NATURE- BASED SOLUTIONS FOR HEALTH:

- Leveraging biodiversity to create health-promoting environments

World Health Organization

IUCN

Acknowledgements

This report was written by Cristina Romanelli (WHO-IUCN Expert Working Group on Biodiversity, Climate change, One Health, WHO Department of Environment, Climate Change and Health) and Alice Taberner (FEBA/IUCN). Contributing authors are: Kobie Brand, Christopher Chandler, Ingrid Coetzee, Omnia el Omrani, Mikhael de Souza, Anthea Dee, Ilaria Firmian, Emily Goodwin, Alison Haugh, Jo Hopkins, Diego Jara, Jonathan Jennings, Naomie Kayitesi, Chetan Kumar, Javier Lastra, Melissa Lim, Catherine Machalaba, Heather Magnan, Marina Maiero, Katherine Poe, Pragyan Pokhrel, Shreya Utkarsh, Michael Van der Werff, and Mariam Wallet Aboubakrine.

WHO expresses its deepest gratitude to Members of the WHO-IUCN Expert Working Group on Biodiversity, Climate change, One Health and Nature-based Solutions who have provided valuable guidance, case studies and lended their time and expertise throughout the development of the report. Members of the WHO-IUCN Expert Working Group on Biodiversity, Climate change, One Health and Nature-based Solutions are: Diarmid Campbell-Lendrum, Marina Maiero, Maria Neira and Cristina Romanelli (WHO Department of Environment, Climate and Health), Ali Raza Rizvi and Kevin Smith (IUCN), Gregory Davies-Jones (IUCN/FEBA), Franck Berthe (World Bank), Kobie Brand (ICLEI), Martin Breed (University of Adelaide), Ingrid Coetzee (ICLEI), David Cooper (CBD), Denise Costa Coitinho Delmuè (UNSCN/ UN Nutrition) Francois Dias (WOAH), Christopher Golden (Harvard School of Public Health), Andy Haines (LSHTM), Irene Hoffman (FAO), Danny Hunter (Biodiversity International), Jonathan Jennings (HiH), Catherine Machalaba (One Health High Level Expert Panel), Scott Newman (FAO), Stineke Oenema (UNSCN/UN Nutrition), Hindou Oumarou Ibrahim (UNPFII), Unnikrishnan Payyappallimana (UNU IAS), Marianela Araya-Quesada (CBD), Doreen Robinson (UNEP), Suneetha Subramanian (UNU IAS), Juan Vasquez (CITES), Neil Vora (Conservation International), Mariam Wallet Aboubakrine (Ărramăt), Chadia Wannous (WOAH), Cristina Zucca (UNEP).

For additional review comments we also thank

Anu Adhikari, Zornitza Aguilar, Selena Ahmed, Andy Bastable, Martin Breed, Daniel Buss, Gregory Davies-Jones, John de la Parra, Mouhamadou Anoard Fall, Andy Haines, Skylar Hopkins, Charles Karangwa**,** Conor Kretsch, Rohini Mukherjee, Renata Muylaert, Rodrigo Paillalef, Unnikrishnan Payyappallimana, Lisa Pharoah**,** Karla Sofia Pita, Paula Prist, Peter Stoett, Suneetha Subramanian, Theadora Swift-Koller.

We also thank numerous individuals also involved at various stages of development of the report.
Pipit Aneaknithi, Fabrice De Clerck, Carine Cruz-Payan, Alexandra Egorova, Emily Goodwin, Delilah Griswold, Daniel Hougendobler, Rayan Kassem, Shyama Kuruvilla, Hongying Li, Alexandra Payne, Elizabeth Pleuss, Loreta Rufo, and members of the IUCN Health and Well-being Specialist Group who submitted case studies: Marco Garrido Cumbrera, Denise Hewlett, Fabio T. Lazzerini, Robyn Molsher Special thanks also to all panellists and participants of the early WHO consultations with Indigenous Peoples, chaired by Mukaro Borero

and with youth, led by Omnia el Omrani and Rayan Kassem. This report was developed with Indigenous Peoples organizations, Ărramăt and Pimachiowin Aki, who were involved in and actively contributed to the writing of this report, and benefited from the review of Rodrigo Paillalef (UNPFII).

The report was developed under the overall guidance of Maria Neira (Director, Environment, Climate Change and Health, WHO) and Ali Raza Rizvi (Global Head, Climate Change and Energy Transition, IUCN).

We also thank Friends of Ecosystem-based Adaptation (FEBA) and the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV).

Finally, we express our sincere apologies to any individuals or agencies who were unintentionally omitted.

Cover Photo Credits:
(from top left to bottom right) 1. Graeme Williams 2. Biodiversity International/C. Zanzaniani. 3. Luiz Guimaraes 4. Mega Casearia 5. Sandy Leo 6. Akhlas Uddin, Biodiversity International 7. Malorie Hibon 8. Minc 9. Alex Hudson 10. Malorie Hibon 11. Biodiversity International/Biodiversity for Food and Nutrition Project 12. Saga Areng 13. A. Drucker, Biodiversity International 14. Firdaus Roslan 15. Marion Botella 16. Simon Fanger

<u>This is an unedited, pre-print version. Do not quote or cite.</u>

Table of Contents

Acronyms and Abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
AFROHUN	Africa One Health University Network
AMR	Antimicrobial Resistance
ATACH	Alliance for Transformative Action on Climate and Health
BC	British Columbia
BMP	Best Management Practice
BMUV	German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety & Consumer Protection.
CBD	Convention on Biological Diversity
CCA	Climate Change Adaptation
CCM	Connecting Climate Minds
CIAT	International Center for Tropical Agriculture
COMFAS	Coalition of Municipal Fisherfolk Associations
COP	Conference of the Parties
CRP	C- Reactive Protein
DRC	Democratic Republic of the Congo
DRR	Disaster Risk Reduction
Eco- DRR	Ecosystem-based Disaster Risk Reduction
EPIC	Ecosystems Protecting Infrastructure and Communities
GBF	Global Biodiversity Framework
GDP	Gross Domestic Product
GEF	Global Environment Facility
FAO	Food and Agriculture Organization of the United Nations
FEBA	Friends of Ecosystem-based Adaptation (EbA)
FMO	Dutch Development Bank
FONAFIFO	Fondo Nacional de Financiamiento Forestal
FPIC	Free Prior and Informed Consent
HIH	Health In Harmony
IFAD	International Fund for Agricultural Development
IKI	International Climate Initiative
IPAF	Indigenous Peoples' Assistance Facility
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change

