well established)* {1.3.2}. Global policies, such as the Sustainable Development Goals, call for greater integration in policy design and implementation. The Sustainable Development Goals, with their inclusive vision for both people and the planet, recognizes the interactions among its 17 Goals and the need for integration across them. Other flagship global frameworks focused on specific challenges, such as the Kunming-Montreal Global Biodiversity Framework, the United Nations Convention to Combat Desertification and the Paris Agreement each recognize complementary overlap among them {1.3.2}. The Nexus Assessment is also consistent with the One Health approach, which recognizes the interconnectedness of human, animal and environmental health {1.2.1}. The scope of the assessment also expands beyond government or public sector initiatives and recognizes the important role of multiple actors, including the private sector {1.3.3}. It is anticipated that the findings of the assessment will stimulate implementation of nexus approaches within the whole of government and whole of society, while delivering co-benefits for biodiversity, water, food, health and climate change {1.1.4}.

1.1 INTRODUCTION

1.1.1 Defining the nexus and nexus for this assessment

The world is facing unprecedented environmental, social and economic crises of increasing complexity and magnitude (D. Biggs *et al.,* 2011; Smil, 2008). These crises are interconnected. The escalation of any single crisis can trigger or intensify other crises, resulting in a complex web of interrelated, compounding and cascading risks (Falk *et al.,* 2023; Lawrence *et al.,* 2020; Pescaroli & Alexander, 2018). One example is the connection between ecosystem degradation and climate change, with a decline in the former leading to a reduction of carbon sinks and exacerbation of climate change processes (Chotte *et al.,* 2019; Habibullah *et al.,* 2022; Maxwell *et al.,* 2016; Newbold *et al.,* 2015). Another example is the connection between nature and human health, where biodiversity loss is linked to the emergence of novel diseases (IPBES, 2020; Platto *et al.,* 2021).

The Nexus Assessment addresses the complex and interconnected nature of environmental, social and economic crises, including biodiversity loss, climate change, food and water insecurity, and global pandemics. The word "nexus" is derived from the Latin *nectere*, meaning to bind or connect (Estoque, 2023; Liu, Hull, *et al.,* 2018). It describes the interlinkages among two or more elements, sectors or systems (adapted from Estoque 2023). This includes their social, economic and environmental components and how the elements interact across scales, geographic regions and ecosystems. "Nexus elements" are defined as an individual entity, component or sector of the nexus for which a change in state may impact the status of other nexus elements given element interlinkages and interdependencies. "Nexus interlinkages" or "nexus interactions" are defined as influences between multiple elements in a system. "Nexus interdependencies" are defined as how one or more elements in a system are dependent on another to function. Specifically, the Nexus Assessment critically evaluates evidence on interlinkages and interdependencies among the five nexus elements of biodiversity, water, food, human health and climate change – collectively referred to as "the nexus" in this assessment **(Box 1.1)**. Climate change is included as it has important and increasing interactions with biodiversity as a driver of biodiversity loss and through climate change adaptation and mitigation actions. Although energy is not considered as a nexus element, relevant aspects of energy systems are assessed where they have interlinkages with biodiversity, water, food, health and climate change adaptation and mitigation. Other systems, such as land and soil, are considered to be cross-cutting rather than stand-alone nexus elements (see **Chapter 7**, **section 7.2**).

The relationships among the five nexus elements are conceptualized in **Figure 1.1**. Biodiversity is shown at the core of the nexus underpinning major components of water, food and human health, while climate change is shown as the outer envelope driving interactions with the other four nexus elements of biodiversity, water, food and health.

A "nexus approach" focuses on a holistic understanding of the interlinkages and interdependencies between sectors or systems to develop integrated and adaptive decisions that aim to maximize synergies and minimize trade-offs (adapted from Estoque, 2023). "Holistic" understandings are those that are based on consideration of complete systems that are more than the sum of individual parts (Meadows, 2008). A "trade-off" is defined as a situation where enhancement of a desirable outcome in one element leads to deterioration of another element, while a "synergy" is defined as the enhancement of a desirable outcome in one element that leads to enhancement of another element (adapted from (IPBES, 2018d).

A nexus approach is important because despite the intertwined nature of the threats to biodiversity, water, food, health and climate (Estoque, 2023; Penuelas *et al.,* 2020; Hopkins *et al.,* 2022; Des Roches *et al.,* 2021), policies and actions often address these threats in isolation, resulting in potential misalignment (Schmidt-Traub *et al.,* 2019), unplanned trade-offs or unintended consequences (Adhikari *et al.,* 2023; Suckling *et al.,* 2021). The Nexus Assessment informs coherent and coordinated policies and actions for addressing these threats and accelerating progress towards achieving the 2030 Agenda for Sustainable Development and its interlinked 17 Sustainable Development Goals

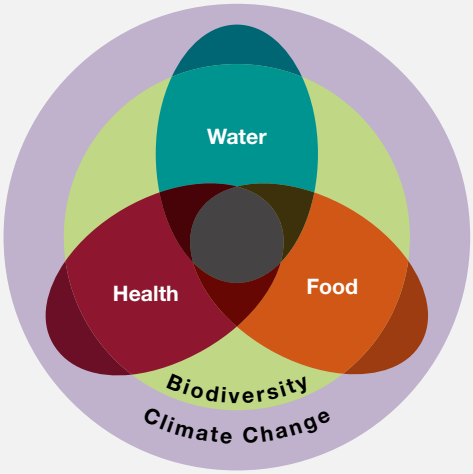

Figure 1 1 **Simplified conceptualization of "the nexus" considered in this assessment showing the relationships between the five nexus elements of biodiversity, water, food, health and climate change.**

Box 1 1 Definitions of the five elements in the Nexus Assessment.

See assessment glossary for further details.

Biodiversity is the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are a part. This includes variation in genetic, phenotypic, phylogenetic and functional attributes, as well as changes in abundance and distribution over time and space within and among species, biological communities and ecosystems (CBD, 1992; IPBES, 2019b). The assessment covers terrestrial, freshwater and marine ecosystems.

Water covers inland waters as defined by the Convention on Biological Diversity (CBD, 1992). This includes all waters (fresh, brackish and salt water) located or adjacent to land boundaries and encompasses nearshore/coastal marine environments and "lakes, rivers, ponds, streams, groundwater, springs, cave waters, floodplains, as well as bogs, marshes and swamps".

Food covers any substance, whether processed, semi-processed or raw, which is intended for human consumption (shortened from FAO and WHO (2019)). Nutritious foods refer to safe foods that contribute essential nutrients such as vitamins and minerals (micronutrients), fibre and other components to healthy diets that are beneficial for growth, health and development, guarding against malnutrition (FAO *et al.,* 2022). Food systems encompass the entire range of actors (from local to industrial producers) and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, storage, consumption and disposal of food products. They comprise all food products that originate from crop and livestock production, forestry, fisheries and aquaculture, as well as the broader economic, societal and natural environments in which these diverse production systems are embedded (shortened from FAO, (2021)).

Health is the state of human physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1946). The assessment recognizes the link between human health, animal health, plant health and ecosystem health and the need to achieve equity of health outcomes in addressing all elements of the nexus and contributing to sustainable futures (Adisasmito *et al.,* 2022).

Climate change refers to alterations of global climate resulting directly or indirectly from human activities that alter the atmospheric composition, beyond what is observed from natural climate variability over comparable time periods (UNFCCC, 1992). This assessment also considers climate action, including adaptation and mitigation strategies (IPCC, 2018, 2022a), and examines related aspects of the energy system and of land use change that are relevant to such action.

(SDGs) in combination with the implementation of other policy frameworks such as the Kunming-Montreal Global Biodiversity Framework (Wanger *et al.,* 2020) and the Paris Agreement (Gomez-Echeverri, 2018; Hermwille *et al.,* 2023).

The majority of current environmental crises threatening biodiversity, water, food, health and climate can be attributed to increased human activities (FAO, 2022; Newbold *et al.,* 2019). Globally, over 70% of land and 87% of sea surface area are directly affected by human use (Ellis *et al.,* 2021; IPCC, 2019a; Jones *et al.,* 2018; Williams *et al.,* 2020), with different degrees of alteration or degradation of ecosystem properties and processes (Gaston *et al.,* 2014; IPBES, 2018a). Such activities have significantly increased access to food, water, medicine, energy, technology and material goods globally (Steffen *et al.,* 2015), greatly improving human health and well-being in the short-term. However, their continued and growing impact on the environment is not sustainable (Hoekstra & Wiedmann, 2014; Raudsepp-Hearne *et al.,* 2010) and endangers long-term human well-being. These impacts include degradation of natural habitats and biodiversity loss (IPBES, 2019b); increased greenhouse gas emissions (IPCC, 2023a); reduced productivity of land and seas (IPCC, 2019a; Montfort *et al.,* 2021; Worm, 2016); overuse of freshwater (United Nations, 2018b); numerous sources of pollution in the soil (Rodríguez-Eugenio *et al.,* 2018), in freshwater and oceans (Azevedo-Santos *et al.,* 2021; Compa *et al.,* 2019; United Nations, 2021) and in the air (Health Effects Institute, 2020); and the emergence and spread of known and unknown diseases (Gibb *et al.,* 2020; IPBES, 2020; Mora *et al.,* 2022). Humanity's increasing impact on the environment threatens to cross ecological and physical limits leading to damaging and potentially catastrophic effects on humanity and the planet (IPCC, 2022a; Isbell *et al.,* 2023; Richardson *et al.,* 2023).

Environmental crises do not impact everyone equally and, thus, justice and equity are important considerations in determining risks and benefits across nexus elements (Chiabai *et al.,* 2018; Islam & Winkel, 2017; Roe *et al.,* 2019). Groups who rely more directly on natural resources, such as small-scale farmers, fishers and pastoralists, are more vulnerable to changes in the environment (IPCC, 2014, 2022a). IPLC, in particular, can be disproportionately affected by compounding environmental degradation and pollution (Fernández-Llamazares *et al.,* 2020), loss of livelihoods (Blackmore *et al.,* 2021; Dawson *et al.,* 2023; Torres-Vitolas *et al.,* 2019) and a lack of access to, or appropriation by others, of environmental resources that facilitate adaptation (IPBES, 2019b; Parraguez-Vergara *et al.,* 2016). These impacts challenge traditionally dynamic systems for environmental management, the use and

transmission of ILK and the ability of IPLC to conserve and sustainably manage biodiversity that are also relevant to broader society (IPBES, 2019b).

The asymmetries of impacts mirror inequalities in resource access and vulnerabilities, among and within regions or countries (King & Harrington, 2018; Meyfroidt *et al.,* 2022). Land, materials, energy and labour are transferred from lower-income regions or countries to higher-income regions or countries through trade. This results in a small, wealthy fraction of the world's population claiming the majority of resources, while severely damaging the environment, often in distant locations (Hickel, Dorninger, *et al.,* 2022; Hickel, O'Neill, *et al.,* 2022; Oteros-Rozas *et al.,* 2019; Rammelt *et al.,* 2022). Addressing these pronounced inequalities by redistributing not only the benefits of nature but also the risks and responsibilities has been seen as a pathway ensuring a fairer and more equitable distribution of positive and negative effects (Gupta *et al.,* 2023; Rammelt *et al.,* 2023).

Environmental crises and the distribution of their impacts are exacerbated by siloed policy approaches, where single sector policies are developed and implemented in isolation and without regard to interlinkages among nexus elements. Such policies often fail to solve environmental crises because they tend to focus on short-term goals and narrow interests (Aggestam *et al.,* 2023; Tudose *et al.,* 2021). For example, short-term solutions to water scarcity may rely on unsustainable water extraction methods, which provide temporary relief but can lead to further depletion of water resources, ecological damage and increased conflicts over water allocation in the long run (Alotaibi *et al.,* 2023; Ingrao *et al.,* 2023). For instance, the 2023 water shortage crises in Uruguay forced the government to temporarily allow tap water standards to exceed national drinkability criteria, doubling the sodium levels and nearly tripling the chloride content, posing potential health risks. This is despite efforts by the Uruguay Government to recognize drinking water as a human right in its constitution in 2004 (Harris & Roa-García, 2013; Trimble *et al.,* 2021). This extreme water crisis, which occurred during a period of exceptional drought, was exacerbated by water use and runoff from agriculture and livestock in the region (Chalar *et al.,* 2011, 2013; Gorgoglione *et al.,* 2020).

A further example of siloed policy approaches is policies promoting economic growth without considering the broader environmental and social implications that can lead to resource depletion, biodiversity loss and pollution (Ali *et al.,* 2023; Higgins, 2014). Such policies often result in fragmented approaches with different government agencies or departments working independently on specific issues (Artioli *et al.,* 2017; Oseland, 2019). This lack of coordination can lead to conflicting objectives and inefficient use of resources (Bach & Wegrich, 2019; De Waal *et al.,* 2019), and spatial separation of environmental impacts from economic benefits (Carrasco *et al.,* 2017; Hull & Liu, 2018).

Siloed policies can also create gaps and loopholes that allow harmful practices to continue; for example, agricultural policies that prioritize maximizing crop yield without considering water conservation or water quality issues can result in excessive water usage and/or eutrophication of water resources (Bernhardt *et al.,* 2017; Leenhardt *et al.,* 2022; Newell *et al.,* 2019). Furthermore, such approaches tend to maintain the *status quo* by focusing on the immediate symptoms of environmental challenges, rather than addressing their root causes (Tàbara *et al.,* 2019), and have been shown to inadvertently exacerbate problems by resulting in more trade-offs (Amri *et al.,* 2022).

Policy approaches to improve outcomes across the nexus elements, termed in this assessment as "nexus governance" (see **section 1.3**), involve different actors implementing actions in an integrated, inclusive and interconnected manner when addressing environmental crises that cut across multiple sectors (Estoque, 2023; Penuelas *et al.,* 2020). Recognizing the interdependencies and interactions among sectors (Harrison *et al.,* 2016, 2019) supports the development of holistic policies and actions that aim to maximize synergies and minimize trade-offs between the nexus elements of biodiversity, water, food, health and climate change (Bleischwitz *et al.,* 2018; Liu, Hull, *et al.,* 2018). This coordination across sectors enhances policy coherence and optimizes resource allocation (Chaffin *et al.,* 2016; Pahl-Wostl, 2019).

Nexus governance approaches also foster knowledge sharing, collective action and collaboration across actors and nations (Kroll *et al.,* 2019; Pradhan *et al.,* 2017). Such collective efforts focused on a shared and inclusive vision or set of policy goals can lead to more effective and efficient solutions by pooling resources and sharing best practices, expertise and technologies to develop innovative and integrated responses (Eisenmenger *et al.,* 2020; Joensuu *et al.,* 2020). They can also seek to redistribute power across the nexus to support those most affected by negative outcomes, while providing an important opportunity to address the historical, distributional, procedural and contextual dimensions of justice and equity (Dawson *et al.,* 2018; Klein *et al.,* 2015). These circumstances emphasize the importance of nexus governance at all levels and across multiple scales, particularly for designing response options that account for interactions among different policies, institutions, actors and knowledge systems (Stringer *et al.,* 2018) to address trade-offs while enhancing social, cultural, environmental, economic and health outcomes (Kroll *et al.,* 2019; Rasul & Neupane, 2021; van Zanten & van Tulder, 2021a).

Figure 1.2 provides a conceptual example showing the potential interlinkages and outcomes for biodiversity, water, food, health and climate change between policies based on siloed and nexus approaches. The figure deliberately oversimplifies the complex interactions between policies

and nexus outcomes and presents an extreme illustration of differences between the two approaches to demonstrate the potential benefits of the nexus approach. Interlinkages between response options and nexus elements are multifaceted with synergies and trade-offs potentially emerging from both approaches, which may differ by location and change over time as context, actors and interactions evolve. However, increasing research into these interlinkages is providing a growing empirical evidence base of the benefits of a nexus approach (e.g., **Box 1.2**).

