

What do we know about **THE FUTURE OF THE ENVIRONMENT AND BIODIVERSITY IN RELATION TO FOOD SYSTEMS?**

Elisabetta Gotor (Bioversity International) and Cargele Masso (CGIAR)

Key messages

- The environment's proper functioning is essential for a better life on Earth, including maintaining, enhancing, and restoring biodiversity and ecosystem services. While the environment is driven by external factors and shocks as well as interventions within the global food system, it simultaneously drives the overall health and stability of the planet. This relationship involves complex interactions and tipping points, which foresight research needs to capture in analyzing alternative future pathways for food system transformation.
- A sustainable and resilient environment requires holistic approaches, strategies, and policies to address environmental stresses and promote conservation, regeneration, and coexistence with nature. These include practices that respect ecological boundaries, reduce resource consumption and conflict, foster biodiversity, and enhance ecosystem recovery and adaptability. Foresight research is essential to help decision-makers understand synergies and trade-offs between long-term public goods benefits and short-term private costs from resource use and management.
- Addressing food systems challenges – including root causes of environmental degradation and biodiversity loss – requires sustainable land and soil management, conservation efforts, and food production practices, in addition to economic viability and social inclusion. Foresight analysis can help policymakers, communities, and industries make informed decisions and prioritize and deploy effective and holistic strategies at the biodiversity-climate-society nexus.

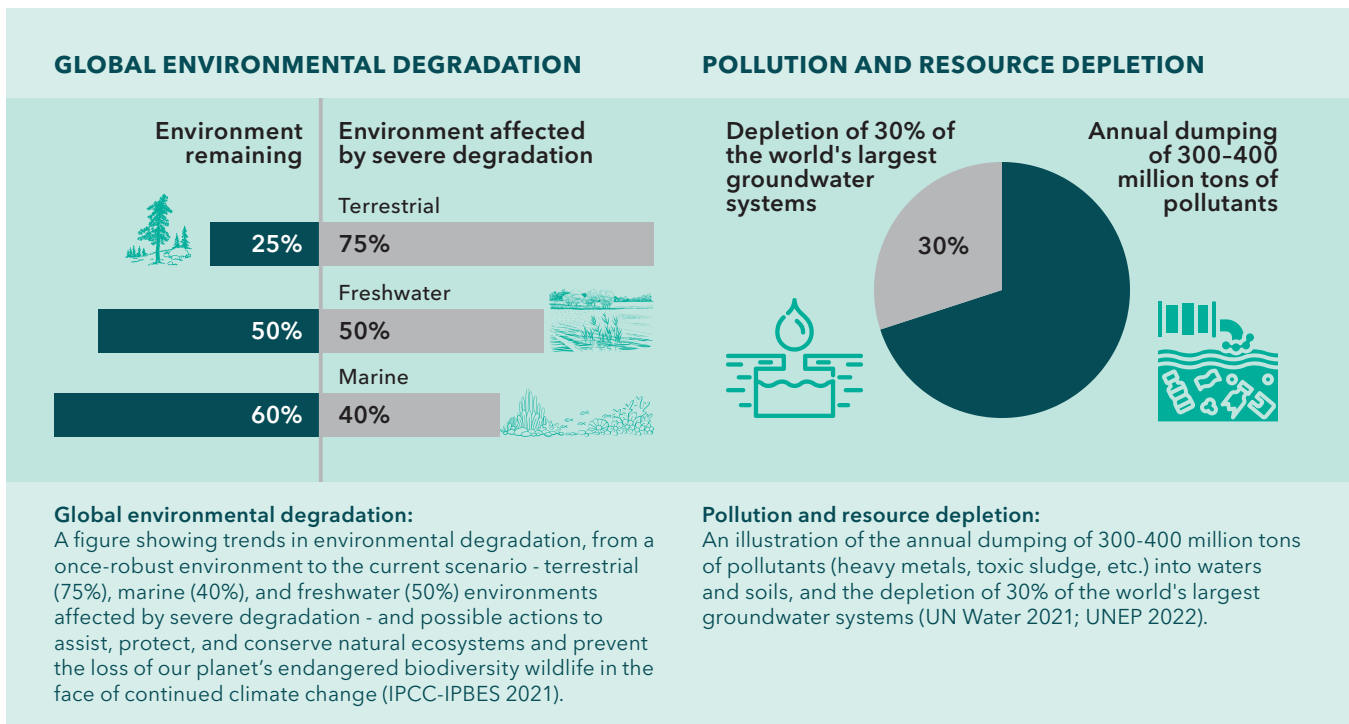
RECENT TRENDS AND CHALLENGES

Responsible natural resource management is urgently needed. The global food system is currently responsible for 21-37 percent of total net greenhouse gas emissions (Olivier et al. 2018), contributing to global warming exceeding 1°C. Projections suggest that by 2050, agricultural land will expand by 400 million hectares, reducing forested and natural land. This loss threatens

biodiversity and essential ecosystem services like carbon storage and water regulation provided by forests (IPCC 2021; FAO 2022; FOLU 2019). Figure 1 shows current environmental degradation trends that require action to transition to biodiversity and ecosystem function gains.