IUCN	International Union for Conservation of Nature
KMGBF	Kunming-Montreal Global Biodiversity Framework
KPI	Key Performance Indicators
LAC	Latin America and the Caribbean
LiDAR	Light Detection and Ranging
M&E	Monitoring & Evaluation
MELT	Mentored Experiential Learning and Training
NbS	Nature-based Solutions
NC	Nature Connectedness
NCD	Non-Communicable Diseases
NDC	Nationally Determined Contributions
NGO	Non- Governmental Organization
NPR	Nepalese Rupee
NDVI	Normalized Difference Vegetation
NYCDEP	New York City Department of Environmental Protection
OH	One Health
OHHLEP	One Health High Level Expert Panel
PAHO	Pan American Health Organization
PES	Payment for Ecosystem Services
PLUS	Stabilising Land Use Project
PTFI	Periodic Table of Food Initiative
PTSD	Post Traumatic Stress Disorder
SARS	Severe Acute Respiratory Syndrome
SCNL	Society for the Conservation of Nature of Liberia
SDG	Sustainable Development Goal
SIDS	Small Island Developing State
TWT	Tiger Worm Toilet
UHC	Universal Health Coverage
UHI	Urban Heat Island
UN	United Nations
UN DESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNDRIP	United Nations Declaration on the Rights of Indigenous People
UN DRR	United Nations Office for Disaster Risk Reduction
UNEA	United Nations Environment Assembly
UNEP	United Nations Environmental Programme

UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly
UN- HABITAT	United Nations Human Settlements Programme
US	United States
USAID	United States Agency for International Development
USD	United States Dollar
WAC	Watershed Agricultural Council
WAP	Watershed Agricultural Program
WASH	Water, Sanitation and Hygiene
WFP	Whole Farm Plan
WHO	World Health Organization
WOAH	World Organisation for Animal Health
WWF	World Wildlife Fund for Nature

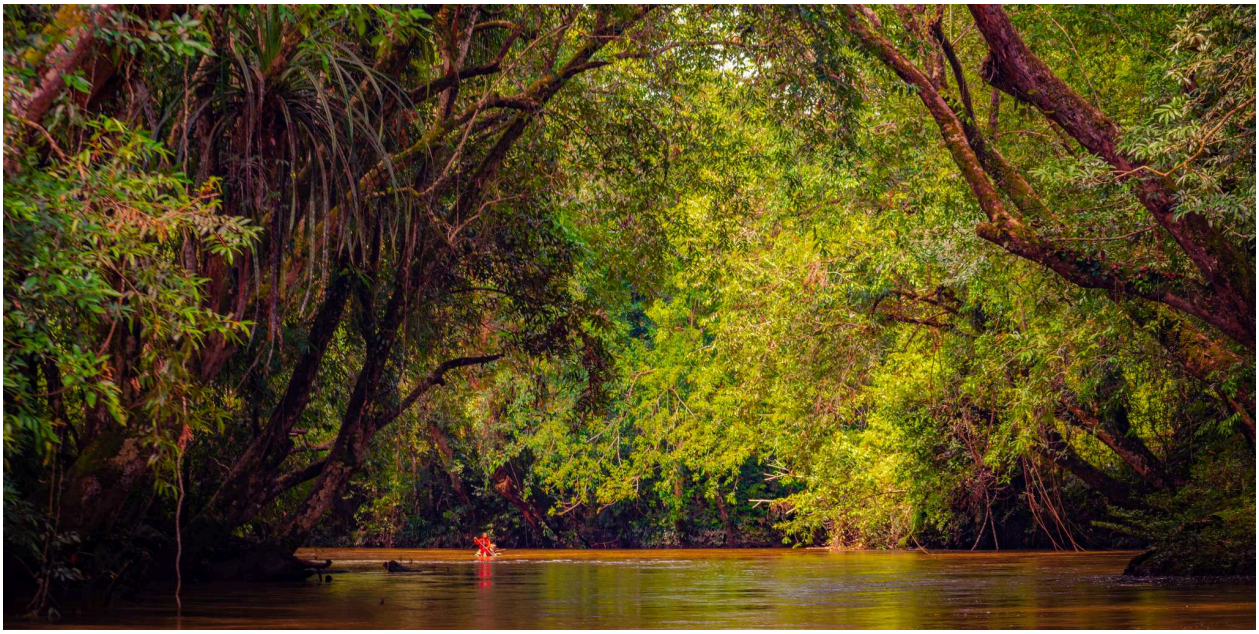


Photo Credit: Sandy Leo

Introduction: An Evolving Political Landscape

The world is confronting an unprecedented convergence of environmental and societal crises that threaten the health and well-being of humanity. Biodiversity loss, climate change, and pollution — interconnected forces driving what is now recognized as a planetary emergency — are pushing Earth's natural systems beyond critical tipping points, destabilizing the ecosystems that sustain life.[1] Recent assessments reveal that six of nine planetary boundaries—including those for climate change, biodiversity loss, land-system change, freshwater use, and pollution from chemicals and nutrient runoff—have been breached, amplifying immediate and long-term health risks, exacerbating climate-related weather extremes, and undermining ecosystem resilience.[2] These environmental crises are further compounded by other pressures such as violent conflict, economic instability, displacement, and social inequalities, which together create a perfect storm of vulnerability and risk for people and planet.[3] These intersecting forces result in cascading impacts on ecosystems and human health, manifesting

[1] Rockström, J., et al. (2023): Safe and Just Earth System Boundaries. Nature 619:102-111.

[2] Rockström, J., et al. (2023): Safe and Just Earth System Boundaries. Nature 619:102-111.

[3] Stoett, P., Daszak, P., Romanelli, C., Machalaba, C., Behringer, R., Chalk, F., et al. (2016). Avoiding Catastrophes: Seeking Synergies among The Public Health, Environmental Protection, and Human Security Sectors. The Lancet Global Health, 4(10), e680-e681.

as increased disease burdens, rising rates of non-communicable and infectious diseases, worsening food insecurity, shrinking access to safe water, deteriorating air quality, and degraded soil health.[4][5][6]

As we continue to transgress these planetary boundaries, the most devastating effects are borne by the world's most vulnerable populations— including women, Indigenous Peoples, marginalized communities, children, refugees and displaced peoples, and those in low- and middle-income countries — exposing the deep inequities embedded in global health and environmental governance. The urgency of these challenges demands integrated, transformative action that builds a healthier and more resilient future for all, while ensuring that efforts to restore ecosystem and human health also promote equity and justice.[7][8]

In response to these growing challenges, global policy developments have addressed the escalating threats posed by biodiversity loss, climate change, and other drivers of global environmental change through a rights-based approach, building upon a steady progression of global commitments at the intersection of human rights and the sustainable management of natural resources. For example, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation (Nagoya Protocol), adopted in 2010, reinforced the global commitment to equity by providing that Indigenous Peoples and local communities should benefit from the use of genetic resources, including those linked to health-related innovations. However, implementation and compliance efforts have generally been uneven and slow to materialize.