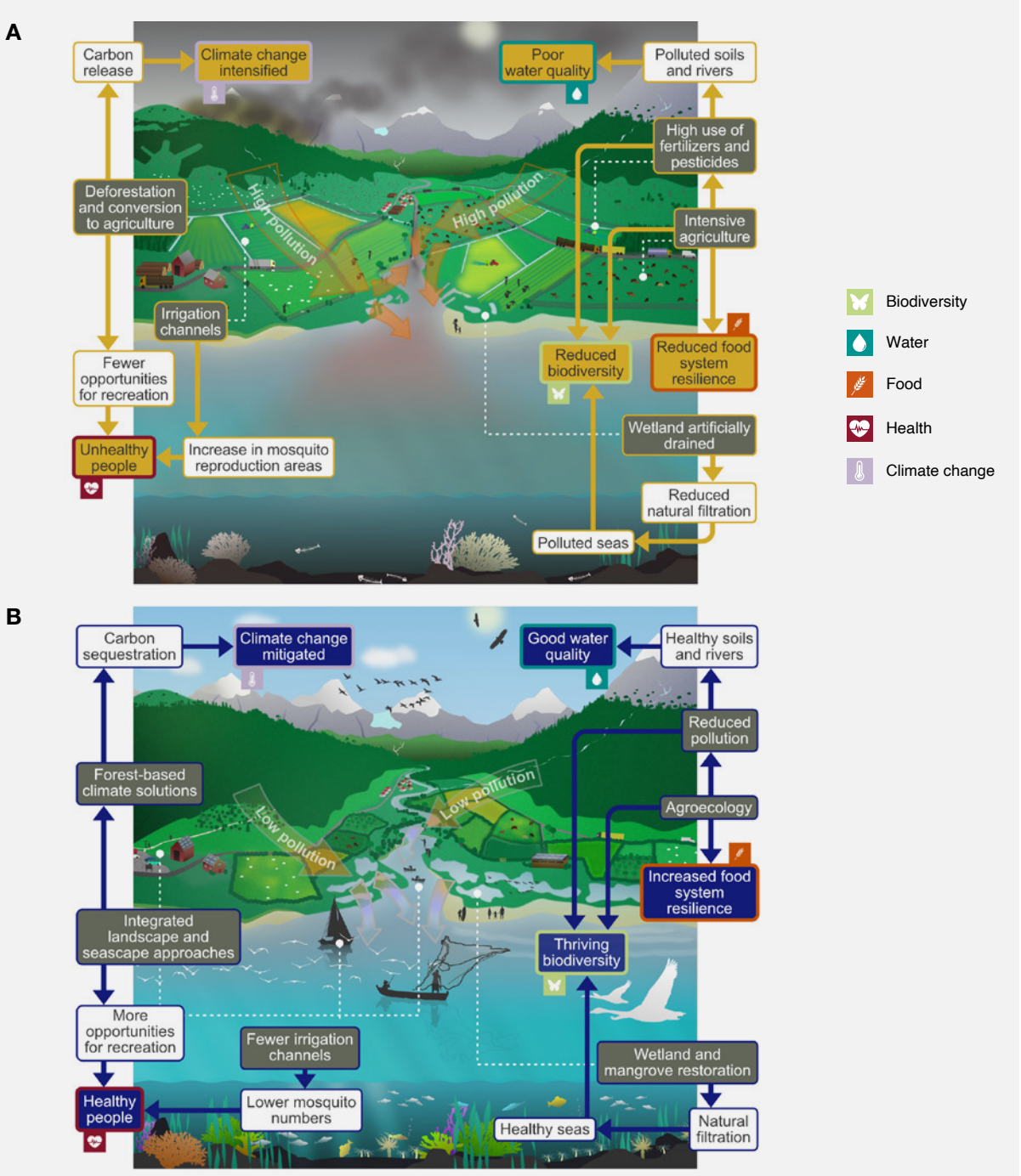

Figure 1 2 **Simplified comparative landscapes illustrating (A) siloed and (B) nexus approaches to managing the interlinkages among biodiversity, water, food, health and climate change.**

(A) Siloed approach: the interlinkages shown in this example are based on evidence of past and current trends in nexus interlinkages from **Chapter 2** (**sections 2.3**, **2.4** and **2.5**). Intensive agriculture practices, based on monocultures and heavy use of pesticides and

Figure 1 2

fertilizers, have increased crop susceptibility to diseases, reduced food system resilience and biodiversity and led to polluted soils and rivers. The expansion of agricultural lands has led to deforestation, contributing to carbon emissions that exacerbate climate change and reducing landscape diversity that impacts opportunities for recreation that are important for physical and mental health. Irrigation channels may inadvertently favour disease vector populations, such as mosquitoes, affecting human health. Wetland loss can increase pollution and sediment transfer to oceans, affecting marine biodiversity. **(B)** Nexus approach: the interlinkages in this example are based on evidence from the response options assessed in **Chapter 5**. Integrated landscape and seascape approaches **(Chapter 5.1, section 5.1.9)** and forest-based climate solutions **(Chapter 5.5, section 5.5.12)** can contribute to carbon sequestration and reduce pesticide and nutrient pollution, providing benefits for climate change, water and biodiversity. Diversified landscapes also offer greater opportunities for recreation, improving human health and well-being. Agroecological approaches **(Chapter 5.1, section 5.1.3; Chapter 5.5, section 5.5.11)** reduce pesticide and nutrient pollution and improve crop resilience to diseases, providing benefits to food security, biodiversity and water quality. Restoring wetlands **(Chapter 5.4, section 5.4.8; Chapter 5.5, section 5.5.4)** limits nutrient runoff into rivers and the oceans, maintaining water quality and supporting biodiversity and carbon sequestration.

Box 1 2 **A nexus approach to addressing water quality, food security, infectious diseases and poverty in the St Louis - Richard Toll region of Senegal.**

This box describes a case study that shows how, after a siloed approach that led to the construction of a dam, a nexus approach can provide a profitable win-win approach to addressing food and water access, poverty alleviation, infectious disease control and environmental sustainability (Rohr *et al.,* 2023).

Many communities around the world lack sustainable solutions to the interconnected challenges of water quality, food security, infectious diseases and poverty. In the St Louis - Richard Toll region of Senegal, the Diama dam was built between 2014 and 2016 to reduce saltwater intrusion and facilitate irrigation. This led to an increase in the area under cultivation and the use of synthetic fertilizers (urea) on extended fields. This, in turn, encouraged the growth of submerged invasive aquatic vegetation, blocking water access points and providing a habitat for freshwater snails that transmit two species of *Schistosoma* flatworm parasites that penetrates human skin causing schistosomiasis, the world's second most common parasitic human disease after malaria, which affects more than 200 million people worldwide.

By understanding the nexus interlinkages involved in this challenge, this study identified the simple, low-cost local intervention of removing aquatic vegetation and tested its effectiveness in a three-year randomized controlled trial in 16 communities. Removal of invasive submerged vegetation from water access points successfully decreased infection rates for one of the Schistosoma species in school children by 0.68 and increased access to water points. In addition, the vegetation removal did not have any detectable long-term adverse effects on local water quality or freshwater biodiversity. Furthermore, the removed vegetation was used to improve food production. This was done by using it as a much cheaper replacement to traditional livestock feed and by converting it to compost to fertilize crop production. Compost increased onion and pepper yields to a significantly higher degree than urea fertilizer and decreased onion rot, with a subsequent more profitable cost-to benefit ratio ranging from 2.7 to 4.0.

The study suggests the removal of submerged vegetation intervention could be scaled up using remote sensing to identify suitable areas. The case study illustrates how relatively simple, low-cost actions can address environmental and equity challenges by providing multiple co-benefits for health, food, water and poverty alleviation, thereby improving economic, social and environmental sustainability together.

1.1.2 Nexus challenges and opportunities

Despite increasing evidence of the benefits of nexus approaches for integrated decision-making, several key challenges have limited its uptake in policy and practice. These have been categorized into five types of challenges:

1) Nexus complexity challenges – the way society understands the nexus, its boundaries and dynamics;

2) Nexus governance challenges – the way society works together to manage and govern within the nexus;

3) Nexus values challenges – the way society views and values the nexus;

4) Nexus scaling challenges – the way society uses scaling for successful nexus approaches and gathers evidence to monitor and adapt them;

5) Nexus financing challenges – the way society finances the nexus.

The five challenges that need to be addressed to advance practical implementation of nexus approaches are discussed in this section alongside the impacts and

potential opportunities of overcoming each challenge. They are described further in **Chapters 4**, **5**, **6** and **7** in relation to designing and implementing nexus response options.

1.1.2.1 Nexus complexity challenges

One of the biggest strengths and challenges of a nexus approach is its complexity. A nexus approach moves away from siloed ways of thinking, anchored in particular disciplines, sectors, knowledge systems and world views, towards a more holistic and pluralistic approach that embraces complexity and uncertainty, spans boundaries and considers the interdependencies, dynamics, fluxes and feedback loops between different nexus elements (e.g., biodiversity, water, food, health and climate change), in both positive and negative ways (Howarth & Monasterolo, 2016; O'Connor *et al.,* 2021; Walker *et al.,* 2003). For example, adopting policies and practices to enhance the positive interactions between food production and biodiversity can provide benefits for both people and nature (Sietz *et al.,* 2022).

However, complexity among elements and their interrelations may also lead to a range of positive, neutral and negative outcomes for different actors and elements that are expected, unexpected, unbalanced, emergent and unintentional (Bennett *et al.,* 2019; Blythe *et al.,* 2018; Gill *et al.,* 2023). Adopting a dynamic and adaptive approach to nexus thinking that embeds continuous evaluation, learning and the ability to course correct is vital for developing integrated solutions (Chambers *et al.,* 2022; Fazey *et al.,* 2018; Howarth & Monasterolo, 2016; Sellers *et al.,* 2019). Such an approach must be able to respond as new knowledge on nexus elements, outcomes and dynamics becomes available as well as external influences and unforeseen events that can influence the nexus system in unexpected ways. One example for tackling these challenges is integrated landscape and seascape approaches, which are 'wholescape' approaches (Ross *et al.,* 2022) for exploring human-environment interactions and their positive (synergies) and negative (trade-offs) outcomes (Nishi & Yamazaki, 2020). Such approaches embrace adaptive multi-actor co-management arrangements to dynamically explore synergistic solutions (Karimova & Lee, 2022; Ross *et al.,* 2022) (see **Chapter 5.1, section 5.1.9** for detailed examples).

Overcoming this nexus challenge by embracing complexity enables agility through change, while enhancing the potential for achieving synergistic outcomes across biodiversity, water, food, health and climate change together. Complexity is discussed in more detail across the assessment, but especially in **Chapters 4** and **5**.

1.1.2.2 Nexus governance challenges

Effective governance is essential for widespread implementation and adoption of nexus approaches that deliver effective outcomes (FAO, 2018; Fernandes Torres *et al.,* 2019). Business-as-usual governance approaches tend to be fragmented with different departments working in isolation on their own policy agendas and within their own timeframes. In contrast, nexus governance takes a holistic approach, integrating multiple sectors and conceptualizations to deliver multiple co-benefits across the nexus elements (IPBES, 2022c; Weitz *et al.,* 2017). The concept of nexus governance has emphasized the need for a range of holistic and/or integrated governance solutions tailored to specific contexts (Al-Saidi & Elagib, 2017; Pahl-Wostl, 2019; Weitz *et al.,* 2017). Nexus governance can be both incremental and transformational, but has been identified as being most effective when it is integrative, transdisciplinary, inclusive, equitable, accountable, and adaptive (Pickering *et al.,* 2022; Visseren-Hamakers & Kok, 2022) (see **Chapter 4, section 4.5**).

While the benefits of nexus governance are broadly acknowledged, challenges remain around integration (Al-Saidi & Elagib, 2017), implementation (Shannak *et al.,* 2018), power asymmetries (Vallet *et al.,* 2020) and capacity (Kelemen *et al.,* 2023). These challenges are further exacerbated by a general focus on characterizing nexus issues rather than proactively working towards solutions (Voelker *et al.,* 2022). Improved nexus governance approaches and decision-support tools are needed that identify leverage points within existing systems for achieving more holistic policy and action (see **Chapter 4, section 4.6**). In addition, better understanding of which specific governance solutions are best aligned to particular circumstances is needed to identify effective solutions and enhance nexus outcomes (Nguyen *et al.,* 2019) (see **Chapter 4, section 4.7**). For example, transboundary basin governance has been recognized as a useful approach for enhancing regional cooperation on water, energy and food in the Eastern Nile Basin (Al-Saidi & Hefny, 2018). Similarly, polycentric governance has been recognized as an effective method for integrating the management of water and energy in the Spanish irrigation sector through a diversity of local institutional and operational adaptations (Villamayor-Tomas, 2018). Drawing lessons from successful experiences is ideal, but in cases where these are lacking, experimentation or "learning by doing" can help test new processes, ideas and structures for nexus governance, which can be iteratively revised based on learning from both successes and failures (De Búrca *et al.,* 2014; Wolfe, 2018). This approach enables adaptive decision-making and governance (Lawford, 2019).

Overcoming nexus governance challenges strengthens the role of different actors across biodiversity, water, food, health and climate change in co-designing integrated response

options that are effective, efficient and fit-for-purpose in delivering multiple outcomes. Nexus governance is discussed in more detail in **section 1.3** and **Chapter 4**.

1.1.2.3 Nexus values challenges

A core challenge for designing nexus approaches is responding to the diverse values of various actors who perceive and engage with nature differently, and so view nexus challenges in different ways (Aggestam *et al.,* 2023; Schulz *et al.,* 2017). These diverse values and motivations shape how relationships between nexus elements are conceptualized and how challenges are perceived and identified (Hopkins *et al.,* 2021; Proctor *et al.,* 2021). Understanding these values can help avoid the nexus becoming an empty 'buzzword' (Cairns & Krzywoszynska, 2016), build trust among actors and support more integrated decision-making (Urbinatti *et al.,* 2020). Embracing tensions and linguistic challenges among different actors, world views, values and practices is necessary to develop a holistic understanding of nexus elements and their interactions (Gagnon *et al.,* 2022). This involves being open to different conceptualizations of nature and of the nexus itself, and related concepts like sustainability or conservation (Kohler *et al.,* 2019; Virtanen *et al.,* 2020). For example, participants in the IPBES Nexus Assessment ILK dialogues shared how their communities conceptualize the nexus among the five elements in a more holistic and inter-relational manner than many scientific models used today (see **section 1.2.2**).

Values, particularly those emphasizing nature's economic value, influence how synergies and trade-offs are considered when developing nexus response options (IPBES, 2022c). Recognizing pluralistic values from the outset can reveal potential conflicts early, while targeted conflict resolution training can help identify common goals, maximize synergies and address trade-offs (Fazey *et al.,* 2018; Norström *et al.,* 2020). Encouraging trust and reflexivity within nexus approaches is critical to be able to constructively navigate divergences among different actors and values (Chambers *et al.,* 2022; Fuller Transformation Collaborative, 2019; L. Pereira *et al.,* 2020).

Addressing challenges related to nexus values enables the inclusion of diverse actors' priorities in biodiversity, water, food, health and climate change. Including a diverse group of actors helps navigate nexus processes more effectively, promoting a shared understanding of appropriate response options and supporting collective action. The assessment discusses values more comprehensively in **Chapters 4** and **6**.

1.1.2.4 Nexus scaling challenges

The uptake and mainstreaming of nexus approaches requires careful consideration of the data, tools, metrics, knowledge and capacity available across scales relevant to implementation (Albrecht *et al.,* 2018). Spatial scales are critical in planning and policy-making decisions, but the spatial scale of decision-making (e.g., administrative boundaries) may differ from the most relevant spatial scale for capturing different biophysical or human processes within each nexus element (e.g., fields, farms, catchments, or biogeographical regions). Temporal scales are also critical in decision-making as the temporal scales of management and processes within each of the nexus elements, and across the broader system as a whole, may not align (Cumming *et al.,* 2006). Accounting for cross-scale interlinkages and feedback loops is important for bridging between global change processes and local realities (Fürst *et al.,* 2017; Geneletti, 2015; Seppelt *et al.,* 2018). Scale mismatch, where data is collected at a different scale to decision-making, is common in existing policy and practice, leading to a deficit of usable and actionable knowledge (Jarvis *et al.,* 2015). New tools and indicators that enable monitoring of the nexus elements and their interlinkages at the relevant scales will be important for tracking progress on the success of nexus approaches.

A major scale challenge relates to the risks and benefits of nexus approaches often being unevenly distributed across scales (Gallagher *et al.,* 2016), with local people frequently bearing the local and personal costs of decision-making done elsewhere. For example, the creation of new protected areas that displace communities, or restrict lives and livelihoods, can place the costs of achieving international conservation agendas onto local people who may already be vulnerable or most at risk (Bennett *et al.,* 2017; Zafra-Calvo *et al.,* 2019). The development of nexus response options, and any associated benefits and risks, thus needs to better account for these scale challenges to be able to deliver nexus solutions that are both effective and socially just. Being able to share and scale successful response options will be vital for achieving broader impact, which will require greater collaboration (Brondízio *et al.,* 2016; Covarrubias *et al.,* 2019), knowledge co-production (Howarth & Monasterolo, 2017; Norström *et al.,* 2020) and social learning (Ernst, 2019; Lotz-Sisitka *et al.,* 2015, 2016) between different actors and scales.

Targeted work to overcome nexus scaling challenges across biodiversity, water, food, health and climate change can help identify the key processes and enabling conditions to best share and replicate success. Scaling is discussed in more detail across the report, but especially in **Chapters 4** and **7**.