Over the past 50 years, population growth – coupled with a 15 percent per-person increase in material consumption since 1980 – has driven alarming surges in biomass extraction, fossil fuel consumption, and mineral and

FIGURE 1 Current environmental degradation trends



GLOBAL MULTI-SECTOR RISKS



Global mean temperature rises from 1.5°C to 3°C

Global multi-sector risks:

A representation of the increase in multi-sector risks as global mean temperature rises from 1.5°C to 3°C, with a breakdown of impacts by region, especially focusing on Africa and Asia (Byers et al. 2018).

SOIL EROSION PROJECTIONS



Projected 13% to 22.5% increase in soil erosion in the EU and UK by 2050

Soil erosion projections:

A representation of the projected 13% to 22.5% increase in soil erosion in the EU and UK by 2050, with emphasis on rainfall erosivity (Panagos et al. 2021).

LAND USE CHANGES BY 2050



A projected expansion of agricultural land by 400 million hectares

Land use changes by 2050:

A projected expansion of agricultural land by 400 million hectares and its effects on forests and biodiversity (FAO 2022; IPCC-IPBES 2021).

metal exploitation (IPCC-IPBES 2021). Depletion of the world's largest groundwater systems has reached about 30 percent, and over 80 percent of global wastewater is discharged untreated, exacerbating environmental pollution. Simultaneously, massive amounts of heavy metals, solvents, toxic sludge, and other pollutants – 300 million to 400 million tons annually – are dumped into the world's waters and soils. Coastal ecosystems suffer from extremely low oxygen levels, causing severe ecological degradation in terrestrial and marine environments (UN Water 2021; UNEP 2022).

These environmental impacts are widespread (Figure 1), with 75 percent of the terrestrial environment, 40 percent of the marine environment, and 50 percent of streams experiencing severe degradation, resulting in significant losses of wild animal biomass and plant life (IPCC-IPBES 2021; Tudge et al. 2021). Preserving genetic diversity within crops, animals, and fisheries is crucial for resilient food systems, particularly in terms of pest and disease resistance (FAO 2010, 2020). Alarming, global pollinator declines threaten the reliability of pollinator-dependent crop yields, making them less dependable than pollinator-independent crops (Smith et al. 2022). Similar challenges are reported in fisheries, such as the loss of fish diversity in Lake Victoria as a consequence of the introduction of the invasive Nile perch, as well as expansion of invasive plants in terrestrial ecosystems.

LATEST FORESIGHT RESEARCH

Projections for 2050 indicate a high confidence in increased population and income, changes in consumption patterns, and heightened demand for food, feed, and water (van Dijk et al. 2021; IPCC 2019). Demographic and economic factors, dietary shifts (for example, to plant-based diets in affluent countries), innovation, trade, and governance will be key drivers of these changes. While the global goal is to achieve a more sustainable and resilient environment, the diversity in environmental characteristics, motivations, interests, preferences, and values across different regions necessitates localized solutions (Townsend et al. 2020). Therefore, transitioning to a multi-actor and multiscale governance model is deemed vital for creating a sustainable future that addresses the unique challenges and opportunities in different local contexts (Wynberg et al. 2023).

Recent foresight research has highlighted critical challenges, offering insights into water scarcity, "hotspots" across sectors, the delicate balance between population and agricultural productivity, and the environmental impacts of agricultural practices.

Water scarcity, identified as a major concern for specific regions in the future, presents a complex problem with large uncertainties. In their study, Greve et al. (2018) find that median water scarcity and the associated range of uncertainty are generally on the increase worldwide, including for many major river basins. They propose a decision-making framework that identifies four representative clusters of specific water policy challenges and needs. Huang et al. (2021) propose a potential solution through adaptive inner-basin water allocation measures, demonstrating that such interventions could lead to a 12 percent decrease in the global population exposed to water scarcity by 2050. However, they note that adaptive measures may intensify agricultural water scarcity in the upstream area of the basins.

Byers et al. (2018) broaden this perspective, assessing the interactions between climate change risks and socioeconomic development by calculating 14 impact indicators across water, energy, and land sectors. Their study finds that global exposure to multisector risks doubles when the global mean temperature (GMT) increases from 1.5°C to 2°C, doubles again with a 3°C GMT increase, and is approximately six times higher in scenarios characterized by high poverty and inequality. While 85–95 percent of global exposure to multisector risks is concentrated in Asian and African regions, these regions also account for 91–98 percent of the exposed and vulnerable population (depending on the SSP (shared socioeconomic pathway)/GMT combination), with approximately one-half of this population located in South Asia. In higher warming scenarios, a growing proportion of the exposed and vulnerable population is found in African regions. This proportion ranges from 7–17 percent at 1.5°C, doubles to 14–30 percent at 2°C, and doubles again to 27–51 percent at 3°C. Therefore, focusing on reducing poverty, mitigating emissions, promoting adaptation, and achieving targets in the water, energy, and land sectors have the potential to significantly reduce multisector climate risks for vulnerable populations.