In July 2022, the United Nations General Assembly (UNGA) adopted a landmark resolution affirming the universal human right to a clean, healthy, and sustainable environment.[9] This resolution calls for urgent, transformative actions to combat environmental degradation—targeting its key drivers, including climate change, biodiversity loss, and pollution, which combine to threaten human rights, ecosystem and human health. The resolution urges states and global actors to implement inclusive policies that prioritize environmental protection as a means to uphold these fundamental human rights, underscoring the need for equitable,

---

[4] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review.

[5] United Nations Convention to Combat Desertification (2022). Global Land Outlook: Second Edition. Land Restoration for Recovery and Resilience.

[6] Food and Agriculture Organization of the United Nations, United Nations Environment Programme. (2021): Global Assessment of Soil Pollution: A Hidden Reality. Rome.

[7] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review.

[8] Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., de Souza Dias, B. F., et al. (2015). Safeguarding Human Health in the Anthropocene Epoch: Report of The Rockefeller Foundation–Lancet Commission on Planetary Health. The Lancet, 386(10007), 1973-2028.

[9] United Nations General Assembly (2022). Resolution Adopted by the General Assembly on 28 July 2022: The Human Right to a Clean, Healthy and Sustainable Environment. A/RES/76/300.

cross-sectoral strategies that support Health for All and leave no one behind.[10] In the same year, other resolutions adopted by the United Nations Environment Assembly (UNEA) reaffirmed the need for integrated approaches to tackle the health impacts of biodiversity loss, pollution, and environmental degradation, and for the first time, a common definition of Nature-Based Solutions (NbS) was adopted in resolution UNEP/EA.5/Res.5.[11] Complementing this, the international community also resolved to strengthen biodiversity and health linkages by calling for One Health strategies to prevent future health threats linked to environmental crises.[12] These developments provided continuity and coherence with several other resolutions previously adopted by the Conferences of the Parties to the CBD, which also called for a strengthening of the One Health approach.[13]

Building on this momentum, the Kunming-Montreal Global Biodiversity Framework (KMGBF), adopted in December 2022, recognizes the interconnections between biodiversity and health, urging its national implementation to consider the One Health approach and other holistic, evidence-based strategies. The Framework calls for urgent, cross-sectoral collaboration to reduce pressures on biodiversity, through approaches that mitigate health risks such as zoonotic diseases, and ensure equitable access to biodiversity-related health technologies.[14] The Framework also emphasizes biodiversity's role in supporting ecosystem resilience and underscores the importance of integrating biodiversity conservation with climate action, highlighting the need for healthy ecosystems to safeguard both human and planetary health.

---

[10] Universal Health Coverage (UHC) is a global health priority outlined by WHO, aiming to ensure that all individuals and communities receive the health services they need without suffering financial hardship. UHC is fundamental to achieving Health for All and is rooted in the principles of equity, access to quality services, and financial protection, as enshrined in the 1978 Alma-Ata Declaration and reaffirmed in subsequent global health initiatives, including WHO's advocacy for health promotion and primary health care.
See: World Health Organization. (2021). Universal Health Coverage (UHC) and the 2030 Agenda for Sustainable Development. Retrieved from https://www.who.int/health-topics/universal-health-coverage.

[11] In line with the resolution, NbS was defined as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits[...]".

[12] See UNEP/EA.5/Res.6 " Biodiversity and Health".

[13] See for example: CBD COP 12 Decision XII/21 (2014), Biodiversity and Human Health. This decision emphasizes the integration of biodiversity and health, particularly through the One Health approach.
Available from: https://www.cbd.int/doc/decisions/cop-12/cop-12-dec-21-en.pdf
See also, CBD COP 14 Decision 14/4 (2018) "Health and Biodiversity". This decision adopted the biodiversity-inclusive One Health guidance, encouraging countries to integrate One Health and other holistic approaches into biodiversity and health policies. Available from: https://www.cbd.int/doc/decisions/cop-14/cop-14-dec-04-en.pdf
Moreover, in 2022 CBD COP 15 Decision 15/4 "Health and Biodiversity" further calls for a strengthening the role of One Health in biodiversity conservation and health policies, and calls for the finalization of a Global Action Plan on biodiversity and health, to be considered for adoption at CBD COP 16. Available from: https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

[14] Convention on Biological Diversity (CBD) (2023): Kunming-Montreal Global Biodiversity Framework. Available from: https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

These developments build upon long-standing global health promotion efforts. Notably, the WHO's 1978 Alma-Ata Declaration[15] was a milestone that positioned health as a fundamental human right, emphasizing equity and social justice in global health efforts. Building on this, the WHO's Ottawa Charter for health promotion[16] in 1986 called for health promotion strategies that prioritize environments conducive to well-being. The Charter highlighted the role of natural environments in fostering public health, stressing the importance of healthy environments as part of a comprehensive health strategy. Together, these milestones laid the foundations for global commitments to integrate health and environmental protection, but persistently uneven implementation across regions, coupled with a growing planetary emergency, reflects the urgent need to scale up ambition and enhance global solidarity to address escalating and concurrent environmental and health crises.

Efforts to address the health impacts of climate change within broader environmental and climate policy frameworks have also increased in recent years. Adopted in 2019, the WHO's Global Strategy on Health, Environment, and Climate Change aims to address environmental health threats through proactive prevention measures, integrating health considerations into all policy decisions and strengthening disease prevention and health promotion efforts. At UNFCCC COP 26 in 2021, health gained attention with initiatives calling for climate-resilient health systems and greater recognition of the health co-benefits of climate action.[17][18][19] The momentum continued in 2023 with the adoption of the UAE Climate and Health Declaration which emphasized the integration of health into climate policy and embedding resilience into health systems.[20]

In May 2024, the Seventy-seventh World Health Assembly (WHA) adopted a key resolution on climate and health, calling for urgent action to build climate-resilient health systems. This resolution advocates for the integration of One Health principles into health system adaptation and mitigation strategies to address the health impacts of climate change, including extreme weather events, on biodiversity, emerging infectious diseases and food-, water- and vector-borne diseases. It also highlights the need for coordinated, cross-sectoral efforts to

---

[15] Declaration of Alma Ata, available from https://cdn.who.int/media/docs/default-source/documents/almaata-declaration-en.pdf?sfvrsn=7b3c2167_2

[16] Ottawa Charter for Health Promotion, available from: https://www.who.int/publications/i/item/WH-1987

[17] See for example World Health Organization. (2021). The Health Argument for Climate Action. Available at: www.who.int/publications/i/item/cop26-special-report-on-climate-change-and-health.