1.1.2.5 Nexus financial challenges

Nexus solutions require integrated financial approaches and flows. Yet current financial systems and mechanisms are not adequately designed for implementing nexus approaches, as they tend to prioritize the monetized instrumental and

direct benefits of nature or a single nexus element, e.g. food production (IPBES, 2019b; TEEB, 2018). The wider and indirect benefits of nature tend to be undervalued, or are viewed as externalities (Dasgupta, 2021a; Nedopil, 2022). Not only does such an approach present missed opportunities for achieving multiple co-benefits, but failure to account for feedback loops in the system can deliver perverse outcomes for other nexus elements while incentivizing greater damage to nature overall. For example, financing mechanisms such as Reducing Emissions from Deforestation and Degradation in Developing Countries (REDD+) have received criticism for increasing social inequalities in some communities which has led to local resistance (Dokken *et al.,* 2014; Leggett & Lovell, 2012), resulting in negative outcomes for deforestation counter to the initial goals of the programme (Gebara & Agrawal, 2017). Not accounting for nexus interlinkages undermines the potential of finance mechanisms, as well as underestimating systemic financial risk (Kedward *et al.,* 2023).

Sustainable long-term solutions can only be achieved with sufficient and appropriate funding. More than half of global Gross Domestic Product is highly or moderately dependent on nature (Evison *et al.,* 2023; Herweijer *et al.,* 2020). Yet despite this, nature-positive financial flows and mechanisms are considerably underfunded. Gaps in financing to support biodiversity have been estimated to be anywhere from $300 billion to $1 trillion per year (Credit Suisse *et al.,* 2014; Deutz *et al.,* 2020). In contrast, it has been estimated that governments annually spend between $635 to $850 billion on agricultural subsidies alone (Deutz *et al.,* 2020). As much as $7 trillion in funding across public subsidies and private investments are considered harmful to the biosphere (UNEP, 2023), and this stark difference between nature-positive and nature-negative funding demonstrates a clear mismatch in spending and priorities (see **Figure SPM.12** and **Chapter 6, section 6.2**). Target 19 of the Kunming-Montreal Global Biodiversity Framework (CBD, 2022) directly addresses the importance of financing to mobilize at least $200 billion per year by 2030 and provides an important opportunity to embed nexus approaches in these processes. Emerging voluntary initiatives in the private sector can also support a nexus approach to finance, such as the Taskforce on Nature-related Financial Disclosures (TNFD, 2023) and the Science-Based Targets Network (SBTN, 2020), which require companies to consider potential opportunities, risks and trade-offs between nexus elements. Working with feedback loops and interlinkages between nexus elements can provide a cost-effective approach to nexus finance that provides benefits to multiple elements and the broader system at no extra cost or even cost savings (Markantonis *et al.,* 2019; Simpson & Jewitt, 2019).

Existing financial flows and mechanisms can achieve cost-effective co-benefits between biodiversity, water, food, health and climate change by embracing nexus approaches. Yet, identifying additional nexus finance options are critical for delivering nexus solutions to the degree required for a sustainable and just future. Response options for enhancing financial flows to biodiversity and the other nexus elements are discussed in more detail in **Chapter 6**.

1.1.3 Key policy-relevant questions for the Nexus Assessment

The Nexus Assessment aims to provide answers to the following policy-relevant questions that were developed by the author team based on the approved scoping report (Decision IPBES 8/1):

- What are the status and past trends in interactions among biodiversity, water, food, health and climate change ("the nexus") and how have past drivers, actions and policies affected these nexus elements positively and negatively? What are the most important nexus interactions that should be considered for decision-making? Addressed in **Chapter 2**.

- How might the nexus elements and interdependencies change in the future, and what pathways and scenarios could lead to sustainable futures that address the nexus elements synergistically with minimal trade-offs? Addressed in **Chapter 3**.

- Which factors (economic and financial, technical and technological, social, institutional, cultural and behavioural) facilitate or obstruct pathways to achieve a sustainable future? Which tools and policy options exist to help decision-makers navigate the complexity of the nexus and consider the existence of a diversity of values, including perspectives and knowledge of IPLC? Addressed in **Chapter 4**.

- What are the response options (both incremental and transformative) available to actors at all levels that address the interlinkages among the nexus elements? Which are complementary and synergistic (and which will require trade-offs) for the achievement of pathways towards sustainable futures? Addressed in **Chapter 5**.

- How can financial actors and economic sectors be aligned to facilitate and accelerate the implementation of response options (and with what tools, instruments and enabling conditions) to achieve synergies among nexus elements and pathways towards sustainable futures? Addressed in **Chapter 6**.

- What response options are the most influential in determining the achievement of multiple internationally agreed goals with minimal trade-offs, which of these options can be driven most efficiently by specific actors

within a sector and which require collaborative action across multiple sectors and actors, and what pathways are needed to realize these options and goals? Addressed in **Chapters 5** to **7**.

1.1.4 Relevance of the Nexus Assessment

The Nexus Assessment offers an opportunity to address the nexus challenges and deliver multiple co-benefits for biodiversity, water, food, health and climate change simultaneously. Embedding nexus approaches into research, policy and practice can identify the pathways for delivering a sustainable and socially just future for all. Potential impacts of the assessment are listed below in several thematic clusters.

Knowledge and understanding:

- Improved understanding of interlinkages across the nexus elements
- Identification of key synergies and trade-offs between the nexus elements
- Evaluation of a diversity of response options that can enhance multiple nexus elements at the same time in different contexts and scales for different actors
- Strengthened understanding of how response options can be combined and sequenced to manage the nexus elements more sustainably

Values:

- Recognition of multiple values, world views and knowledges that effect the nexus
- Facilitation of cross-sector and cross-scale multi-stakeholder collaboration
- Support for Indigenous-led and rights-based approaches that benefit IPLC in managing across nexus elements

Finance:

- Sustainable financing to close the biodiversity gap with synergies to the other nexus elements
- Identification of innovative nexus finance tools and mechanisms to reduce the debt burden of low-income countries
- Streamlined resource allocation through optimisation of strategies that simultaneously address multiple nexus elements
- Identification of new investment opportunities that yield co-benefits across nexus elements to promote sustainable use

Policy and practice:

- Facilitation of evidence-based decision-making taking account of complex interactions across nexus elements
- Identification of the components of nexus governance to reduce unintended consequences across sectors and support equitable resource distribution and more just outcomes
- Guidance for holistic and multi-actor policy and socio-political options to address the nexus, including roadmaps for action
- Comparisons of possible negative and unintended outcomes associated with previously siloed approaches, enhancing the overall effectiveness of environmental governance
- Evidence of successful nexus approaches that can be adapted and scaled elsewhere
- Improved evidence and action for viable and cost-effective nexus solutions that are fit-for-context
- Development of adaptive strategies that address interconnected nexus challenges in a changing climate
- Enhanced capacities to deliver multiple co-benefits across actors
- Strengthening of the knowledge-policy-practice interface and identifying and closing knowledge-implementation gaps

1.2 CONCEPTUAL UNDERSTANDING OF THE NEXUS

Several conceptual tools and approaches have been developed to tackle inter-related problems at multiple scales. These include formal conceptual framings of nexus thinking and underpinning concepts such as systems dynamics. In everyday life, individuals, communities and cultures have evolved and developed practices and approaches that address nexus challenges. Such approaches have also informed the development of policy frameworks in many contexts, such as the SDGs and the Kunming-Montreal Global Biodiversity Framework, that build

upon nexus thinking. **Section 1.2** syntheses some of these approaches to support conceptualization of the nexus for this assessment.

1.2.1 Nexus approaches and related concepts in the scientific literature

The term 'nexus' has come to represent a cluster of interlinkages between major components of contemporary society, including but not limited to the five focal elements of this assessment (Estoque, 2023; van Zanten & van Tulder, 2021b). Studies of nexus approaches have focused on sectors or societal dimensions affected by nexus interlinkages, such as poverty (Fürst *et al.,* 2017; Liu, Hull, *et al.,* 2018) and vulnerability (Shukla *et al.,* 2021; Vidal Merino *et al.,* 2019) and cover scales that may extend across national, regional or global levels.

The simplest nexus studies have focused on interactions between pairs of nexus elements, such as food-energy, climate change-food (Cholo *et al.,* 2019), water-health (Paudel *et al.,* 2021) and water-energy (Hussey & Pittock, 2012). However, nexus studies are now beginning to cover greater numbers of elements such as food, water and energy (Allam & Eltahir, 2019; Newell *et al.,* 2019; Scott *et al.,* 2015); food, water, land, climate change and/or biodiversity (Estoque, 2023; Sietz & Neudert, 2022; van den Elsen *et al.,* 2020); and water, food, energy, ecosystems, land and materials (EEA, 2022). These studies highlight the challenges that result from tackling problems with nexus elements in isolation, rather than taking account of the increasingly apparent interrelationships between these problems.

The challenge of untangling interactions across multiple nexus elements has attracted and stimulated a wide range of approaches (Adhikari *et al.,* 2023; Albrecht *et al.,* 2018; Liu, Hull, *et al.,* 2018). Some nexus approaches analyze interlinkages between elements numerically or symbolically, e.g., through modelling or as interaction scores or arrows (Adhikari *et al.,* 2023). Other nexus approaches emphasize the holistic and irreducible nature of nexus interactions in terms of whole systems of context-dependent spatial and temporal interdependencies (linkages) between system components (nodes) that lead to emergent properties (Meadows, 2008). The approach taken in a study is dependent on the aims and context of the problem and system under investigation, but approaches often focus on understanding relationships between elements in a system through key concepts such as cascading effects, compounding effects, feedback loops, thresholds, tipping points, telecoupling and spillover effects (see **Box 1.3** for definitions and further information on these nexus concepts).

Box 1 3 **Key definitions of nexus concepts regarding interlinkages.**

Cascading impact: In this assessment, defined as when a change in one nexus element results in a chain of negative impacts on other elements. Other definitions highlight how cascades are similar to a domino effect, and occur when a change in one variable, particularly if it surpasses a certain threshold, results in consequences and changes in other variables and/or thresholds. These changes can also interact with one another and propagate across different spatial scales, either from larger to smaller or vice versa (Brovkin *et al.,* 2021; Knight *et al.,* 2005).

Compounding impact: In this assessment, defined as when changes in one or several nexus elements exacerbate negative impacts on another element. Other definitions emphasize how changes in a response variable result from the combined effects of multiple variables or drivers, which may be non-linear and not follow additive patterns (Pidgen & Mallik, 2013; Zuo & Gao, 2021). Examples of drivers relevant to the nexus that can add to or modify each other's effects, and potentially lead to exacerbation of negative impacts, include climate change, land and sea-use changes, overexploitation of resources, pollution and invasive alien species (IPBES, 2019b).

Feedbacks: In this assessment, feedbacks are defined as changes in the interlinkages among multiple nexus elements that reinforce or balance an initial change. Feedback loops play a crucial role in understanding and managing the complex relationships between elements of the nexus (Liu, 2017; Liu *et al.,* 2013; O'Connor *et al.,* 2021). An example of a self-reinforcing feedback loop is where climate change results in biodiversity loss, which in turn leads to greater carbon emissions and ultimately more climate change. Feedback loops can become important if critical thresholds or tipping points are reached. For example, a severe drought (a trigger), which, when combined with other factors, such as increasing temperatures (a feedback), can push a region's water resources beyond a critical threshold, resulting in widespread water scarcity.

Threshold: This term refers to the levels of a parameter or condition beyond which a system undergoes significant change (Berdugo *et al.,* 2020; Keith *et al.,* 2015; Scheffer *et al.,* 2012). Early identification of thresholds is crucial to help decision-makers and stakeholders make informed decisions about resource management, strategic policy formulation and proactive risk mitigation. Unlike tipping points, systems approaching thresholds may still have the potential for mitigation or reversal if action is taken before the threshold is crossed. The Millenium Ecosystem Assessment (2005) recognized the significance of thresholds in the interactions between ecosystems and human well-being. The latest

Box 1 3

Intergovernmental Panel on Climate Change (IPCC) report (IPCC, 2022b) identified critical thresholds for the timely implementation of climate change adaptation measures in terms of their feasibility, effectiveness and potential to deliver co-benefits such as improved health outcomes, recognizing that small changes in an environmental driver can lead to large responses in the ecosystem (IPCC, 2023b).

Tipping points: A critical threshold beyond which a system reorganizes, often abruptly and/or irreversibly (IPCC, 2022a); further perturbation causes rapid change and prevents the system from returning to its former state (IPBES, 2019b). Tipping points are important in understanding complex systems, where small perturbations can trigger large and often unexpected changes (Barnosky *et al.,* 2012; Ditlevsen & Johnsen, 2010). Real-time data collection and analysis for informed decision-making and timely action can help to prevent or mitigate climate change tipping points (IPCC, 2022a).

Telecoupling: An umbrella concept that encompasses various socio-economic and environmental interactions over distances (Hull & Liu, 2018; Liu *et al.,* 2013). It involves distant exchanges of information, energy and matter (e.g., people, goods, products, capital) at multiple spatial, temporal and organizational scales. (IPBES, 2019a). Examples are international trade, tourism, migration, foreign investment, species invasion, payments for ecosystem services, water transfer, information dissemination, knowledge transfer and technology transfer (IPBES, 2019b; Liu *et al.,* 2015; Mancilla García *et al.,* 2020; Martín-López *et al.,* 2019). A related term is teleconnection.

Spillover: This term has two meanings: (i) in the context of socio-ecological systems, spillover effects refer to human impacts or natural disturbances beyond system boundaries. These effects can be positive or negative, socio-economic or/and environmental and can be more profound than the effects within the focal system (IPBES, 2019b; Liu, Dou, *et al.,* 2018); (ii) in the context of human health, spillover refers to the transmission of a pathogen from one species to another. This transmission includes instances where an animal-borne virus, crosses over to infect another species, potentially including humans (IPBES, 2020; Vora *et al.,* 2022).

A wide range of other approaches include nexus thinking. The ecosystem approach, a strategy for the integrated management of land, water and living resources, emphasizes interactions within, and functioning of, natural systems and the importance of managing interdependencies between systems in a holistic way to achieve multiple outcomes for nature and people in an equitable way (Waylen *et al.,* 2014). Similarly, socio-ecological systems approaches focus on complex and context-specific interactions between people (human/social systems) and nature (ecological/biophysical systems), including the multiple time-space scales and feedbacks that impact the dynamics and processes of the system (S. L. Collins *et al.,* 2011; O'Connor *et al.,* 2021).

Planetary boundaries approaches (Biermann & Kim, 2020) and related concepts of a 'safe and just' operating space have been developed with a focus on biodiversity and benefits from nature to people (DeClerck *et al.,* 2021; Mohamed *et al.,* 2022; Obura *et al.,* 2023) and freshwater availability (Stewart-Koster *et al.,* 2023). Such approaches include alternative economic models that emphasize the need for equitable distribution of wealth to deliver acceptable benefits and rights to people within biophysical planetary boundaries so that socially-inclusive, environmentally sustainable and economically viable development can be achieved (Raworth, 2017).

Nexus approaches may be characterized by their constituent components, actors, scales and world views. For example, pluriversal approaches emphasize the importance of recognizing a diversity of world views and conceptualizations of planetary well-being, particularly from perspectives that are typically marginalized in global environmental policy discourse and opposed to market-based development models (Demaria & Kothari, 2017). Landscape and seascape approaches also focus on how multiple stakeholders may interact and balance multiple objectives, spatial heterogeneity and connectivity across scales, within and across land and marine systems (Pörtner *et al.,* 2021; J. Reed *et al.,* 2021).

Some approaches have evolved from a focal element of the nexus. For instance, the One Health approach is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems (see **Box 1.4**). Similarly, agroecological approaches (FAO, 2018; HLPE, 2019) adopt nexus thinking and socio-ecological system conceptualizations through processes of knowledge co-creation, combining science with the traditional and local knowledge of food producers, including IPLC, to design and manage farms, landscapes and food systems. These approaches address complexity and context, while emphasizing equity, enhancing farmers autonomy and adaptive capacity, and empowering producers and communities as key agents of change. In particular, the Ten Elements of Agroecology is an analytical framework that supports the design of adapted pathways for agriculture and food systems transformation based on visual narratives that depict interlinkages between key elements (Barrios *et al.,* 2020).

Finally, approaches that synthesize across cases and contexts have been developed to promote cumulative learning. These include middle-range theories of causal mechanisms (Meyfroidt *et al.,* 2018) and archetype analysis depicting recurrent patterns of factors and processes that influence the sustainability of social-ecological systems (Oberlack *et al.,* 2019; Sietz *et al.,* 2019). Archetype analysis can also support the tailoring of nexus response options by revealing recurrent trade-offs and synergies between multiple response options, configurations of policy processes and instruments as well as factors enabling or restricting policy effectiveness (Oberlack *et al.,* 2023).