A critical aspect addressed by a recent multimodel analysis emphasizes that the balance between changes in population and agricultural productivity is pivotal in

determining the pressure for future expansion of crop- and pastureland (Stehfest et al. 2019). However, the authors highlight that land use regulations are under-represented in models and should receive more attention in future assessments, while modeling is critical to inform effective land use policies and planning. Similarly, Springmann et al. (2018) explore the environmental impacts of increases in agricultural yields and how changes in food management, technology, and transition to healthy diets may help mitigate these impacts. They estimate that implementing these measures – especially those targeting food loss and waste – can reduce environmental pressures on the food system by 25–45 percent compared to the 2050 baseline projection in medium-ambition scenarios, and by 30–60 percent in high-ambition scenarios.

Bergstrom et al. (2021) contribute valuable insights by examining the current state and trajectories of 19 ecosystems across diverse latitudes and environments. Their “3As” framework – awareness, anticipation, and action – guides decision-making in the face of chronic “pressures” and acute “pulses” affecting terrestrial and marine ecosystems collapse (for example, loss of services and species). Key recommended policy actions include aligning global climate policies with Paris Agreement targets, enhancing protected area management, incentivizing sustainable land use, adopting adaptive management, integrating Indigenous knowledge, boosting research funding, and fostering international collaboration.

Finally, Panagos et al. (2021) shift the focus to soil erosion by water within the agricultural areas of the European Union and the United Kingdom, projecting a significant increase of 13.0–22.5 percent by 2050 due to a combination of climate change and land use patterns. While a shift to more pastureland could potentially reduce erosion by 3 percent, the projected increases in rainfall erosivity are expected to counteract this effect, leading to overall increases in soil erosion. The study suggests that the most effective strategy is to tie the EU Common Agricultural Policy incentives to environmental performance in a targeted manner. For optimal results, soil conservation measures, such as cover crops and reduced tillage, should be applied to at least 50 percent of erosion hotspots to mitigate both water and wind erosion.

Collectively, these studies paint a comprehensive picture of the challenges we face, but they also offer promising solutions. Proactive policy and investment decisions today

can play a crucial role in mitigating resource depletion’s impacts and contributing to a more resilient environment. The importance of adaptive and forward-looking strategies in resource management emerges as a recurring theme, underscoring the need for a holistic and proactive approach to address these complex environmental issues on a global scale. In the current climate crisis, models to help decision-makers optimize the synergies among the environmental, agricultural, economic, and social inclusion dimensions of food systems are required more than ever.

KEY GAPS AND OPPORTUNITIES FOR FORESIGHT RESEARCH

Despite significant advances in foresight research on environmental sustainability, several key gaps and questions remain.

First, foresight analysis is needed to identify sustainable practices for land, soil, and water management, especially in developing countries and regions where resource pressures are substantial. However, these practices also remain critical in selected food production systems of developed countries.

Second, both understanding the link between ecosystem functions and services and optimizing trade-offs across sociocultural systems, food systems, and land and water systems are crucial for building resilience (Karki et al. 2018; Panyadee et al. 2018; Rahman et al. 2011; Sharma et al. 2018). In the past, society focused more on provisioning services (that is, increasing agricultural production) at the expense of regulating cultural and supporting services. In the future, there is a need for understanding ecosystem linkages (Walker et al. 2010) and for optimization across the nexus between sociocultural factors, pressures for economic growth, and food, land, soil, and water systems.

Third, future research should focus on enhancing productivity to meet the needs of the growing global population while effectively managing competition for land and water. The impact of both short- and long-term system shocks on the ability to adapt to environmental changes also requires thorough investigation (Benton

et al. 2018). The development of early warning systems and recovery measures is essential for effective adaptive strategies (Kramer et al. 2019; Nkiaka et al. 2019; Street et al. 2019).

Finally, understanding the local nuances and factors that influence sustainable practices is critical, necessitating a transition to a contextualized multi-actor and multiscale governance model (Wynberg et al. 2023). Holistically addressing these gaps and questions will contribute to a more comprehensive understanding of the challenges and opportunities for achieving a sustainable and resilient environment and food system.

This chapter was supported by the CGIAR Research Initiative on Foresight and the CGIAR Science Program on Policy Innovations. We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund.

The authors of this chapter are **Elisabetta Gotor**, a Principal Scientist and Lead of the Performance, Innovation and Strategic Analysis for Impact Program at Bioversity International; and **Cargele Masso**, with CGIAR, based at the International Livestock Research Institute (ILRI) in Nairobi, Kenya.

The authors would like to thank Chiara Livorno, currently a PhD candidate in Development Economics and Local Systems with the University of Florence, for her contribution to the literature review.

Related chapters on the future of food system drivers and impacts, regional and national perspectives, food commodities, and foresight tools are available in our [Table of Contents](#).

Citation: Gotor, E., and C. Masso. 2025. "What Do We Know About the Future of the Environment and Biodiversity in Relation to Food Systems?" In *What Do We Know About the Future of Food Systems?*, eds. K. Wiebe and E. Gotor, Chapter 5. Washington, DC: IFPRI. <https://hdl.handle.net/10568/175019>

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