[18] The Alliance for Transformative Action on Climate and Health (ATACH), launched at COP 26, supports the development of climate-resilient and low-carbon health systems. This was a significant step in promoting climate-resilient health systems, aligning health and climate goals.See for example: World Health Organization. (2021). WHO-led Alliance for Transformative Action on Climate and Health (ATACH). Available at: www.who.int/news/item/09-11-2021-who-led-initiative-launched-at-cop26-to-strengthen-climate-resilient-health-systems.

[19]The following year, the COP 27 "Climate Action and Nutrition (I-CAN)" initiative, institutionalized at COP 26, brought further attention to the link between climate change, health, and nutrition. This initiative acknowledges the need for policies that address both climate and nutrition, highlighting how climate-resilient food systems can deliver health co-benefits. World Health Organization. (2022). Climate Action and Nutrition (I-CAN) Initiative. Available at: www.who.int/initiatives/cop27-climate-action-and-nutrition.

[20] United Arab Emirates. (2023). UAE Climate and Health Declaration. Adopted at the Twenty-Eighth Conference of the Parties (COP28) to the United Nations Framework Convention on Climate Change (UNFCCC), Dubai, United Arab Emirates.

strengthen health systems' capacity to withstand environmental shocks and stresses while ensuring that health systems contribute to global climate action.[21] Additionally, the WHO General Programme of Work 2025–2028 further emphasizes the importance of addressing environmental determinants of health and ensuring equitable access to healthcare, particularly for the most vulnerable populations. It recognizes climate change as a major threat to global public health, highlighting the need to integrate climate resilience and sustainability into health systems to protect the most vulnerable populations and address the root causes of ill health.[22]

Safeguarding health, biodiversity and ecosystems requires dismantling barriers between public health, environmental conservation, agriculture, urban planning, and other sectors. Global frameworks such as the KMGBF and the Paris Climate Agreement emphasize the interdependent themes of biodiversity conservation, ecosystem restoration, and climate action as essential for sustaining both a healthy environment and human health. These agreements call for coordinated efforts to reduce pressures on ecosystems while ensuring long-term social and ecological resilience.

Photo Credit: Biodiversity International/L. De Lapeyre de Bellaire

[21] World Health Assembly. (2024). Resolution WHA77.14: Climate Change and Health. Seventy-seventh World Health Assembly, Geneva, 2024. Retrieved from https://apps.who.int/gb/ebwha/pdf_files/WHA77/A77_R14-en.pdf.

[22] See WHO Fourteenth General Programme of Work 2025-2028 https://www.who.int/about/general-programme-of-work/fourteenth#:~:text=The%20Fourteenth%20General%20Programme%20of,track%2C%20while%20future%2Dproofing%20health

Converging Global Crises

The world faces a convergence of environmental and societal crises—not as isolated events, but as interconnected threats that synergistically amplify negative impacts on health. This section explores these intertwined challenges, highlighting key thematic areas and regional variations. The urgency to address these interconnected issues is paramount, demanding integrated strategies that prioritize both ecosystem and human health.

I. A Synergistic Threat to Health

Despite the critical role healthy ecosystems play in providing life-sustaining ecosystem services — such as carbon sequestration, water purification, and disease regulation — deforestation, habitat destruction, and land-use changes, among other drivers, have gravely hindered the capacity of ecosystems to function effectively. Biodiversity is declining at rates unprecedented in human history, with vertebrate species alone declining by over two-thirds since 1970, as a result of human-induced pressures such as habitat loss, overexploitation, invasive alien species, and climate change.[23]

For example, intact forests play crucial roles in carbon sequestration, water purification, and disease regulation; their degradation and loss not only contributes to climate change but also increases the risks of natural disasters, food insecurity, and zoonotic and vector-borne diseases.[24][25] Natural and restored ecosystems such as intact forests and wetlands offer critical services essential for human health, including regulating water cycles, temperature, and disease vectors.[26] Conversely, deforestation and forest degradation, which contribute up to an estimated 13% of global greenhouse gas emissions, not only drive climate change[27] but also heighten the risk of zoonotic

[23] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). Global Assessment Report on Biodiversity and Ecosystem Services. IPBES Secretariat.

[24] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services. IPBES Secretariat.

[25] Intergovernmental Panel on Climate Change (2023). Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

[26] International Union for the Conservation of Nature (IUCN), Promoting Human Health through the Global Biodiversity Framework: Linking Forests and Human Health in National Biodiversity Strategies and Action Plans, Information Brief. https://iucn.org/resources/information-brief/promoting-human-health-through-global-biodiversity-framework-linking

[27] Intergovernmental Panel on Climate Change (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

diseases, such as Ebola, alongside vector-borne diseases like malaria and Lyme disease, by disrupting ecosystems, altering wildlife patterns and habitats, and increasing human-wildlife and human-livestock interactions.[28][29]

The health impacts of ecosystem degradation are felt most acutely among vulnerable populations, where reduced access to clean water, healthy soils, plants used as food and medicines, and greater exposure to extreme weather events can significantly contribute to malnutrition, food and water insecurity, and heat-related illnesses, particularly in sub-Saharan Africa and Southeast Asia.[30]

Soil plays a critical role in regulating the climate by storing more carbon than the atmosphere and vegetation combined, with an estimated 1,500 gigatons of organic carbon stored globally.[31] It supports biodiversity, providing habitat for approximately 25% of all living species, with soil biodiversity being essential for nutrient cycling and ecosystem functioning.[32] Additionally, soil filters and stores freshwater, regulating around 17,000 km^3 of fresh water, and plays a vital role in breaking down contaminants, removing up to 90% of pesticide residues through microbial activity.[33] Conversely, soil degradation, largely caused by land-use intensification including unsustainable agricultural practices[34], undermines food security by reducing crop yields and increasing the reliance on inputs such as fertilizers. This decline in soil health diminishes the land's productivity and the nutritional quality of the food grown, which contributes to broader health risks. Studies show that degraded soils provide fewer nutrients for crops, resulting in less nutritious food. This, in turn, exacerbates malnutrition and related health challenges, particularly in regions that are already vulnerable to food insecurity.[35][36]

As soil degradation reduces the nutritional quality of food and exacerbates malnutrition, it similarly threatens another critical source of health and well-being: medicinal plants, which are increasingly at risk due to habitat loss and environmental degradation. Medicinal plants, used in both traditional and modern healthcare systems,

---

[28] For example, strong associations between forest loss and Ebola outbreaks, with outbreaks typically occurring within two years of significant deforestation in affected regions. See for example Olivero, J., Fa, J.E., Real, R., et al. (2017). Recent loss of closed forests is associated with Ebola virus disease outbreaks. Scientific Reports, 7: 14291.