1.2.2 Nexus concepts in cultural contexts and world views

Nexus thinking is not a recent phenomenon. Understanding of the world and interactions of its human and non-human elements from a nexus lens may be observed in many world cultures and philosophies. Empirical views on the nexus build on the fact that biodiversity and nature, land and soil, livestock and crops, food systems, water and ocean, medicines and health systems, well-being, community, elders, spirituality, knowledge, practices, values, governance, relationships, energy flows, the universe and cosmos are perceived as part of a single holistic system,

Box 1 4 **Definitions of health, One Health and other holistic frameworks in the Nexus Assessment.**

One Health recognizes the health of humans, domestic and wild animals, plants and the wider environment (including ecosystems) are closely linked and interdependent (Adisasmito *et al.,* 2022). The term came from the biomedical health sector, but recent reappraisal of the term led to a definition supported by the Quadripartite of the Food and Agricultural Organisation (FAO), World Organisation for Animal Health (WOAH), United Nations Environment Programme (UNEP) and World Health Organisation (WHO). This definition balances the sectors and encompasses reflections that come from *Eco-Health* (by highlighting the ecocentric versus anthropocentric scope) and *Planetary Health* (explicitly acknowledging the relevance of environmental/ecosystem health) concepts to ensure threats to ecosystems, water, energy, air, food, climate and sustainable development are all considered (Adisasmito *et al.,* 2022).

The concept has been widely taken up, with research on One Health now globally distributed, if still overly represented among higher income countries and mostly focused on infectious diseases. Researchers referring to Planetary Health are still largely dominated by high income countries but focus more on planetary boundary-related elements (Castañeda *et al.,* 2023). Common themes are present in both though and the new One Health definition aims to address these epistemic differences and encourage researchers and practitioners to consider sustainability issues in current and future work. For example, the Quadripartite released a One Health Joint Plan of Action and *"The guide to implementing the One Health Joint Plan of Action at national level "* during the United Nations Framework Convention on Climate Change COP28.

The precise One Health definition endorsed by the Quadripartite and used in this assessment is (Adisasmito *et al.,* 2022):

"One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent.

The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for healthy food, water, energy, and air, acting on climate change and contributing to sustainable development.

Key underlying principles include:

1. Equity between sectors and disciplines;
2. Sociopolitical and multicultural parity (the doctrine that all people are equal and deserve equal rights and opportunities) and inclusion and engagement of communities and marginalized voices;
3. Socioecological equilibrium that seeks a harmonious balance between human-animal- environment interaction and acknowledging the importance of biodiversity, access to sufficient natural space and resources, and the intrinsic value of all living things within the ecosystem;
4. Stewardship and the responsibility of humans to change behaviour and adopt sustainable solutions that recognize the importance of animal welfare and the integrity of the whole ecosystem, thus securing the well-being of current and future generations;
5. Transdisciplinarity and multisectoral collaboration, which includes all relevant disciplines, both modern and traditional forms of knowledge and a broad representative array of perspectives."

For brevity and clarity in the assessment, however, when referring to 'health', we refer specifically to human health, unless otherwise explicitly preceded by another word, such as animal health, plant health or ecosystem health, or a conceptual or theoretical approach or framework, such as *One Health*, *Eco-health* or *Planetary Health*.

rather than as separate elements (Berkes, 2012; Redvers *et al.,* 2022).

Different world views frame these relationships differently (Erazo Acosta, 2020; Querejazu, 2016) based on people's values and lived experiences, shaping a 'pluriverse' which has been framed as breaking with development paradigms to provide other alternatives (Demaria & Kothari, 2017; Escobar, 2015; Kaul *et al.,* 2022; Kothari *et al.,* 2019). Examples may be found in such ancient religions as Hinduism in India with its beliefs and practices based on the eternal law of Dharma and Nature (Lipner, 2012); in Zoroastrianism in Iran with its seven macro/ micro-cosmic principles rooted in the ever-connected natural powers: animal and plant kingdoms, sky and minerals, fire, earth, water, and the universe itself (Ahura Mazda) (Skjærvø, 2012); and in traditional Chinese culture (Wang, 2007, 2023), where the five cosmic elements of 木 mù 火 huǒ 土 tǔ 金 jīn 水 shuǐ (wood-fire-earth-metal-water) are connected by the eternal energy of 氣 qì (flux) in people and the universe (*The Complete Works of Zhuangzi*, 2013).

In many IPLC cultures and languages the elements of the nexus exist as an integral whole, with people seen as its indispensable part. This also explains why the term nexus is difficult to translate and rarely has a direct equivalent in Indigenous and local languages (Sangha, 2020; Sangha *et al.,* 2018). Indigenous perceptions of well-being are often rooted in physical, human and sacred worlds (Sangha *et al.,* 2015), where the interlinkages between people and country (i.e., understood as a lived environment) are recognized (Walsh *et al.,* 2013). **Figure 1.3** illustrates diverse examples of conceptualizations of the nexus within various geographic and socio-cultural contexts created by the participants of the ILK dialogue workshops for the Nexus Assessment (IPBES, 2022a, 2023a, 2023b).

These conceptualizations, on the one hand, reflect place-based lived experiences of humans and their surrounding environment. They underpin the notion of living in harmony with floral, faunal and abiotic elements of living landscapes and waterscapes/ seascapes, such as trees, rivers, farmlands, pastures, grazing animals, fish and microbes for Guna/ Kuna people (Panama) and Karamojong people (Uganda). Conserving such highly biodiverse land and seascapes is essential for meeting livelihood demands and maintaining or strengthening traditional ties with the land and water (IPBES, 2019b). On the other hand, IPLC visualizations of the nexus are also intrinsically linked to Indigenous and local philosophies, world views and belief systems. In addition to the seen environment, these conceptualizations step into the *perceived* environment of complex interconnections between all living and non-living things, such as natural and customary laws, spirituality, values and knowledge, reciprocity and responsibility in the images from Mexico, Russian Federation, Philippines and the Andean region **(Figure 1.3)**.

Based on the ILK dialogue workshops (IPBES, 2022a, 2023a, 2023b), reviewed literature (Pictou, 2021; Stoeckl *et al.,* 2021) and the call for contributions on ILK, a wide spectrum of nexus-relevant concepts shared in common by many IPLC around the world was arranged into five categories (**Figure 1.3**, center). They include: self-determination, access to and caring for lands, waters and territories (e.g., representing management systems, customary governance and practices); spirituality and rituals (e.g., ceremony and traditions); relationality, reciprocity and responsibility (e.g., including kinship and respect, rights and duties); sustainability, adaptation, innovation and resilience (e.g., survival capacity and ingenuity); and temporality and inter-generational wisdom and language (e.g., relations with ancestors, present and future generations, and inter-generational knowledge transfer) (Berkes, 2012; Bisong & Andrew-Essien, 2010; Erazo Acosta, 2020; Walsh *et al.,* 2013). Dynamic balance, circular motion and energy flow are placed at the center of these concepts as a common source where all concepts begin and where they come back to, erasing the boundaries between the seen and the unseen, between now and then. These intergenerational and cross-scale linkages, nested in the concept of genealogy and connectivity between past, present and future, play an imperative role in ILK perspectives on the nexus (Parsons *et al.,* 2021; Wu *et al.,* 2022).

Perception of these five common concepts within Indigenous and local languages has been an important topic of all ILK dialogue workshops for this assessment (IPBES, 2022a, 2023a, 2023b). With the ability of written and spoken languages to communicate the truest essence of perceived reality within a given cultural context (Batzin, 2023; Gagnon *et al.,* 2022), nexus-relevant words and phrases in Indigenous and local languages reflect the world views, cosmologies and values of their speakers (Sa'qawei Paq'tism Randolph Bowers, 2010; Yotti Kingsley *et al.,* 2013). Examples from Indigenous and local languages are often descriptive and multi-dimensional; for example, *In lu'um, In lu'umil* of the Yucatec Maya people (Mexico) means 'my land, soil, where I was born'. They also show a high level of interconnectedness between the five common concepts. For example, the concept of *Enkanyit* of the Maasai people (Kenya and Tanzania) stands for the 'mutual respect and honour for both humanity and environment' and relates to the concepts of caring, relationality and sustainability (**Table 1.1** and **Appendix 1**). Indigenous and local linguistic representations are rarely suitable for word-for-word translations into other languages, as they represent intricate place-based and context-sensitive narratives.

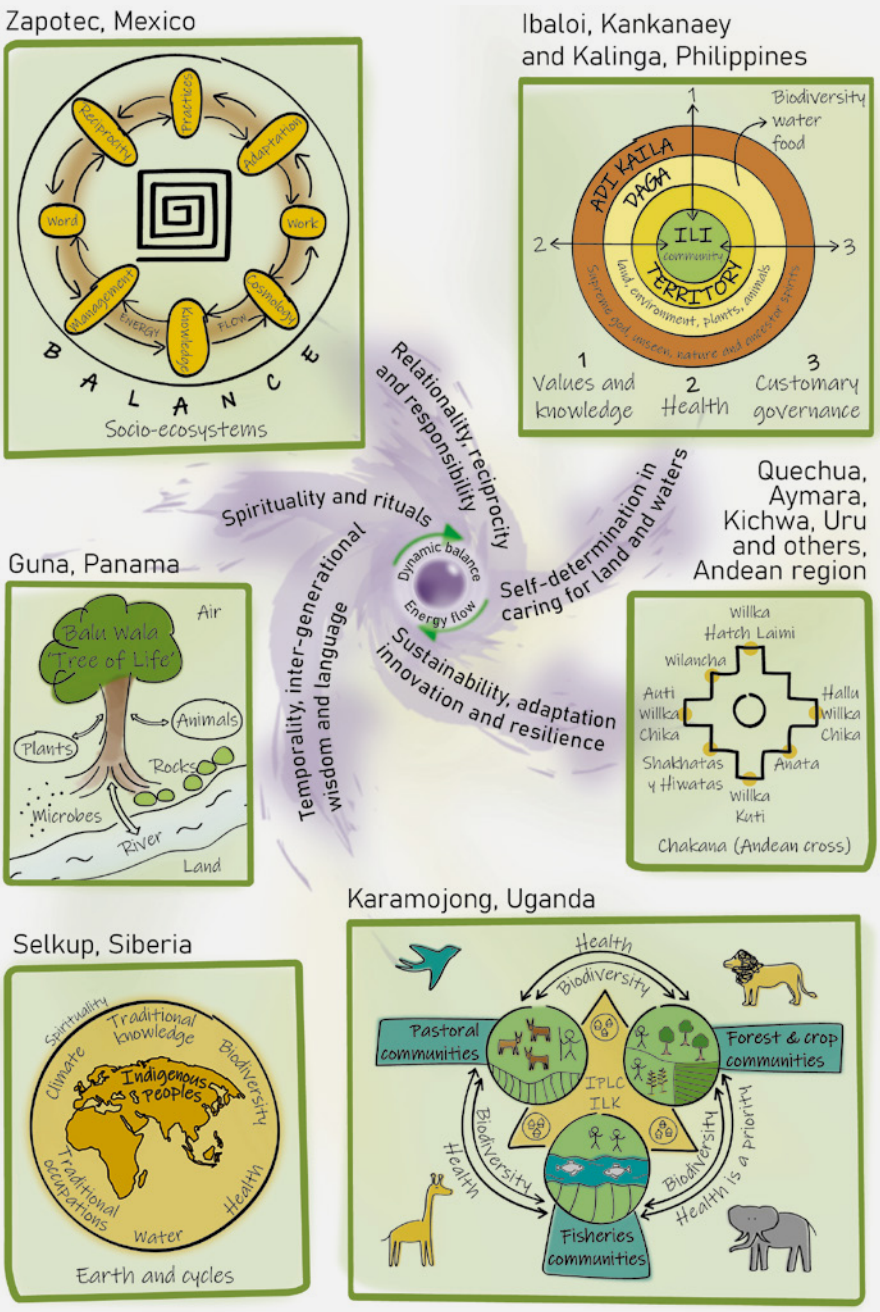

Figure 1 3 **Examples of conceptualizations of the nexus by Indigenous Peoples and local communities.**

The drawings were created by the participants of the Indigenous and local knowledge dialogue workshops for the Nexus Assessment (IPBES, 2022a, 2023a, 2023b). They represent a circle of life among the Karamojong people in Uganda (drawing by Loupa Pius); a circle of interdependence and mutual support among living and non-living things, material and spiritual realms of the Selkup people in Siberia, Russian Federation (drawing by Polina Shulbaeva); a tree of life for the Kuna/Guna of Panama (drawing by Onel Masadule); as shared energy, complexity and complementarity for the Zapotec in Mexico (drawing by Yesenia Hernandez); concentric circles of community (Ili)-land (Daga)- the 'unseen' (Adi Kaila)- and health (Salun-At) for communities such as the Ibaloi, Kankanaey and Kalinga in the Philippines with knowledge, culture, values and customary governance cutting across all circles (drawing by Maria Elena Regpala, Joji Cariño and Florence Daguitan); and as four cardinal directions and complementarity of the opposing sides within the Chakana/Andean cross as used by the Indigenous Peoples in the Andean region such as Quechua, Aymara, Kichwa, Uru and others (drawing by Q"apaj Conde). At the center of the figure are five categories of common concepts cutting across these various views on the nexus.

Table 1 1 **Examples of representations of the common concepts relevant to the nexus within Indigenous and local languages.**

Contributions from Akiwiy, Cilo, Hanna Deng, Sumi · Dongi, Collins Handa, Aslak Holmberg, A-Jiao Lin, Ongoo · Osay, Loupa Pius, Kamal Kumar Rai, Francisco J. Rosado-May, José Tek, Nick Roskruge, and Yu-Hua Yang are gratefully acknowledged. Please see Appendix 1.1, **Table 1.A.1** for the full version of the table.

Common concepts relevant to the nexus in the English language	Selected representations of the common concepts relevant to the nexus in Indigenous and local languages
Dynamic balance, energy flow	• *Mauri* (life force/ natural energy), Māori, New Zealand • *U juul k'iin U yooxol k'iin* (sunlight as a source of energy and light), Yucatec Maya, Mexico • *Ngigup lu ka etish, amwanis ka kolong* (work effort and the sun heatwaves), Ngakarimojong, Uganda
Self-determination, access to and caring for lands, waters and territories	• *Tino Rangatiratanga Chiueftai/nshgip* (self-determination) and *Kaitiakitanga* (guardianship), Māori, New Zealand • *Chhasumkha* (land), *Chhapung* (territories) and *Kawa* (water), Kirant Sampang, Nepal) • *Gizaagi'in and Ganawendan (I love you, to look after)* Anishinaabemowins-speaking nations, USA and Canada (Gagnon *et al.,* 2022)
Spirituality, rituals and traditions	• *Pixanil* (spirit and soul that make people alive), Yucatec Maya, Mexico • *Mundhum, ridhum, hadhum* (spiritual practices), Kirant Sampang, Nepal • *Bakelan* (celebration following an important work effort or life event), Amis, Taiwan, China • *Emuronot kakiriket* (spiritual healing, ancestral spirits to protect and guide the community), Ngakarimojong, Uganda
Temporality, inter-generational knowledge, wisdom and language	• *Miatsil ichil u kuxtal wíiniko' Ojelil ichil u kuxtal wíiniko* (high level of wisdom transmitted for the well-being of people in life), Yucatec Maya, Mexico • *Temalawma ay sanem na tasaw* (wisdom of elders) Kavalan, Taiwan, China • *Angajep-Ngageyepa-erowori* (the tongue that speaks languages), Ngakarimojong, Uganda
Relationality, reciprocity and responsibility (rights and duties)	• *Suma qamaña* (living well, in a harmonious relationship), Quechua and Ayamara, Andes • *Tri Hiti Karana* (the interconnectedness of people, nature and the spirit world) Balinese, Indonesia (Risna *et al.,* 2022) • *Gizhaadan* (to guard), Anishinaabemowin-speaking nations, USA and Canada (Gagnon *et al.,* 2022)
Sustainability, adaptation, innovation and resilience	• *Birgejupmi* (livelihood, survival capacity, the way people (individuals and communities) maintain themselves; requires know-how skills, resourcefulness, reflexivity and competence), Saami, Finland • *Anku* (resilience), Quechua, Andes • *Digo* (sustainability), Kirant Sampang, Nepal • *Anakinit ibore dadang, kori epedor akiyar alotomor ngiruwa ngulu eponito dadang* (being able to survive, adapt to different conditions as they come), Ngakarimojong, Uganda

Resulting from their world views emphasizing integration with nature, IPLC play a vital role in managing and contributing to the diversity of natural ecosystems across the globe, helping to sustain ecologically intact landscapes and thus the integrity of various nexus elements, e.g., in forests (Fa *et al.,* 2020; Garnett *et al.,* 2018), peatlands (Hiller & Fisher, 2023) and seascapes (Thaman *et al.,* 2017). IPLC governance of biodiverse territories is often associated with lower levels of deforestation and forest degradation as compared with neighbouring, non-Indigenous managed lands (Schleicher *et al.,* 2017; Sze *et al.,* 2022). IPLC have total or partial tenure rights or management influence over around 25% of the Earth's land surface (Garnett *et al.,* 2018). As such their active involvement in decision-making around the nexus elements of biodiversity, water, food and climate change is particularly important, with linked positive benefits on IPLC health and well-being **(Box 1.5)**.

Examples of the nexus approach towards sustainable interactions with the lived environment may also be seen in the world views, spatial thinking and life practices of many non-Indigenous communities. For many European peasants, small-scale fishers and pastoralist groups, for example, perception of self cannot be separated from the entire geography, biology and the environment where they belong (Pierotti, 2018). Pastoral groups very often hold the view that they are part of nature, and their knowledge of the land stems from the lived experiences with livestock and pasture as well as from their ancestors (Easdale & Aguiar, 2018; Roué & Molnár, 2017).

Box 1 5 ***Biodiverse wetland-rice systems and wild foods in Wayand, India.***[2]

Indigenous Peoples and local communities' food systems are often intimately connected to, and dependent upon, biodiverse landscapes, and tightly linked to other nexus elements. Throughout the assessment, each chapter will highlight an aspect of IPLC food systems, indicated by blue text headings in boxes showing these common case studies. These are then summed up in **Chapter 7**, online **Supplementary material 7.1** at the end of assessment. The attention given to this common case study of IPLC food systems was a result of discussion among the members of the ILK liaison group of the assessment in order to identify an issue that could highlight the importance of ILK and IPLC regarding nexus issues. The following case study opens with an example of the importance of these issues for many IPLC.

In the Western Ghats of Kerala state in India, the Adivasis (a general term for the 11 different ethnic groups in this area) manage rice crop diversity and harvest wild food within a global biodiversity hotspot. The district name of Wayanad translates to "land of rice fields", with the region's rice agro-ecosystem consisting of wetlands, managed paddy fields and mixed tree-crop systems. The paddy fields (known as *vayals*) are highly interconnected with surrounding landscapes of home gardens and forests joined by streams and canals. More than 300 species of vascular plants have been found in these wetland/paddy field landscapes, representing 15% of the known flora of the entire district. One particular type of rice called *"navara"* is known to have medicinal properties, while other local varieties particularly resistant to flood, drought, pest and diseases are cultivated and conserved by the communities. Collection of wild leafy vegetables and yams in nearby evergreen forests, dry deciduous forests and tea estates supply additional nutritive benefits that are often higher than more widespread cultivated varieties like amaranth.

Wild food collection is especially important for community food security and resilience to climate events like drought that would otherwise lead to food scarcity. ILK regarding these sources of food, medicines, religious and other uses remain high among these communities, with average households using 165 wild plants, of which women are often the primary collectors. As such, wild-collected food plays a crucial role in protecting both local food security as well as maintaining culturally important interactions with ecologically rich landscapes. Yet declines in traditional paddy/wetland production (a reduction of half the land area since 2006) and resulting loss of agroecological knowledge has been caused by a shift away from an interconnected food and biodiversity system. The area has seen restrictions in accessing the forests, expansion of cash cropping, spread of invasive alien species and cultural pressures around higher prestige foods. These changes have resulted in declines in wild food collection and knowledge and, in reverse of food security objectives, increasing malnutrition and health impacts.

Recent interventions from a "Green Health Programme" funded by a local foundation have focused on revitalizing practices through developing women's self-help groups advised by Ayurvedic healers and nutritionists; collection, conservation and cultivation of medicinal plants; marketing of *navara* medicinal rice for sale; rainwater storage for droughts; and promoting home nutrition gardens to reduce the pressure on wild habitats. "People's Biodiversity Registers" for recording of local knowledge on important flora have been developed to facilitate access and benefit-sharing mechanisms, allowing for location-specific, culturally-relevant and sustainably-integrated biodiversity conservation, healthcare and food production practices.

Sources: Bhatt *et al.,* 2023; Narayanan *et al.,* 2011; Pradeepkumar *et al.,* 2015; Prajeesh *et al.,* 2014.

1.2.3 Applying the IPBES conceptual framework to nexus interactions

The IPBES conceptual framework structures the assessment and synthesis of people's interactions with the environment (Díaz *et al.,* 2015). It comprises six main components of social-ecological systems — anthropogenic assets, indirect drivers, direct drivers, nature, nature's contributions to people and human well-being. While interactions between these components can be mapped in the IPBES conceptual framework, interactions *within* components cannot. As many nexus challenges arise from interactions within components e.g., direct drivers of water, food and health systems, this section maps the five nexus elements considered in this assessment to each component of the IPBES conceptual framework along with nexus response options for addressing interlinked problems through coordinated action by multiple actors **(Figure 1.4)**. A more detailed mapping is described in **Chapter 2, section 2.2**.

Nexus elements interact in complex ways and can be thought of as interweaving threads that run through the different components of the IPBES conceptual framework. Biodiversity — across terrestrial, freshwater and marine realms — sits within the 'nature' box. All five nexus elements are related to the 'nature's contributions to people' box, for example, through material contributions such as food and feed, regulating contributions such as pollination and regulation of freshwater water quality and climate, and non-material contributions such as physical and psychological experiences. All elements are also related to the 'good

2. Common case study highlighting Indigenous Peoples' and local communities' (IPLC) food systems. See **Chapters 2** to **4**, **5.1** to **5.5** and **6** for additional IPLC food system case studies. Lessons learned from the common case studies are presented in **Chapter 7**, online **Supplementary material 7.1**.

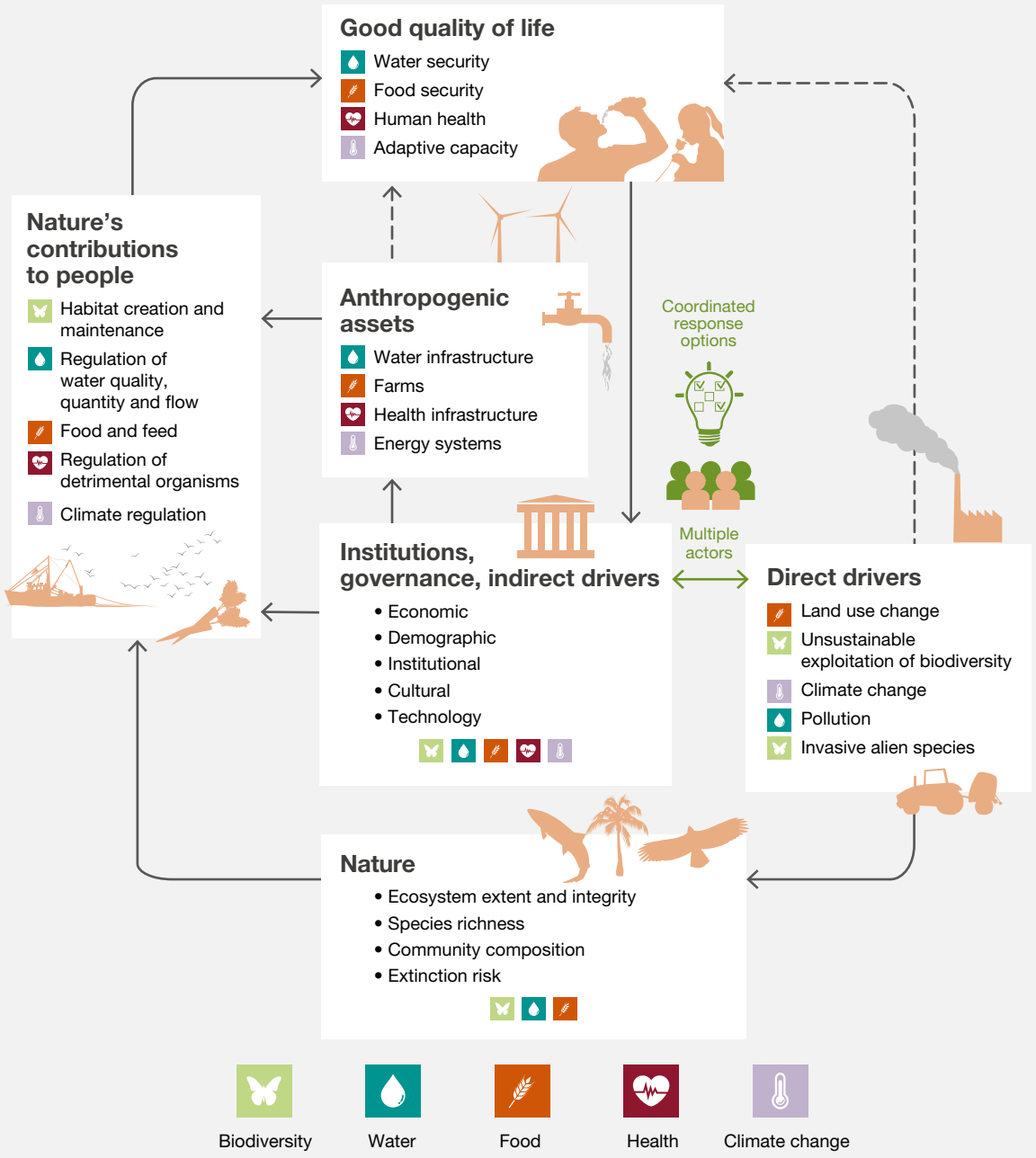

Figure 1 4 **The five elements of the nexus mapped to the six components of the IPBES conceptual framework, including the role of multiple actors in delivering coordinated response options with nexus-wide benefits.**

Note that only examples are shown; see **Figure 2.1 in Chapter 2** for a more detailed version.

quality of life' box in terms of health and well-being, including food and water security.

Drivers of change refer to "all those external factors that affect nature, anthropogenic assets, nature's contributions to people and a good quality of life" (Díaz *et al.,* 2015). Indirect drivers include patterns of human organization and socioeconomic activity, e.g., cultural, economic and demographic changes, that mediate direct drivers of change such as land/sea-use change. The nexus element of climate change fits into the 'direct drivers' box. However, nexus elements are not always easily separated into direct and indirect drivers (Rounsevell *et al.,* 2010). For example, the other nexus elements can act as both negative drivers (e.g., food production to biodiversity and water) as well as positive co-benefits (e.g., biodiversity and water to food, or food to health).

'Anthropogenic assets' differ for each of the nexus elements. For example, water may be associated with irrigation infrastructure, food with farms, health with hospitals and other healthcare infrastructure, and climate change with energy production or carbon dioxide removal infrastructure. The 'institutions, governance and indirect drivers' box is strongly associated with actors who may associate themselves with one or more of the nexus elements. Response options emerge from institutions and governance systems, with some options being most efficiently driven by specific actors within a nexus element and others requiring collaborative and coordinated action across multiple elements and actors. Nexus response options encompass combinations of voluntary or mandatory policies, strategies, measures and interventions that target nexus elements and interlinkages or their indirect drivers. Nexus governance, response options and actors are introduced in more detail in **section 1.3** and **Box 1.6**.

Actors may hold different values regarding nexus elements that affect how they diagnose nexus challenges and identify response options that deliver benefits to multiple nexus elements. The IPBES Values Assessment identified four perspectives on human-nature relationships, ranging from instrumental (living from nature) to relational (living as nature), with 'living in nature' and 'living with nature' in between. These perspectives are not mutually exclusive and often overlap. The Nature Futures Framework (L. M. Pereira *et al.,* 2020) captures human-nature values in a triangular space, illustrating orientations towards intrinsic (nature for nature), relational (nature as culture) and instrumental (nature for society) values. The space within the triangle represents a continuum or gradient between these three non-mutually exclusive value perspectives. Both frameworks can help capture the plurality of value perspectives on nature in understanding nexus challenges and addressing them through nexus response options.

1.3 RELEVANCE AND IMPACT OF THE NEXUS ASSESSMENT FOR GOVERNANCE

1.3.1 Key governance concepts used in the Nexus Assessment

Several key governance concepts are related to the nexus **(Box 1.6)**. These are central to understanding the assessment's focus on actors and response options. They are also closely linked to, and iteratively interact with, governance concepts used in the Transformative Change Assessment. Nexus governance and transformative governance are the terms used consistently in both assessments and the interlinkages, complementarities and differences between them are described in **Box 1.6**.

Box 1 6 **Key governance concepts used in the Nexus Assessment.**

Governance is an umbrella concept for the full range of means for deciding, managing, implementing and monitoring policies and measures, including the ways that combinations of formal and informal and public and private institutions (including actions, norms, rules and rulemaking systems) are structured, sustained and regulated (IPBES, 2019b, 2023d). Governance approaches determine the processes and channels through which decisions are made and implemented, and how power and responsibilities are distributed and exercised between actors (see **Chapter 4, section 4.2.2**). An inclusive concept of governance recognizes the contributions of many types of actors across a broad range of levels (IPBES, 2022c).

Nexus governance as used in this assessment refers to the systematic coordinating structures and processes that enhance the engagement of multiple actors through horizontal (e.g., across various nexus elements at one scale) and vertical (e.g., cross-scale connectivity or multilevel governance) channels to address nexus challenges, identify policy and sociopolitical options, and manage their implementation towards just sustainable futures (see also further discussion in **Chapter 4**). Nexus governance aims to achieve policy coherence to meet international and domestic goals and objectives with appropriate response options that manage and minimize trade-offs, while promoting synergies and co-benefits across scales and time, such as through recognizing and supporting the actions of societal actors through arenas of engagement (e.g., the many different settings, places, spaces and contexts within which governance actors interact to shape nexus approaches and initiatives (Schipper *et al.,* 2022)). Nexus governance is thus broader than integrated governance and other related approaches. **Chapter 4** identifies five key components as important for nexus governance: integrative, holistic and transdisciplinary framing of problems and solutions; inclusive approaches that bring about enhanced arenas of actor engagement; normative considerations of equity and justice, alongside accountability; enhanced mechanisms and processes for collaboration and coordination across scales and sectors; and adaptive, reflexive and experimental approaches to learn from what works and to scale these solutions (see **Chapter 4, section 4.5.4**).

Box 1 6

Transformative governance refers to the formal and informal (public and private) rules, rule-making systems and actor-networks at all levels of human society (from local to global) that enable transformative change towards biodiversity conservation and sustainable development more broadly (Visseren-Hamakers *et al.,* 2021; Visseren-Hamakers & Kok, 2022). In line with the IPBES Thematic Assessment of the Underlying Causes of Biodiversity Loss and the Determinants of Transformative Change and Options for Achieving the 2050 Vision for Biodiversity (Transformative Change Assessment), this assessment defines transformative change as fundamental, system-wide shifts across views, structures and practices. When such shifts address the underlying causes of biodiversity loss and nature's decline, transformative change contributes to a just and sustainable world. Transformative governance thus refers to an alteration of existing configurations of views, structures and practices to enable effective and just biodiversity governance. Actions include integrative governance that revises decision-making processes, an inclusive governance that creates ownership and deliberation among stakeholders, a global and multi-level governance that addresses global interdependencies, as well as an adaptive governance that continuously evaluates and revises regulatory and holds responsible actors accountable for addressing biodiversity related issues.

Actors in the context of the nexus are any individual or group that is directly or indirectly, formally or informally, associated with or affected by the nexus elements and response options. Actors seek to influence public decisions and enable action to address societal aspirations, needs and concerns. Examples of actor categories include governments, the private sector, non-governmental organisations, civil society organisations and IPLC, each of whom may have their own stakes and interests (see **Table 1.1**). Actors also operate in relation to one another, with some wielding more influence than others over decision-making, while some may be more affected by decisions made by others (see also **Chapter 4**).

Policy and sociopolitical options refer to the range of theoretical and practical frameworks for implementing sustainable management approaches, including diverse sets of human actions to address specific issues, needs, objectives and opportunities in the governance and management of nexus challenges. The policy and sociopolitical options that are the focus of this assessment include those that account for a diversity of world views, behaviours, norms and values and which are aimed at accelerating transitions towards just and sustainable futures (see **Chapter 4**).

Response options are one type of policy and sociopolitical option. These are defined as actions or policies available to a range of actors that address specific challenges or opportunities in the governance and management of one or more elements of the nexus, with the goal of achieving positive and equitable outcomes across multiple nexus elements (see also **Chapter 5.0**). Response options can include voluntary or mandatory policies, strategies, measures and interventions intended to change nexus elements, interlinkages between them and direct or indirect drivers shaping them. The assessment particularly focuses on actions, policies and enablers as key response options in **Chapter 5**. The response options presented in this assessment are a non-exhaustive list, with implementation dependent on national and local circumstances.