[29] Gibb, R., Redding, D.W., Chin, K.Q., et al. (2020). Zoonotic Host Diversity Increases in Human-Dominated Ecosystems. Frontiers in Veterinary Science, 7: 123.

[30] Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., & Turner, B. (2020). Understanding the Value and Limits of Nature-based Solutions to Climate Change and Other Global Challenges. Philosophical Transactions of the Royal Society B, 375(1794), 20190120.

[31] Lal, R. (2004). Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science, 304(5677), 1623-1627.

[32] Fierer, N. (2017). Embracing the Unknown: Disentangling the Complexities of the Soil Microbiome. Nature Reviews Microbiology, 15(10), 579-590.

[33] Tóth, G., Montanarella, L., & Rusco, E. (2013). Threats to Soil Quality in Europe. Publications Office of the European Union.

[34] FAO (2016) Status of the World's Soil Resources.

[35] Gomiero, T. (2016). Soil Degradation, Land Scarcity, and Food Security: Reviewing a Complex Challenge. Sustainability, 8(3), 281.

[36] Pacheco, F.A.L., Fernandes, L.F.S., Valera, C.A., & Pissarra, T.C.T. (2018). Land Degradation: Multiple Environmental Consequences and Routes to Neutrality. Current Opinion in Environmental Science & Health, 5, 79-86.

are a globally valuable resource for primary healthcare. Over 50,000 to 80,000 plant species are utilized for medicinal purposes worldwide, and nearly 40% of all plant species are now threatened with extinction, including many used for medicinal purposes.[37] An estimated 15,000 medicinal plant species are at risk due to habitat destruction and overharvesting, with 20% of wild resources already nearly exhausted.[38] It has been estimated that, in some communities, up to 80% of the population relies on traditional medicine as a form of primary healthcare. [39]

For Indigenous Peoples, medicinal plants are essential to traditional healthcare systems. Preserving biodiversity is therefore vital for both ecosystem health and the continuation of traditional medicine practices that support community health and resilience.[40] The decline of biodiversity directly threatens these practices and the knowledge systems that sustain them, which are crucial not only for health and well-being but also for maintaining cultural traditions and livelihoods.[41] As large-scale deforestation, unsustainable land use, climate change and other drivers of biodiversity loss continue to threaten the availability of these vital resources, Indigenous Peoples continue to play an essential role of stewardship in their protection and sustainable use. Their traditional knowledge systems and sustainable land management practices are essential to successful biodiversity conservation efforts.[42] Securing land tenure rights, as recognized in the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), is essential for safeguarding biodiversity and ensuring the sustainable use of medicinal plants for future generations.[43][44]

Climate change acts as both a direct and indirect amplifier of health risks. Rising temperatures, altered precipitation patterns, and extreme weather events—such as droughts, floods, and hurricanes— exacerbate health inequities and vulnerability. Heatwaves, which have become more frequent and severe, significantly

---

[37] Kew Gardens (2023). State of the World's Plants and Fungi 2023. Royal Botanic Gardens, Kew. https://www.kew.org/science/state-of-the-worlds-plants-and-fungi

[38] Ross, I. A. (2007). Medicinal Plants of the World, Volume 3: Chemical Constituents, Traditional and Modern Medicinal Uses (Vol. 3). Springer Science & Business Media.

[39] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review. Chapter 6: Traditional Medicine. World Health Organization and Convention on Biological Diversity.

[40] Please see also the *Recommendations towards a resilient future for biodiversity and human health through ancestral and Indigenous knowledge systems,* prepared by the participants at the Global Workshop on Biodiversity, Traditional Knowledge, held in Rio de Janeiro on July 25-27 2023.

[41] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review. Chapter 6: Traditional Medicine. World Health Organization and Convention on Biological Diversity.

[42] Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B, 375(1794), 20190120.

[43] Food and Agriculture Organization of the United Nations, United Nations Environment Programme (2020). State of the World's Forests 2020. Rome.

[44] United Nations Declaration on the Rights of Indigenous Peoples (2007). https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html

increase the risks of heatstroke and cardiovascular diseases, particularly in urban areas lacking green infrastructure.[45] Reduced agricultural yields, worsened by climate change, further undermine food security and exacerbate malnutrition as elevated CO_2 levels are projected to lower the nutritional quality of crops.[4647] Studies show that wheat and rice grown under elevated CO_2 conditions have reduced protein, iron, and zinc content, with some crops showing 10-18% reductions in protein and similar declines in mineral content such as iron and zinc.[48] Climate change also shifts the distribution of disease vectors such as mosquitoes, expanding the risk and range of vector-borne diseases such as malaria, dengue, and Zika, to new regions and populations.[49] In addition to its impacts on physical health, climate change also threatens mental health, particularly among youth. Climate change has been linked to increased climate anxiety, depression, and post-traumatic stress disorder (PTSD) following climate-related disasters, with particularly severe long-term psychological effects on youth who face uncertainty about the future due to climate impacts.[5051]

Biodiversity loss and climate change are closely linked to the emergence and transmission of zoonotic and other diseases. As ecosystems are altered or destroyed—through deforestation, urbanization, and agricultural expansion—the risk of pathogens spilling over from domesticated animals and wildlife to human populations (and vice versa) increases.[52] This interplay is evident in the rise of zoonotic and vector-borne diseases such as Ebola, SARS, MERS, Hendra, and malaria, which have been associated with habitat destruction, wildlife

[45] Intergovernmental Panel on Climate Climate Change (2022): Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the IPCC. Cambridge University Press.

[46] EAT-Lancet (2023): Food, Planet, Health: Healthy Diets from Sustainable Food Systems. EAT-Lancet Commission. https://eatforum.org/eat-lancet-commission/

[47]Mbow,C.,C.Rosenzweig,L.G.Barioni,T.G.Benton,M.Herrero,M.Krishnapillai,E.Liwenga,P.Pradhan,M.G.Rivera-Ferre, T. Sapkota, F.N. Tubiello, Y. Xu, 2019: Food Security. In: Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. Cambridge: University Press.

[48] Myers, S. S., Zanobetti, A., Kloog, I., Huybers, P., Leakey, A.D.B., Bloom, A.J., Carlisle, E., Dietterich, L.H., Fitzgerald, G., Hasegawa, T., Holbrook, N.M., Nelson, R.L., Ottman, M.J., Raboy, V., Sakai, H., Sartor, K.A., Schwartz, J., Seneweera, S., Tausz, M., Usui, Y. (2014). Increasing CO_2 Threatens Human Nutrition. Nature, 510(7503), 139-142.