Policy instruments are the different interventions (including formal rules, laws, social norms and processes, among others) made by decision-makers (ranging from governments and public authorities, intergovernmental organizations, companies, to other actors) to ensure that (public) policy objectives are supported and achieved by influencing the behaviour and actions of others (IPBES, 2022c). IPBES has recognized four major types of policy instruments: Legal and regulatory, economic and financial, social and cultural and rights-based and customary policy instruments (see **Chapter 4, Table 4.4**).

Decision support tools are methods, approaches and techniques that can inform, assist and enhance relevant decision-making, policy-making, governance and implementation at the local, national, regional and international levels, based on science and other knowledge systems including ILK (IPBES, 2018a). In the context of the nexus, these tools can assist in decision analysis and response option design, selection and implementation while particularly addressing cross-cutting nexus issues. Examples include integrated assessment models, multicriteria decision analysis or participatory mapping (see **Chapter 4.6**).

Enablers and barriers are specific characteristics or context of a nexus challenge that facilitate or impair the implementation, operationalization or effectiveness of nexus response option(s) (including governance approaches). These enablers or barriers need not necessarily be unique to the nexus. Categories of enablers include policy effectiveness, institutional capacities, equity, financial and economic behaviour, lifestyle and values, and technology. Many of the potential enablers can be barriers if not managed appropriately (see **Chapter 4, Table 4.6**).

Values are the ways in which people reflect their life goals, beliefs, general guiding principles, opinions or judgements of the importance of specific things in particular situations and contexts (IPBES, 2022c). The IPBES methodological assessment regarding the diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem functions and services (Values Assessment) has noted that value pluralism means there are several values which may be equally correct and fundamental to different communities, and yet in conflict with each other (IPBES, 2022c).

Equity and justice refer to fairness in the consequences, outcomes, costs and benefits of actions or policies. **Distributive equity and justice** relates to the fair allocation

Box 1 6

of benefits, costs and risks, including intergenerational and intragenerational equity. **Procedural equity and justice** encompasses fairness in political processes and participation in decision-making. **Recognition equity and justice** relates to recognizing, valuing and acknowledging respect for different and contextual ways of life, knowledge and cultural difference and capabilities, which can determine who benefits from resources and power (IPBES, 2022c).

1.3.2 Relevance of the Nexus Assessment for policy frameworks

The Nexus Assessment aims to support the development of holistic policies and actions that contribute towards the achievement of multiple global goals and agreements. It does this through the evaluation of response options in term of the degree to which they benefit several elements of the nexus (see **Chapter 5**). Additionally, the assessment supports the concurrent and coherent achievement of biodiversity, climate change, human health and sustainability goals by providing evidence for complementarity and minimization of trade-offs among global agreements and frameworks (Nilsson & Weitz, 2019).

Nexus thinking has particularly been operationalized in global policy through the SDGs. The 2030 Agenda for Sustainable Development was developed as a plan of action for people, planet and prosperity for all countries and stakeholders acting in collaborative partnership, consisting of 17 Goals and 169 targets designed to be integrated and indivisible and balancing the economic, social and environmental dimensions of sustainable development (L. M. Collins, 2018; Folke *et al.,* 2016; Nilsson *et al.,* 2016; Obura, 2020; United Nations Conference on Sustainable Development, 2012). The interactions and interlinkages among the Goals are particularly important to consider, as the five nexus elements are directly related to individual Goals – biodiversity (SDGs 14 & 15), water (SDG 6), food (SDG 2), health (SDG 3) and climate change (SDG 13), with second order interactions with other SDGs, such as gender (SDG 5), poverty (SDG 1), responsible consumption (SDG 12) and others. The Goals also incorporate the transfer of benefits from nature goals through economic goals to societal welfare goals (Obura, 2020; Obura & Treyer, 2022). Because the SDGs are accepted by all countries, they provide a direct pathway to policy relevance at national and international scales for this assessment.

The SDG framing allows for additional nexus elements not addressed in this assessment (e.g., energy, SDG 7) to be readily incorporated for integration and synthesis to improve policy adoption (Estoque, 2023; Liu, Hull, *et al.,* 2018). Indeed, to avoid potentially conflicting goals and targets, these interlinkages within and across the SDGs should be strongly integrated during implementation (Lim *et al.,* 2018; Stafford-Smith *et al.,* 2017), including for sustainable economic growth (Kreinin & Aigner, 2022). In response, countries have operationalized the SDGs to enable cross-cutting action in several different ways, pointing out the need for context-appropriate integrative steps: for example, Denmark has an inter-ministerial group to guide its SDG Action Plan, Turkey has a task force to integrate SDGs into public documents, while Viet Nam has a National Council for Sustainable Development and other institutions for coordinating national climate and SDG policies (OECD, 2019; United Nations, 2019).

In addition to the SDGs, other key global-level policy frameworks and initiatives directly linked to the nexus elements and relevant to the Nexus Assessment are:

Biodiversity:

- **Kunming-Montreal Global Biodiversity Framework:** The Kunming-Montreal Global Biodiversity Framework recognizes that urgent policy action at all levels of governance is required to transform economic, social and financial models to reverse biodiversity loss, referred to in the framework as a "whole-of-government and whole-of-society approach" (section C.7c). Other nexus elements have been emphasized in the adoption and implementation of the Kunming-Montreal Global Biodiversity Framework targets (e.g., recognition of the environmental determinants of health (Willetts *et al.,* 2023), food security and livelihoods (CBD, 2022)). Addressing interlinkages between nexus elements can ensure the Kunming-Montreal Global Biodiversity Framework targets are addressed in an integrated manner and as an indivisible whole (Díaz *et al.,* 2020; Leadley, Gonzalez, *et al.,* 2022; Visconti *et al.,* 2019). Failing to achieve a nexus approach means that a focus on biodiversity targets alone might risk negative outcomes for people's human rights (Bennett *et al.,* 2017; Obura, 2023). Applying a human rights-based approach in the implementation of the new post-2020 agenda has high potential to facilitate transformative changes and halt biodiversity loss (Bennett *et al.,* 2017; Obura, 2023), and has been raised by many in reference to targets for expanded protected areas to avoid failing to recognize Indigenous Peoples' territories and rights (Tauli-Corpuz *et al.,* 2020; Zafra-Calvo *et al.,* 2019).

- **Ecosystem restoration goals:** The Kunming-Montreal Global Biodiversity Framework, the UN Decade of Ecosystem Restoration, the Bonn Challenge and the New York Declaration on Forests are among the global commitments to bring 350 million hectares of the world's deforested and degraded land into restoration by 2030 (UNGA, 2019). Yet, managing restoration efforts to achieve multifunctionality across nexus issues has been challenging (Simonson *et al.,* 2021), particularly with regard to ensuring social benefits and equity (Elias *et al.,* 2022). Afforestation goals focused singularly on carbon rather than considering the interlinkages of people, nature and climate change together may miss important interconnections and co-benefits (Doelman *et al.,* 2020; Leadley, Archer, *et al.,* 2022; Pörtner *et al.,* 2021; Suryaningrum *et al.,* 2022), as have been critiqued for some national restoration plans (Jiang *et al.,* 2021; McElwee & Huu Nghi, 2021), or create competition and demand for land with unintended consequences (Dooley *et al.,* 2022). Collaboration among governments, civil society organizations, businesses and local communities is crucial to collectively address the complex challenges associated with restoring degraded ecosystems and ensuring sustainable and equitable outcomes (Elias *et al.,* 2022).

- **Ocean sustainability goals:** The UN Decade of Ocean Science for Sustainable Development (Ryabinin *et al.,* 2019; UNESCO, 2023) and the UN Convention on the Law of the Sea, including its recent legally binding instrument on the Conservation and Sustainable Use of Marine Biodiversity of Areas Beyond National Jurisdiction, addresses the conservation, use and equity of the world's marine environment, including the 'global commons' of the high seas (UN Convention on the Law of the Sea, 1982). The large extent and distances in the marine environment can prove challenging to pursue opportunities for interactions among nexus elements. Nevertheless, the potential for overlapping national interests in international waters will benefit from synergistic strategies (Claudet *et al.,* 2020), like the nexus approach.

Water:

- **Ramsar Convention:** The Convention on Wetlands of International Importance Especially as Waterfowl Habitat is in the process of developing its fifth strategic plan, and the new strategy will continue to build on goals and targets identified in the fourth strategy around addressing the drivers of wetland loss and degradation, effective conservation and management of Ramsar sites and the wise use of all wetlands (Resolution XII.2 The Ramsar Strategic Plan 2016-2024, 2015). The existing plan identifies nexus relevant priority areas around synergies and enhancing co-operation, as evidence for the creation of a specific annex outlining the contribution of the convention to the SDGs and the Kunming-Montreal Global Biodiversity Framework (Resolution XIV.4 Review of the Fourth Strategic Plan of the Convention on Wetlands, Additions for the Period COP14-COP15 and Framework for the Fifth Strategic Plan, 2022).

- **Water Convention:** The Convention on the Protection and Use of Transboundary Watercourses and International Lakes was initially focused on the UN Economic Commission for Europe (United Nations Economic Commission for Europe, 2013). It has since opened to countries outside the region, and African and Latin America countries have joined the convention. The convention recognizes the potential for transboundary water processes to have interactions with biodiversity, health and climate change (Article 1) and the importance of taking steps to reducing negative inputs from agricultural production (Article 3). The convention also has a specific Protocol on Water and Health (United Nations Economic Commission for Europe, 2022), although the number of countries ratifying this is fewer but growing.

Food:

- **Food systems goals:** A diversity of food systems goals and strategies exist at both the global and local level. At the global level, the UN Food Systems Summits held in 2021 and 2023 aimed to support nations and stakeholders in addressing the issues of climate change, soil degradation and biodiversity loss while also maximizing the co-benefits of a food systems approach across the whole 2030 Agenda for Sustainable Development. The summits served as a forum for new initiatives, creative fixes and strategies to reform food systems and use these changes to advance all of the SDGs, including the development of evidence-based action agendas that discuss nexus-related interlinkages between food and other sectors (von Braun *et al.,* 2021). At the local level, the Milan Urban Food Policy Pact (MUFPP) is an international agreement of Mayors launched in 2015 and signed by over 280 cities representing a total of 460 million inhabitants (MUFPP, 2022). It identifies 621 actions that cities are implementing to achieve sustainable and healthy food systems organized in six categories of governance, sustainable diets and nutrition, social and economic equity, food production, food supply and distribution, and food waste.

- **Global nutrition targets 2025:** in 2012, the WHO approved a set of six global nutrition targets that by 2025 aimed to achieve a 40% reduction in the number of children under 5 who are stunted; achieve a 50% reduction of anaemia in women of reproductive age; achieve a 30% reduction in low birth weight; ensure that

there is no increase in childhood overweight; increase the rate of exclusive breastfeeding in the first 6 months up to at least 50%; and reduce and maintain childhood wasting to less than 5% (World Health Organization, 2014). These goals were incorporated into the 2030 Agenda for Sustainable Development in target 2.2: "end all forms of malnutrition" and thus extended to 2030.

Health:

- **Health policies and goals:** The One Health transition (managing ecosystems, and use of wildlife, promoting healthy ecosystems and healthy people) has been developed as an integrated approach linked to the biodiversity targets of the Convention on Biological Diversity. With the establishment of the One Health High Level Expert Panel (OHHLEP) supported by the World Health Organization (WHO), the World Organization for Animal Health (WOAH); the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP), improved biodiversity and healthy ecosystems have been included as outcomes of the post-SDG era and as key underlying principles of the One Health definition (OHHLEP, 2023).

Climate change:

- **The Paris Agreement:** The Paris Agreement long-term global goals and decisions include substantially reducing global greenhouse gas emissions to limit the global temperature increase to no more than 2 degrees, including reducing emissions from deforestation and forest degradation, and made on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty. This implies an important role in safeguarding water and food security and the right to health, among other components of the agreement (United Nations, 2019). For example, Nationally Determined Contributions (NDC) could be strengthened and implemented using a comprehensive vision of the interlinkages between climate change and other nexus elements to avoid unintended consequences and take advantage of synergies to reinforce mitigation and adaptation. In addition, adaptation planning can potentially benefit from nexus approaches in order to avoid maladaptation pathways that might exacerbate damages to biodiversity and other elements from climate adaptation choices (Rasul & Sharma, 2016).

Cross-cutting:

- **Rights to a healthy environment:** In 2022, the UN General Assembly adopted the resolution *"The human right to a clean, healthy and sustainable environment"* (A/RES/76/300), addressing both substantive and procedural elements. Substantive elements highlight that climate change, air, water and land pollution, the loss of biodiversity and declines in ecosystem services "interfere with the enjoyment of a clean, healthy and sustainable environment". Procedural elements include access to information, the right to participate in decision-making and the rights to remedies. Related policies include the Aarhus Convention (United Nations Economic Commission for Europe, 1998) and the Escazú Agreement (United Nations, 2018a), which focus on access to information, public participation and justice in environmental matters. The International Covenant on Economic, Social and Cultural Rights (ICESCR) (General Assembly Resolution 2200A (XXI): The International Covenant on Civil and Political Rights., 1966) relates to nexus elements in Article 11, which addresses the right to an adequate standard of living, including food and freedom from hunger and Article 12, which covers the right to health. Additionally, in 2010, the UN General Assembly recognized the right to safe and clean drinking water and sanitation as essential for the full enjoyment of life and all human rights (Resolution 64/292. The Human Right to Water and Sanitation., 2010).

- **Soil degradation and desertification goals:** Land Degradation Neutrality (LDN) is a global target of the UN Convention to Combat Desertification (United Nations Convention to Combat Desertification, 1994). The convention has five strategic objectives, among which are improving the living conditions of affected populations, restoring and conserving degraded land, and mitigating the effects of drought. Soils and their health are critical for mitigating poverty, hunger, climate change and land degradation, and underpin multiple SDGs (Lal *et al.,* 2021). They are also indispensable in the production of food, water cycle processes and energy generation from biological systems (Hatfield *et al.,* 2017), as well as playing an important role in human health (Pepper, 2013). Nexus approaches that capture non-linear dynamics between ecosystems, climate change, food and other elements particularly help to achieve LDN (Sietz, Fleskens *et al.,* 2017). The LDN framework aims to integrate land degradation issues into national development plans and policies, promote sustainable land management practices, and improve monitoring and reporting of land degradation.

- **Disaster Risk Reduction goals:** The Sendai Framework for Disaster Risk Reduction was adopted by UN Member States in 2015, and proposes, among other procedures, to articulate the need for improved understanding of disaster risk in all its dimensions of exposure, vulnerability and hazard characteristics from 2015-2030 (UNDRR, 2015). While it does not explicitly reference the term "nexus", the framework calls for similar principles in the need for implementation to be collaborative, integrated and inclusive across different

sectors and scales. It explicitly identifies biodiversity, climate change, food and the environment as key instruments in disaster risk reduction (UNDRR, 2015).

1.3.3 Relevance of the Nexus Assessment to different actors

Although some relationships among elements within the nexus are more established (such as the biophysical impacts of climate change on biodiversity (Pörtner *et al.,* 2021)), how these connections and their consequences are perceived varies according to the actors involved and may even generate tensions between actors, particularly when there are asymmetries of power (Hadad *et al.,* 2021). Multiple actors with a range of conflicting interests can create situations where trade-offs are not explicitly acknowledged (Kurian, 2017). At the same time, some situations can also favour the generation of alliances among actors to collaborate towards common interests in managing complex interactions if sufficient political will and shared values can be generated (Bai *et al.,* 2016; Obura, 2020).

Understanding actors' perspectives is, thus, crucial and illuminates why **Chapter 5** takes an actor-oriented approach to evaluating response options and their nexus-wide implications, as **Chapter 5** is divided into five subchapters that address response options from the perspective of actors within each of the five nexus elements. Such actor-oriented approaches have the potential to evaluate how change happens in situations of complexity (Koleros *et al.,* 2020). For example, it is not always possible to predict how actors will respond to change over time, as numerous variables (in and out of the control of actors) are in play that will impact how they respond to interventions and outcomes. The capacity of an actor to impact the drivers of change or connections between nexus elements does not necessarily scale to the benefit or harm that such actors receive, given internal heterogeneity, power asymmetries and other factors (Granero de Melo *et al.,* 2020). There are also a range of persistent conflicts between actors (e.g., governments acting in opposition to IPLC, or the private sector impacting local communities), and identifying ways these can be resolved across the nexus can help improve governance at multiple scales (Hess & Brown, 2018; Kimengsi *et al.,* 2022).