[49] Intergovernmental Panel on Climate Climate Change (2022): Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the IPCC. Cambridge University Press.

[50] Clayton, S., Manning, C. M., Krygsman, K., Speiser, M. (2017). Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. Washington, D.C.: American Psychological Association, and ecoAmerica.

[51] Intergovernmental Panel on Climate Climate Change (2022): Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the IPCC. Cambridge University Press.

[52] Plowright, R.K., Ahmed, A.N., Coulson, T., Crowther, T.W., Ejotre, I., Faust, C.L., Frick, F.F., Hudson, P.J., Kingston, T., Nameer, P.O., O'mAra, M.T., Peel, A.J., Possingham, H., Razgour, O., Reeder, D.M., Ruiz- Aravena, M., Simmons, N.B., Srinivas, P. N., Tabor, G.M., Tanshi, I., Thompson, I.G., Vanak, A.T., Vora, N.M., Willison, C.E., Keeley, A.T.H. (2024). Ecological Countermeasures to Prevent Pathogen Spillover and Subsequent Pandemics. Nature Communications 15:2577.

exploitation, and other human-induced environmental pressures, that combine with other social and economic pressures to create the conditions in which new diseases can emerge and spread.[53][54] Deforestation, habitat loss, and other land use changes create more frequent human-animal interactions, providing opportunities for pathogens to jump species barriers, making integrated approaches that connect human, animal, plant and ecosystem health, such as One Health, all the more essential.

Pollution adds another critical layer to these interconnected challenges. Greenhouse gas emissions from fossil fuel combustion, industrial activities, and household air pollution drive both climate change and air pollution, while also causing significant damage to ecosystems and biodiversity. Air pollution alone is responsible for over 7 million premature deaths annually, the vast majority in low- and middle-income countries.[55][56] It contributes significantly to respiratory diseases, cardiovascular conditions, strokes, lung cancer, and cognitive impairments.[57][58] In 2019, 99% of the world's population was living in places where the WHO air quality guidelines levels were not met.[59][60] Policies promoting cleaner energy, public transport, and active travel can cut emissions while reducing air pollution and improving public health. For example, studies have found that reducing methane emissions could prevent an estimated 260,000 premature deaths annually from tropospheric ozone exposure, and controlling black carbon, which can significantly improve respiratory and cardiovascular health outcomes.[61] In urban areas, NbS such as increased quality green spaces also have demonstrated important health co-benefits, including through enhanced metabolism and immune function, lower rates of cardiovascular disease and premature mortality, as they improve air quality and provide cooling effects.[62][63][64] Perceived aesthetic benefits of

[53] Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A., Balk, D., Gittleman, J.L., Daszak, P. (2008): Global Trends in Emerging Infectious Diseases. Nature, 451, 990–993.
[54] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2020). Workshop Report on Biodiversity and Pandemics of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.
[55] World Health Organization (2019): Air Pollution fact sheet. Link.
[56] Lelieveld, J., Evans, J.S., Fnais, M., Giannadaki, D., Pozzer, A. (2015): The Contribution of Outdoor Air Pollution Sources to Premature Mortality on a Global Scale. Nature, 525, 367–71.
[57] World Health Organization (2019): Air Pollution fact sheet. Link.
[58] Lelieveld J, Evans JS, Fnais M, Giannadaki D, Pozzer A (2015): The Contribution of Outdoor Air Pollution Sources to Premature Mortality on a Global Scale. Nature, 525, 367–71.
[59] World Health Organization (2021): WHO Global Air Quality Guidelines. Particulate Matter (PM2.5. and PM10), Ozone, Nitrogen Oxide, Sulfur Dioxide and Carbon Monoxide. Geneva: World Health Organization.
[60] World Health Organization (2019): Air Pollution. Link.
[61] Whitmee, S., Green, R., Belesova, K., Hassan, S., Cuevas, S., Murage, P., Picetti, R., Clerq-Roques, R., Murray, K., Falconer, J., Anton, B., Reynolds, T., Waddington, H.S., Hughes, R.C., Spadaro, J., Aguilar Jaber, A., Saheb, Y., Campbell-Lendrum, D., Cortés-Puch, M., Ebi, K., Huxley, R., Mazzucato, M., Oni, T., de Paula, N., Peng, G., Revi, A., Rockström, J., Srivastava, L., Whitmarsh, L., Zougmoré, R., Phumaphi, J., Clar, H., Haines, A. (2024). Pathways to a Healthy Net-Zero Future: Report of the Lancet Pathfinder Commission. The Lancet, 403(10421), 67-110.
[62] Rojas-Rueda, D., Nieuwenhuijsen, M. J., Gascon, M., Perez-Leon, D., Mudu, P. (2019). Green Spaces and Mortality: A Systematic Review and Meta-Analysis of Cohort Studies. The Lancet Planetary Health, 3(11), e469-e477.
[63] Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Rojas-Rueda, D., Plasència, A., Nieuwenhuijsen, M. J. (2016). Residential Green Spaces and Mortality: A Systematic Review. Environment International, 86, 60-67.
[64] Twohig-Bennett, C., Jones, A. (2018): The Health Benefits of The Great Outdoors: A Systematic Review and Meta-Analysis of Greenspace Exposure and Health Outcomes. Environmental Research, 166, 628-637.

urban greening and enhanced feelings of "connectedness" to nature from exposure to urban biodiversity have also been shown to improve mental well-being; the value of urban greening for promoting outdoor physical activity and social engagement is also well established.[6566] These interventions can not only help mitigate the physical impacts of pollution but also support mental and physical health, providing health co-benefits in rapidly urbanizing areas.

Other forms of pollution, such as water pollution, cause over one million deaths annually through waterborne diseases, while soil and chemical pollution contribute to long-term health impacts, including cancer, reproductive harm, and neurological damage.[67] Contaminated water is a significant cause of diarrheal diseases in low- and middle-income countries. Water pollution, arising from untreated sewage, industrial waste, agricultural runoff, and heavy metal contamination, is a major public health concern. The WHO estimates that 1.4 million deaths annually are attributed to unsafe water, sanitation, and hygiene, with the majority of these deaths caused by diarrheal diseases such as cholera, dysentery, and typhoid.[68] Most of these deaths occur in low- and middle-income countries, where waterborne diseases disproportionately impact vulnerable populations.

Plastic pollution has also emerged as an ubiquitous threat to the environment and public health. Microplastics are found in marine and freshwater systems, soil, air, and even food posing potential health risks through ingestion, inhalation, and skin contact.[6970] The breakdown of plastics into micro- and nano-sized particles can cause toxic effects, disrupt ecosystems, and contribute to the contamination of food chains, reinforcing the need to address plastic pollution as part of broader development, environment, and health strategies.[71]

Ecosystem degradation, encompassing deforestation, land-use changes, and the degradation of terrestrial ecosystems, contributes approximately 23% of global anthropogenic greenhouse gas emissions, primarily through agriculture, forestry, and other land use (AFOLU).[72] Food systems contribute heavily to deforestation, land degradation, and climate change through intensive agricultural and livestock production, and the use of

---

[65] Samus, A., Freeman, C., Dickinson, K. J., Van Heezik, Y. (2022). Relationships between Nature Connectedness, Biodiversity of Private Gardens, and Mental Well-being during the Covid-19 Lockdown. Urban Forestry & Urban Greening, 69, 127519.

[66] Reyes-Riveros, R., Altamirano, A., De La Barrera, F., Rozas-Vásquez, D., Vieli, L., Meli, P. (2021). Linking public urban green spaces and human well-being: A systematic review. Urban Forestry & Urban Greening, 61, 127105.

[67] Fuller, R., Landrigan, P. J., Balakrishnan, K., Bathan, G., Bose-O'Reilly, S., Brauer, M., Caravanas, J., Chiles, T., Cohen, A., Corra, L., Cropper, M., Ferraro, G., Hanna, J., Hanrahan, D., Hu, H., Hunter, D., Janata, G., Kupka, R., Lanphear, B., Lichtveld, M., Martin, K., Mustaph, A., Sanchez- Triana, E., Sandilya, K., Schaefli, L., Shaw, J., Seddon, J., Suk, W. Téllez-Roho, M.M., Tan C. (2022). Pollution and Health: A Progress Update. The Lancet Planetary Health, 6(6), e535-e547.

[68] World Health Organization (2022). Sanitation and Health: Key Facts. World Health Organization. Link.

[69] World Health Organization (WHO). (2019c). Microplastics in Drinking Water. Geneva: World Health Organization.

[70] Seewoo, B.J., Goodes, L.M., Thomas, K.V., Rauert, C., Elagali, A., Ponsonby, A.L., Symeonides, C., Dunlop, S.A. (2024). How Do Plastics, Including Microplastics and Plastic-Associated Chemicals, Affect Human Health?. Nature Medicine.

[71] Stoett, P., Scrich, V. M., Elliff, C. I., Andrade, M. M., de M. Grilli, N, Turra, A, (2024). Global Plastic Pollution, Sustainable Development, and Plastic Justice. World Development, Elsevier. 184: 106756.

[72] Intergovernmental Panel on Climate Change (2019): Special Report on Climate Change and Land. Intergovernmental Panel on Climate Change.

fertilizers, pesticides and chemicals.[7374] When considering the broader food system, which includes agricultural production, transportation, processing, and waste, food systems are responsible for nearly one-third of global emissions.[75] Aquatic food systems, including fisheries and aquaculture, further contribute to biodiversity loss and climate change, particularly through unsustainable practices that degrade marine ecosystems and increase methane and carbon emissions from fish farming.[76] The resulting environmental degradation disrupts biodiversity, accelerates climate change, and undermines the capacity of natural systems to deliver essential ecosystem services.[7778]

Transforming global food systems plays a critical role in addressing these interconnected challenges. There is growing consensus on the urgent need to shift food systems towards sustainable healthy diets, and on the vital role which the conservation and sustainable use of biodiversity should play in enhancing nutrition security and building resilience in food systems.[7980818283] This transition, which includes increasing the consumption of fruits, vegetables, nuts and legumes and reducing the consumption of animal products, may reduce the environmental

[73] Clark, M. A., Springmann, M., Hill, J., Tilman, D. (2020): Multiple Health and Environmental Impacts of Foods. Proceedings of the National Academy of Sciences, 117(51), 32741-32750.
[74] Food and Agriculture Organization of the United Nations (2020): The State of World Fisheries and Aquaculture 2020: Sustainability in Action. Rome: Food and Agriculture Organization.
[75] Food systems include emissions from the entire life cycle of food production, which encompasses AFOLU but also factors in transportation, processing, packaging, retail, and waste. According to the EAT-Lancet report (Willet et al., Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems, 2019), food systems are responsible for nearly one-third of global greenhouse gas emissions, also considering post-production processes.
[76] Food and Agriculture Organization of the United Nations (2020): The State of World Fisheries and Aquaculture 2020: Sustainability in Action. Food and Agriculture Organization.
[77] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019): Global Assessment Report on Biodiversity and Ecosystem Services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES Secretariat.
[78] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review.
[79] Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L.J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J.A, de Vries, W., Sibanda, L.M., Afshin, A., Chaudhary, A., Herrero, M., Agustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M. Lindahl, T., Singh, S., Cornell, S.E., Reddy, K.S., Narain, S., Nishtar, S., Murray, C.J.L. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet, 393(10170), 447-492.
[80] Food and Agriculture Organization of the United Nations, World Health Organization (2019): Sustainable Healthy Diets: Guiding Principles. Rome.
[81] Clark, M. A., Springmann, M., Hill, J., Tilman, D. (2020): Multiple Health and Environmental Impacts of Foods. Proceedings of the National Academy of Sciences. 117(51), 32741-32750.
[82] World Health Organization (2020). Guidance on Mainstreaming Biodiversity for Nutrition and Health. Geneva. Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome.
[83] Hunter, D., Gee, E., Borelli, T. (2020). Nourishing People, Nurturing the Environment: Biodiversity for Food Systems Transformation and Healthier Diets. In Biodiversity, Food and Nutrition (pp. 3-20). Routledge.

footprint of food systems by up to 50%,[84] while improving food security and nutrition.[85][86][87] Other health benefits include reducing the prevalence of diet-related diseases such as heart disease, diabetes, and cancer.[88] According to the EAT Lancet Commission, a shift from unhealthy diets can prevent 11 million premature adult deaths annually and drive the transition toward a sustainable global food system by 2050.[89] However, these dietary transitions must also account for cultural contexts, and consider nutritional needs in areas where undernutrition remains prevalent, ensuring that solutions are equitable and tailored.[90] Food system transformation not only requires systemic change in how we produce and consume food but also in how we restore and protect the ecosystems that provide critical services for human health and environmental resilience.[91]

The feedback loops between biodiversity loss, pollution, climate change, and ecosystem degradation intensify health impacts, increasing preventable health risks associated with unhealthy environments and climate change, and increase the vulnerability of socially and economically marginalized communities to disease.[92][93][94] NbS such

[84] Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L.J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J.A, de Vries, W., Sibanda, L.M., Afshin, A., Chaudhary, A., Herrero, M., Agustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M. Lindahl, T., Singh, S., Cornell, S.E., Reddy, K.S., Narain, S., Nishtar, S., Murray, C.J.L. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet, 393(10170), 447-492.