Implementation of a nexus approach will likely require integrative and multilevel governance arrangements, which can include multiple levels working together simultaneously (multilevel coordination) or polycentric governance (multiplicity of overlapping decision-making centres); both can facilitate actor engagement, or stymie it, depending on the context (Juerges *et al.,* 2018; Wyborn *et al.,* 2020; Wiegant *et al.,* 2022). Involvement of multiple actors through deliberative and reflexive stakeholder engagement often increases trust among actors and improves effectiveness (Franz *et al.,* 2018; Lage *et al.,* 2023; Nesheim *et al.,* 2021). There are a broad spectrum of possibilities to facilitate multilevel action, including fostering knowledge co-creation and identifying barriers and opportunities (Howarth & Monasterolo, 2016). The Nexus Assessment, by taking an actor-oriented approach, can help define gaps and needs for different actors, such as value systems and perspectives that differ among actors (IPBES, 2022c) and where there are conflicts among these value systems that nexus approaches may help resolve. Considering actors and stakeholders at the core of a nexus analysis allows for a more bottom-up approach that helps to identify issues that are critical to a specific social, cultural, economic, political and natural context, and defines appropriate scales of operation (Stein *et al.,* 2014). Actors important to nexus governance are listed in **Table 1.2**.

Table 1 2 **Actors important to nexus governance.**

Key actors	Roles	Examples
Global institutions	Global institutions can provide financial, administrative, technical, and advising support. Facilitating agencies play important roles in supporting functional institutions' contributions to global cooperation and integration in regions where overarching institutions are either weak or non-existent.	United Nations agencies: UN Environment Programme (UNEP), Food and Agriculture Organization (FAO), World Health Organization (WHO), World Organisation for Animal Health (WOAH), United Nations Development Programme (UNDP), UN Water, Human Rights Office (UNOHCHR) and others. Intergovernmental organizations: Convention on Biological Diversity (CBD), International Union for Conservation of Nature (IUCN), United Nations Framework Convention on Climate Change (UNFCCC), World Meteorological Organization (WMO), World Trade Organization (WTO), UN Law of the Sea Convention

Table 1 2

Key actors	Roles	Examples
Regional institutions	Regional institutions play a similar role to global institutions but within a more focused area. They do this by serving as catalysts and coordinators – or honest brokers – for regional initiatives, as well as capacity builders and suppliers of knowledge and information on regionalism. They also fund regional projects (Capannelli & Tan, 2012).	Regional organizations like the European Union (EU); Organization of American States (OAS), Association of Southeast Asian Nations (ASEAN) and African Union (AU). Regional economic communities: Economic Community of West African States (ECOWAS), Intergovernmental Authority on Development (IGAD), Southern African Development Community (SADC)
National governments	As one of the key loci of decision-making around the nexus, there are unique barriers and constraints to national government sectoral actors in improving management across nexus issues and scales (Bréthaut *et al.,* 2019; Pahl-Wostl, 2019).	Ministries and government agencies responsible for environment, agriculture, water resources, health, climate change, energy and marine issues. National institutes for research on health, agriculture, environment, development and spatial planning.
Sub-national and local governments and municipalities	Government actors also extend to local or sub-national organizations and institutions. Through policies that encourage community involvement in planning and decision-making, regional and local governments have a substantial opportunity to impact sustainable outcomes (Basson *et al.,* 2018).	City governments and municipal bodies responsible for urban planning and nexus-related management. Other local institutions involved in decision-making across nexus elements.
Knowledge and educational communities	Science and educational institutions can provide actionable knowledge for addressing the nexus. However, they can also reinforce specific ideas, discourses and ways of governing which reinforce the status quo (Skutsch & Turnhout, 2020).	Universities, research centres and think tanks engaged in research on the nexus elements; environmental education institutions; professional societies
Civil society organizations	Civil society plays an important role in drawing attention to negative and positive impacts of current systems and the need for transformation (Kirschke *et al.,* 2016), as well as in providing potential solutions to different nexus challenges (Nesheim *et al.,* 2021).	Non-governmental organizations (NGOs) working on environmental conservation, climate action, public health and sustainable agriculture. Consumer and health advocacy groups promoting sustainable and healthy food systems. Worker and trade unions dealing with labour issues across nexus elements.
Community-based organizations	Community-based organizations can propose diverse solutions not dominated by a single actor. They combine complementary skills, resources and assets from several participants to produce synergies (Eitan *et al.,* 2019).	Community-based organizations focused on local-level engagement, advocacy and sustainable development. This can include grassroots organizations that represent the interests and voice of local communities, such as farmers' and fishers/aquaculturalists' cooperatives/unions, community health organizations, or other local advocacy groups.
Indigenous Peoples and local communities (IPLC)	IPLC often have specific rights to elements of the nexus (e.g., land and water), managed using ILK. In many ILK systems, nexus elements are already perceived as an intrinsically interlinked whole with humans as part of this vision, such as "living in harmony" concepts like Buen vivir/Sumak kawsay/Suma qamaña (Díaz *et al.,* 2015).	Indigenous interest groups, community development associations, tribal councils, ILK holders
Private sector and business organizations	Markets and economic actors can influence and be influenced by nexus elements and their interlinkages across spatial locations, as well as facing risks from changes in the nexus, particularly given globalized trade, supply chains and other economic interlinkages (Franz *et al.,* 2018; Schmidt & Matthews, 2018).	Food and beverage companies, agricultural and forest producers, and agribusinesses. Fishing and aquaculture companies, water utilities and infrastructure companies involved in water management and conservation. Pharmaceutical companies working on health-related research and innovation. Lobby groups representing business interests.
Science-policy interfaces	Knowledge needs in policy and society are critically analysed through capacity building in knowledge-policy interactions. Science-policy interfaces assess problems frequently related to nexus elements(Görg *et al.,* 2016).	Scientific advisory bodies and expert panels that bridge the gap between scientific research and policy development, e.g., IPBES, IPCC

Table 1 2

Key actors	Roles	Examples
Financing institutions	Financial institutions are important in allocating funds for nexus governance and response option development and operation (Schmidt & Matthews, 2018). They can help direct private investment toward the shift to an economy that is resource-efficient, climate-neutral and fair (Campa, 2022).	World Bank, regional development banks, philanthropic organisations and other financial institutions that provide funding and support for projects related to the nexus elements. Central banks and other regulatory institutions that play a role in regulating the financing of nexus elements
Media and the arts	Media and the arts offer methods for achieving global understanding in a variety of contexts. They can be effective instruments for expressing the diversity of communities' identity, disseminating research findings and fostering understanding in cross-disciplinary cooperation (Jónsdóttir, 2017), serving to bolster trust in nexus problem-solving.	Media outlets, journalists and communication platforms, including online social media, that shape public opinion, disseminate information and raise awareness about issues related to the nexus. Artists, performers, writers and cultural institutions that use their creativity to engage people, raise awareness and inspire action on nexus-related issues.

1.3.4 Developing nexus governance approaches

Governing nexus interactions requires improved approaches across sectors and administrative borders, which, despite recent years of attention, often remain focused on sectoral priorities (Venghaus & Hake, 2018). Nexus governance is complex but essential to effectively coordinating across vertical and horizontal channels (Al-Saidi & Elagib, 2017; Artioli *et al.,* 2017; Weitz *et al.,* 2017) in complementary and synergistic ways, and identifying and managing for trade-offs and compounding and cascading challenges (Newell *et al.,* 2019). **Figure 1.5** illustrates the different dimensions of nexus governance. Direct and indirect drivers of biodiversity loss and environmental change cause severe negative impacts on all nexus elements, with some of the elements then becoming drivers of change for other elements (e.g., climate change for food, or food for biodiversity). Siloed conventional approaches address these negative impacts through single-sector approaches and insufficient involvement of diverse actors which further exacerbate negative dynamics. The way out of these business-as-usual approaches is commonly hampered by the five nexus challenges: high complexity, siloed governance, multiple values, inappropriate scaling and lack of financing (see **section 1.1.2**).

Nexus governance enables these challenges to be overcome by focusing on integrative and holistic framings of problems across sectors in transdisciplinary ways of thinking, acting and being. Inclusive approaches encourage co-production of solutions among actors and can help minimize conflicts across values by involving those most likely to be impacted from the outset (Baldwin-Cantello *et al.,* 2023; Gagnon *et al.,* 2022; Karimova & Lee, 2022). Engagement and coordination of actors in an early phase of a project or policy implementation helps identify relevant indirect and direct drivers, as well as nexus challenges that need to be addressed (Hoolohan *et al.,* 2018; Stein & Jaspersen, 2019). Considerations of equity and accountability are critical to overcoming power disparities, and approaches that center justice and equity can deliver solutions that are more intersectional, integrated and intergenerational (E. M. Biggs *et al.,* 2015; Newell *et al.,* 2019). Processes for collaboration and coordination can help to redistribute power in a way that cultivates institutional change and mobilizes the capacities of different actors and knowledge systems (Kelemen *et al.,* 2022; Pascual *et al.,* 2022). Adaptive, reflexive and experimental approaches help to learn from what works and enables processes of interaction between actors that aim for maximizing synergies and co-benefits and reducing trade-offs (see also **Chapter 7, section 7.3**).

Within nexus governance approaches, different actions and policies nest in different ways, with specific response options that address challenges across biodiversity, water, food, health and climate change highlighted in **Chapter 5**. Addressing the nexus challenges via bundles (i.e., combinations or sequences) of response options, including design and implementation of specific policies, can be facilitated by addressing enablers and barriers (see **Chapter 4, section 4.2**), as well as by using decision support tools to evaluate options (see **Chapter 4, section 4.6**). Many of these combinations of actors, response option types and enablers/barriers will influence how trade-offs are anticipated and managed as well as the transformative potential of the response options. Ideally, well-designed response options can maximize synergies and co-benefits across nexus elements **(Chapter 5.6)**, forming stepping stones towards pathways that can facilitate transformative change **(Chapter 7, section 7.3)**.

Scaling of response options is an important part of this process and refers to the acceleration of the adoption and

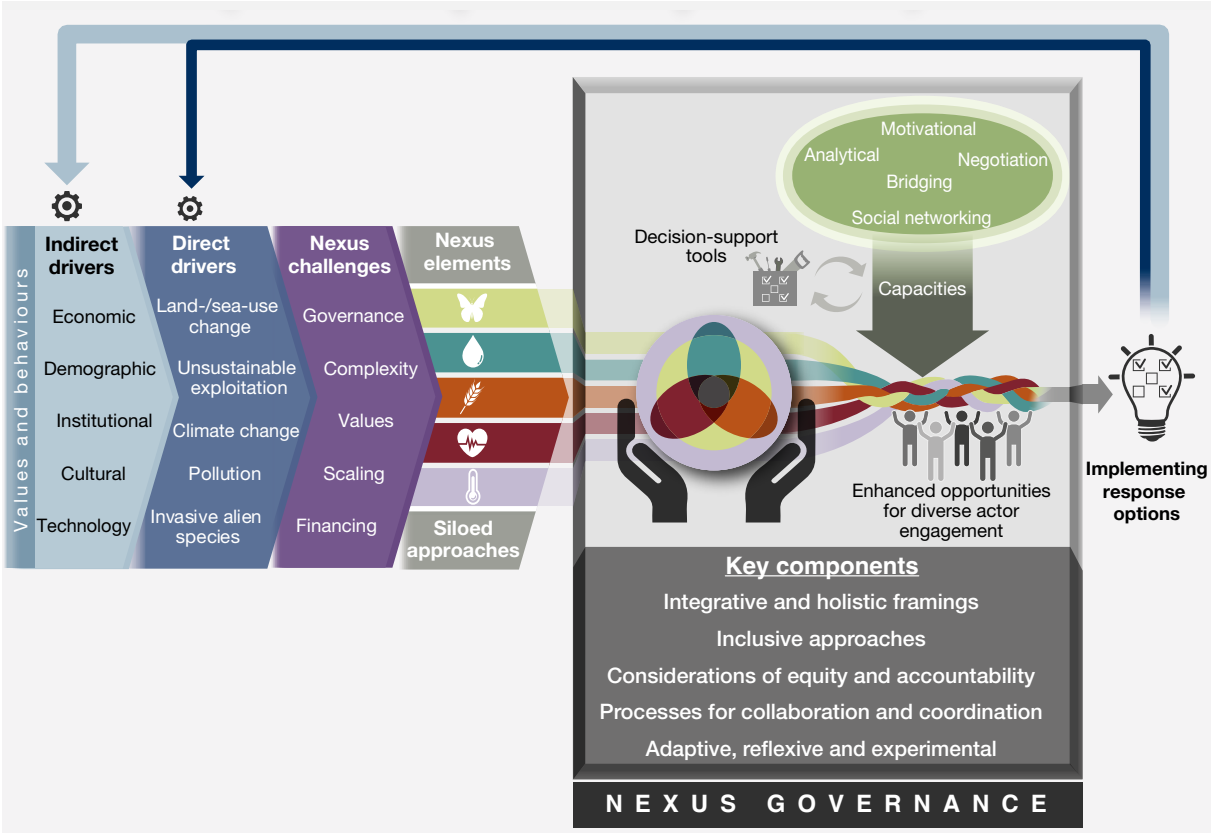

Figure 1 5 **Schematic illustrating nexus governance.**

Indirect and direct drivers create pressures that result in key nexus challenges. As a result, many policies and response options remain siloed. Nexus governance can address both drivers of change and nexus challenges through key components that help create the enabling environment for improving the effectiveness of response options. Nexus governance is explored more deeply in **Chapter 4**.

implementation of effective response options to understand successes and barriers, share what has been learned, normalize these approaches and amplify their impact (Lam *et al.,* 2022; Moore *et al.,* 2015; Tozer *et al.,* 2022). This includes scaling up, which refers to the structural changes required to shift law, policy and institutions towards nexus approaches (Hermans *et al.,* 2016; Moore *et al.,* 2015). Scaling down may also be required where responsibility and accountability is transferred from higher-level actors to address specific challenges and opportunities at a local level through capacity building and the strengthening of local decision-making (Lawford, 2019; Reed & Bruyneel, 2010). Scaling out emphasizes sharing successes and replicating effective response options to increase the uptake of nexus approaches across more scenarios and contexts (Pachico & Fujisaka, 2004; UNESCO, 2021). Scaling deep refers to a focus on the structural and systemic root causes of problems and how potential responses are shaped (Faith, 2021; Lam *et al.,* 2020; Moore *et al.,* 2015). **Chapter 4** provides more examples and explanations of how scaling can help embed nexus approaches in different contexts for more durable solutions.

1.4 LINKS TO IPBES ASSESSMENTS AND OTHER RELEVANT REPORTS

1.4.1 Links to the Transformative Change Assessment

The IPBES Thematic Assessment of the Underlying Causes of Biodiversity Loss and the Determinants of Transformative Change and Options for Achieving the 2050 Vision for Biodiversity (Transformative Change Assessment) aims to offer practical solutions to achieve societal changes for a sustainable use of land, water, energy and materials. The assessment aligns with the 2030 Agenda for Sustainable Development, the 2050 Vision for Biodiversity and is inclusive of IPLC values.

Structural complementarity between the nexus and transformative change assessments was ensured during the scoping processes for both assessments (IPBES,

2021) and by development of the chapter structures of the two assessments:

- Chapter 1 of the Transformative Change Assessment "Transformative change and a sustainable world" corresponds to **Chapters 1** and **2** of the Nexus Assessment in discussing definitions, key concepts, and current challenges and problems.

- Chapter 2 "Visions of a sustainable world – for nature and people", which focuses on qualitative concepts, world views and narratives of the future, complements the Nexus Assessment's **Chapter 3**, which focuses on both qualitative and quantitative scenarios and pathways for achieving sustainable futures that have nexus-wide benefits.

- Chapter 3 "How transformative change occurs" discusses theories and empirical examples of systems changes while Chapter 4 "Overcoming the challenges of achieving transformative change towards a sustainable world" discusses barriers to these transformations. Both Chapters have parallels to **Chapter 4** of the Nexus Assessment, which assesses the concepts, policies, tools and enablers and barriers underpinning nexus governance, as well as **Chapter 6**, which focuses on enablers and barriers in financial systems for supporting biodiversity and the other nexus elements.

- Chapter 5 "Realizing a sustainable world for nature and people: means for transformative strategies, actions and roles for all" focuses on the actors and leverage points by which transformative change can be put into practice. This corresponds to **Chapter 5** in the Nexus Assessment, which takes an actor-oriented approach to understand potential response options that can facilitate movement towards more integrated and sustainable pathways. The Nexus Assessment covers both incremental and transformative approaches in its coverage of response options.

- **Chapter 7** of the Nexus Assessment syntheses these response options for the nexus and serves as a concluding bridge towards how nexus approaches can also help facilitate transformative change. Taking systems approaches are an important condition for transformative change and therefore these aspects of the nexus are covered in the Transformative Change Assessment.

1.4.2 Links to other assessments and reports

Over the last five years various reports and assessments related to biodiversity, water systems, food systems, animal and human health, and climate change have been published. The Nexus Assessment builds upon these publications, which highlight individual crises, by demonstrating their interconnectedness and exploring response options and pathways for human development that collectively address these crises.

1.4.2.1 Biodiversity reports

The relationship between biodiversity and other elements of the nexus is consistently discussed in all IPBES assessments and workshop reports. The assessment report on Pollinators, Pollination and Food Production (Pollination Assessment) (IPBES, 2016) assessed the direct and indirect roles of biodiversity in food production and security, emphasizing the importance of pollinator diversity. Similarly, the genetic diversity of wild and domesticated plants is important for food system resilience to pests, water pressures and climate change (Commission on Genetic Resources for Food and Agriculture, Food and Agriculture Organization of the United Nations, 2010). The IPBES Regional and Global Assessment Reports (IPBES, 2018b, 2018c, 2018d, 2018e, 2019b) assessed past, current and future trends in nature, NCP and quality of life, suggesting various response strategies to address biodiversity loss, many of which intersect with the nexus elements of water, food, health and climate change. The Assessment Report on Land Degradation and Restoration (IPBES, 2018a) warned about the impact of ecosystem degradation on various NCP, including those related to water and food systems, and their impact on quality of life, including human health.

The joint IPBES and IPCC workshop report on Biodiversity and Climate Change (Pörtner *et al.,* 2021) highlighted the need to address both biodiversity loss and climate change simultaneously, given their mutual interlinkages and shared human drivers. The report of the Biodiversity and Pandemics workshop (IPBES, 2020) specifically underscored the link between biodiversity loss and human health, pointing out that human activities drive the emergence of pandemics through mechanisms such as direct land-use change and climate change. Recent reports, such as the IPBES reports on the Sustainable Use of Wild Species (Sustainable Use Assessment) (IPBES, 2022d) and Invasive Alien Species and their Control (Invasive Alien Species Assessment) (IPBES, 2023c) addressed the relationship between biodiversity, NCP, food systems and global change. Finally, the IPBES Values Assessment (IPBES, 2022c) explored how economic and political decisions have historically prioritized certain values of nature, particularly market-based ones, such as those associated with intensive food production, and overlooked the many non-market values associated with NCP, such as climate regulation. The report emphasizes the need to consider the multiple values of nature in policy decisions, which strongly resonates with a nexus approach.

1.4.2.2 Water reports

Numerous water assessments have focused on three nexus-related themes. First, there is a growing need to resolve conflicts over limited and changing freshwater resources for biodiversity and human and food systems (FAO, 2014, 2023; IPBES, 2019b; MacAlister *et al.,* 2023; WHO, 2022). Second, there is a need to effectively govern and manage aquatic ecosystems and natural resources for both humans and nature along with their critical role in climate processes (IPCC, 2019b). Third, there is a need for the identification of overlooked resources, either because they are physically hidden (e.g., groundwater (United Nations, 2022) or undervalued in current global metrics (e.g., inland fisheries (Cooke *et al.,* 2016)). A common message across these assessments is the call for nexus governance and nexus approaches that break down historic silos (United Nations, 2018b). The recent proposed Intergovernmental Science-Policy Platform for Water Sustainability represents a step toward understanding the needs for the water sector, like the role IPBES and IPCC play for biodiversity and climate change, respectively.

1.4.2.3 Food reports

Several global reports have examined food systems and their interactions with various nexus elements. The International Assessment of Agricultural Knowledge, Science and Technology for Development report (IAASTD, 2009), titled "Agriculture at a Crossroads", called for transforming agriculture to achieve sustainable food security. The report criticized large-scale industrial agriculture for its role in biodiversity loss and promoted agroecology as a viable solution to adapt to climate change, provide healthy food and promote biodiversity.

The UN Environment Programme's Green Economy Report (UNEP, 2011) estimated the cost of global agricultural transformation to be approximately a third of the annual agricultural subsidies through to 2050. That same year, the European Union's Standing Committee on Agricultural Research highlighted issues related to natural resource depletion exceeding planetary boundaries and urged a focus on both production and consumption as a key step in the transformation process, i.e., adopting a systems approach (Brunori *et al.,* 2011).

The 2013 UN Conference on Trade and Development report (UNCTAD, 2013) "Wake up before it's too late" advocated for systemic change to an ecological intensification approach, promoting organic, agroecological and other innovative farming practices in the context of trade. In 2016, the UN Environment Programme's report "Linking Food Systems and Natural Resources" (UNEP, 2016) examined the connections between food systems and biodiversity, calling for regenerative agricultural practices. The IPBES report on Land Degradation and Restoration (IPBES, 2018a) emphasized the need for sustainable land management practices to restore degraded lands and improve food security, biodiversity and human health, warning against industrial intensive agricultural practices.

The 2019 IPCC Special Report on Land and Climate Change (IPCC, 2019a) and the FAO report on Climate Change and Food Security (FAO, 2015) assessed the close relationships between food systems and climate change, advocating for changes in both production and consumption to mitigate climate impacts while ensuring food and nutrition security. Similarly, the EAT-Lancet Commission highlighted the interconnectedness of food security, health and climate change urging for transformative changes in food systems (Willett *et al.,* 2019), and advocating for a human-rights approach, in particular the right to well-being, which encompasses the rights of children and the rights of all people to health, adequate food, culture and healthy environments (Swinburn *et al.,* 2019).

1.4.2.4 Health reports

The Global Assessment (IPBES, 2019b) highlighted biodiversity's crucial role for human life, providing essential resources such as food, energy, genetic and medical resources. This report also emphasized nature's contributions to multiple dimensions of human health and well-being, including inspiration and learning, physical and psychological experiences, and supporting identities that are central to quality of life and cultural integrity. The Pollination Assessment (IPBES, 2016) noted the significant contribution of pollinators to healthy human diet and nutrition. Whitmee et al. (2015) highlighted the importance of the integration of social, economic and environmental policies and the creation, synthesis and application of interdisciplinary knowledge for strengthening planetary health.

The IPBES workshop report on Biodiversity and Pandemics (IPBES, 2020) identified the same environmental changes driving biodiversity loss and climate change as the root causes of pandemics. It attributed most pandemics to unsustainable practices such as land-use change, agricultural expansion and intensification, and wildlife trade. The 2022 Lancet Countdown examined climate change's impact on global health and well-being across five key domains, concluding that continued fossil fuel use is exacerbating health issues (Romanello *et al.,* 2022).

In 2023, WHO, WOAH, FAO and UNEP endorsed a new One Health definition (OHHLEP, 2023) acknowledging the interdependence of human, animal, plant and environmental health. The approach can be expanded to contribute to well-being and sustainable development through the interlinkages among the five nexus elements, as emphasized by the CBD's call for a biodiversity-inclusive One Health transition (CBD, 2018, 2020). The Invasive Alien Species

Assessment (IPBES, 2023c) stressed the potential of biological invasions to negatively impact on economies, food and water security, and human health, advocating for interdisciplinary approaches like the One Health framework.

1.4.2.5 Climate change reports

In recent years a multitude of reports and assessments addressing the pressing issue of climate change have been published. The IPCC has played a pivotal role by producing a blend of regular and specialized assessment reports. The regular assessment cycle reports are periodically updated, with the Sixth Assessment Report being the most recent effort of Working Groups I, II, and III (IPCC, 2021, 2022a, 2022b). Working Group I focuses on the assessment of the physical science of climate change (IPCC, 2021) but informs the assessment of adaptation and mitigation policies, which are the focus of Working Groups II and III, respectively. The Working Group II report focuses on the impacts and vulnerabilities of climate change, in addition to evaluating adaptation options, and covers terrestrial, freshwater, oceans and coastal ecosystems and their services, water, food, fibre and other ecosystem products, and health and well-being (IPCC, 2022a). The Working Group III report evaluates the technological, economic and policy interventions available to mitigate climate change, including in the agriculture, forestry and other land uses sector and considering cross-sectoral perspectives (IPCC, 2022b). The integrated approach across the three IPCC working groups is essential for effectively addressing the challenges posed by climate change and promoting sustainable development pathways for the future.

Additionally, special reports within the sixth assessment cycle provided evidence on specific aspects of the climate system, such as the Global Warming of 1.5°C report (IPCC, 2018) and the Special Report on Climate Change and Land (IPCC, 2019a), with the latter particularly focusing on links between climate change and food systems. The Special Report on Ocean and Cryosphere in a Changing Climate (2019) underscored the profound effects of climate change on these vital systems, stressing their role in regulating the Earth's climate. These changes pose significant risks to coastal communities, biodiversity and economies worldwide, highlighting the urgent need for ambitious mitigation and adaptation measures to safeguard vulnerable ecosystems and societies.

In addition, the UN Environment Programme's Emissions Gap Report (UNEP, 2022a) and several national climate assessments (e.g., HM Government, 2022; Reidmiller *et al.,* 2018) have been published, calling for widespread, rapid and systemic transformation to achieve both climate mitigation and adaptation long-term global goals of the Paris Agreement, which resonates with the integrated nature of nexus approaches for achieving a sustainable and resilient future.

1.4.2.6 Cross-cutting reports

Crossing all five nexus elements are the series of Global Environment Outlook (GEO) reports by the UN Environment Programme, which serve as comprehensive and authoritative assessments of the state of the global environment. The most recently published, the sixth Global Environment Outlook (GEO-6) (UNEP, 2019), used the Drivers-Pressures-State-Impact-Response approach to assess the global situation of the state of the environment, its relevant challenges, policies and ways forward. The elements of the nexus were represented in GEO-6 from the *Healthy Planet, Healthy People* perspective with an emphasis on the socio-economic dimensions affecting the state of the global environment (terrestrial and marine biodiversity, freshwater, land and soil). Climate change was listed among the five main drivers affecting the health of the planet, with food (coupled with energy and waste) as the main socio-economic systems with far-reaching environmental effects. The upcoming GEO-7 report will expand on GEO-6 by evaluating the condition and trajectories of the global environment, their repercussions on human welfare, and the attainment of the SDGs for various stakeholders. The report aims to provide insights into the potential environmental and socio-economic consequences of transformative changes in the interdependent systems of food, energy and pollution. The GEO reports also consider the interconnections between different nexus elements and their impact on ecosystems and human well-being.

1.5 STRUCTURE OF THE NEXUS ASSESSMENT

1.5.1 Methods and approaches used in the assessment

In undertaking the Nexus Assessment, chapter author teams have identified, extracted and assessed knowledge from multiple sources, including recent scientific and grey literature, ILK-related information from workshops and contributed materials and input from experts and practitioners. Information and knowledge gathering activities in the assessment included but are not limited to:

- Peer-reviewed literature and other appropriate publications – authors reviewed peer-reviewed scientific publications and other reports and publications from the grey literature up to the cut-off date of 19 November 2023.
- Indigenous and local knowledge – three ILK dialogues workshops were conducted to gather input and

integrate knowledge, values and perspectives from IPLC. These occurred on 29 June to 1 July 2022 (jointly with the Transformative Change Assessment), 17 to 19 January 2023 and 27 to 29 November 2023 and have associated reports (IPBES, 2022a, 2023a, 2023b). Further, an online call for contributions took place from 13 April to 31 May 2023 following the methodological guidance for working with ILK in IPBES.

- Expert assessment – author teams used Delphi-like methods or Multi-Criteria Decision Analysis to prioritize and score response options on different criteria after reviewing relevant literature (see chapter-specific text for more details). Input from experts external to the author team were also integrated through the role of Contributing Authors.

- Government and practitioner perspectives – two external reviews of the entire assessment and three government reviews of the summary for policymakers provided comments.

Chapter authors have undertaken further analyses to meet chapter objectives, with specific details of knowledge gathering and other methodologies used summarized within each Chapter and detailed in related data management reports. Each chapter also reports on knowledge, data and capacity gaps and how these might be filled to progress evidence underpinning nexus approaches. The gaps are summarized across the assessment in **Chapter 7, section 7.4**.

1.5.2 Sequence of chapters

The Nexus Assessment consists of seven chapters that collectively assess and synthesize knowledge on the interlinkages among biodiversity, water, food, health and climate change to inform the development of policies and actions (see **Figure 1.6**).

Chapter 1 defines the scope of the assessment and the key policy-relevant questions it will answer, and how it links to, and adds value to, previous assessments. It also describes the conceptual understanding of the nexus and its relation to the IPBES conceptual framework.

Chapters 2 and **3** focus on past, present and future nexus interlinkages.

- **Chapter 2** provides an overview of the empirical evidence for the current status and past trends in interlinkages between the nexus elements, including how they can be attributed to drivers (both direct and indirect). This involves the identification of which past actions or policies have affected elements of the nexus.

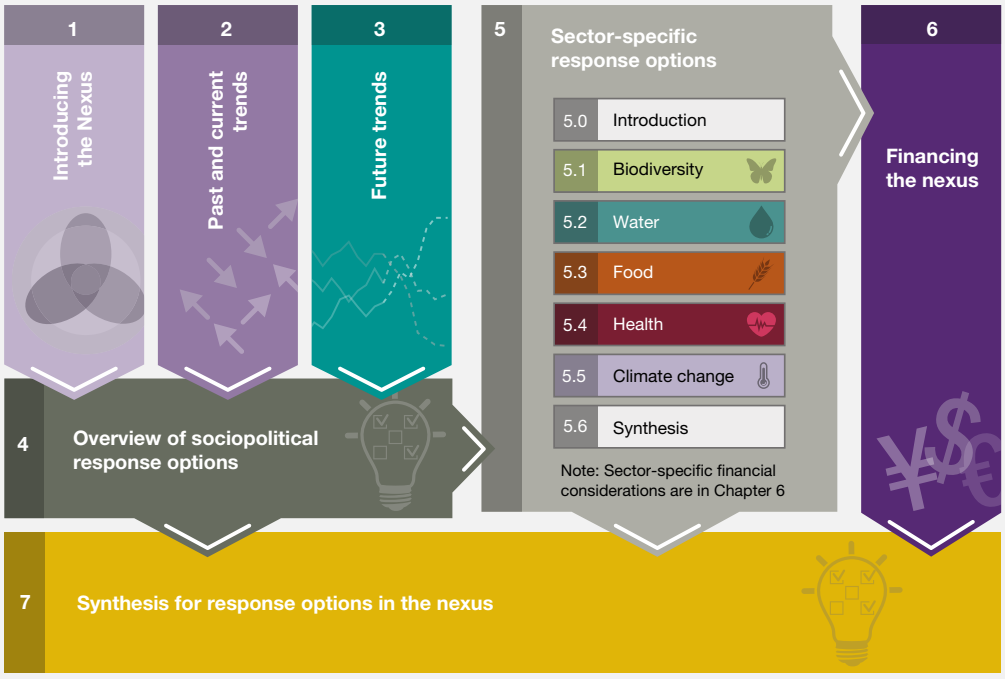

Figure 1 6 **Organization of the Nexus Assessment chapters.**

- **Chapter 3** assesses future trends in the nexus from scenario studies covering all relevant direct and indirect drivers. It includes scenarios that are both positive and negative for biodiversity but has a specific focus on pathways to sustainable futures which demonstrate nexus-wide benefits. It also links scenario outcomes to policy goals, such as the SDGs.

Chapters 4 to **7** focus on response options that address the past and current trends in nexus interactions described in **Chapter 2**, while moving towards the sustainable futures identified in **Chapter 3**.

- **Chapter 4** provides an overview of nexus governance and the theoretical frameworks and tools for evaluating the broad range of policy and sociopolitical options across the nexus that could facilitate and accelerate the transition to sustainable futures. This includes the role of decision support tools and scaling in facilitating nexus thinking across actors and policy sectors.

- **Chapter 5** describes response option in detail by assessing the potential for different sets of actors to create the changes identified in **Chapter 4**. It is structured into sub-sections focused on actors in different policy sectors covering biodiversity **(5.1)**, water **(5.2)**, food **(5.3)**, health **(5.4)** and climate change adaptation and mitigation **(5.5)**. Importantly, each sub-section in **Chapter 5** assesses relevant response options from a holistic multi-sectoral and multi-dimensional viewpoint.

- **Chapter 6** describes the role of actors in the financial sector in the implementation of response options. This includes the governance of financial flows and an assessment of the funding that will be necessary for implementing the response options considered in **Chapter 5**.

Finally, **Chapter 7** integrates the knowledge on response options from **Chapters 4, 5** and **6** in the context of the past, present and future trends in nexus interlinkages described in **Chapters 2** and **3** and the necessity and urgency of action. The synthesis focuses on the interactions and relationships between multiple actors at all levels and across sectors, presented in the form of a “road map for nexus action”. **Chapter 7** also includes a summary of capacity, knowledge and technology gaps.

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