[85] Clark, M. A., Springmann, M., Hill, J., Tilman, D. (2020): Multiple Health and Environmental Impacts of Foods. Proceedings of the National Academy of Sciences. 117(51), 32741-32750.

[86] World Health Organization (2020). Guidance on Mainstreaming Biodiversity for Nutrition and Health. Geneva. Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome.

[87] Zaccari, C., De Vivo, R., Pawera, L., Termote, C., Hunter, D., Borelli, T., Kettle, C.J., Maas, B., Novotny, I., Cherico Wanger, T., Dullo, M.E., Fadda, C., Gee, E. (2023). Lessons Learned from the Second International Agrobiodiversity Congress: Adopting Agricultural Biodiversity As A Catalyst for Transformative Global Food Systems. Current Opinion in Environmental Science & Health, 31, 100411.

[88] Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L.J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J.A, de Vries, W., Sibanda, L.M., Afshin, A., Chaudhary, A., Herrero, M., Agustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M. Lindahl, T., Singh, S., Cornell, S.E., Reddy, K.S., Narain, S., Nishtar, S., Murray, C.J.L. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet, 393(10170), 447-492.

[89] EAT-Lancet Commission (2023): Summary Report: Healthy Diets From Sustainable Food Systems. EAT-Lancet Commission. Link.

[90] EAT-Lancet Commission (2023): Summary Report: Healthy Diets From Sustainable Food Systems. EAT-Lancet Commission. Link.

[91] World Health Organization (2020). Guidance on Mainstreaming Biodiversity for Nutrition and Health. Geneva. Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome.

[92] World Health Organization (2018c): Preventing Disease through Healthy Environments: A Global Assessment of the Burden of Disease from Environmental Risks. World Health Organization.

[93] Murray, M. H., Buckley, J., Byers, K. A., Fake, K., Lehrer, E. W., Magle, S. B., Stone, C., Tuten, H., Schell, C. J. (2022). One Health for All: Advancing Human and Ecosystem Health in Cities by Integrating an Environmental Justice Lens. Annual Review of Ecology, Evolution, and Systematics, 53(1), 403-426.

[94] Dasandi, N., Cai, W., Friberg, P., Jankin, S., Kuylenstierna, J., Nilsson, M. (2022). The Inclusion of Health in Major Global Reports on Climate Change and Biodiversity. BMJ Global Health, 7(6), e008731.

as reforestation, wetland restoration, and sustainable agricultural practices could contribute up to 30% of the climate mitigation needed by 2030.[9596] NbS, including those that contribute to food system transformation, can not only mitigate emissions but also offer co-benefits for human health by improving air and water quality, enhancing food security and nutrition, reducing disaster risks, and minimizing disease risks associated with contaminated air, water and soil. Additionally, NBS can contribute to supporting mental health outcomes and improve access to medicines derived from nature.[97]

II. Variations in Vulnerability and Resilience

The impacts of converging global crises are not uniformly distributed. Regional variations in vulnerability and resilience are significantly influenced by socioeconomic factors, geographic location, and existing inequalities. Notable geographic, sociocultural, and economic disparities also exist between rural and urban areas, and within cities. For example, access to reliable drinking water is significantly lower for low-income populations residing in informal urban settlements.[98] A nuanced understanding of regional, national and local contexts is important to the development of effective and socially-just policy responses.[99]

For example, Sub-Saharan Africa is highly vulnerable to land degradation and habitat destruction, often associated with deforestation for agricultural expansion and human settlements. These activities threaten essential ecosystem services such as pollination, water purification and food production, while exacerbating food insecurity, water scarcity, and the risk of infectious diseases.[100] Deforestation, associated land use changes and climate change combine to create ideal conditions for mosquito breeding, intensifying their spread and have been found to exacerbate the incidence of vector-borne diseases such as malaria.[101102] Sub-Saharan Africa carries a

---

[95] Intergovernmental Panel on Climate Change (2019): Special Report on Climate Change and Land. Intergovernmental Panel on Climate Change.

[96] Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., Turner, B. (2020). Understanding the Value and Limits of Nature-based Solutions to Climate Change and Other Global Challenges. Philosophical Transactions of the Royal Society B, 375(1794), 20190120.

[97] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review.

[98] World Health Organization, United Nations Children's Fund. (2021) Progress on Household Drinking Water, Sanitation and Hygiene 2000-2020: Five Years into the SDGs. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF).

[99] Rigolon, A., Owusu, R. O., Becerra, M., Cheng, Y. D., Christensen, J., Connolly, J. J., Corbin, C.N.E., Douglas, J.A., Fernandez, M., Jennings, V., Ito, J., Mullenbach, L.E., Nesbitt, L., Jelks, N. O., Walker, R., Viera, S., Romero, Espiricueta, A. (2024). Advancing Green Space Equity Via Policy Change: A Scoping Review and Research Agenda. Environmental Science & Policy, 157, 103765.

[100] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2019). Global Assessment Report on Biodiversity and Ecosystem Services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: IPBES Secretariat.

[101] Shah, H. A., Carrasco, L. R., Hamlet, A., Murray, K. A. (2022). Exploring Agricultural Land-Use and Childhood Malaria Associations in Sub-Saharan Africa. Scientific Reports, 12(1), 4124.

[102] Patz, J. A., Olson, S. H., Uejio, C. K., & Gibbs, H. K. (2008). Disease Emergence from Global Climate and Land Use Change. Medical Clinics of North America, 92(6), 1473-1491.

disproportionately high share of the global malaria burden, accounting for approximately 94% of all malaria cases, with approximately 78% of all malaria deaths in the region being in children under 5 years of age.[103] Deforestation and land degradation also reduce the quality of soil further contributing to widespread food insecurity, water scarcity and increased exposure to waterborne diseases such as cholera, typhoid fever and dysentery.

Significant geographic, sociocultural, and economic disparities continue to exist, not only between rural and urban regions but also within cities themselves.[104] In Sub-Saharan Africa, only 13% of rural populations have access to safely managed drinking water, compared to 54% in urban areas. [105] Comprehensive systematic reviews that consider the health benefits of all NbS are limited. However, research on wetland restoration and urban green spaces indicates that these NbS can reduce disease vectors, improve water quality, and lower respiratory and waterborne disease incidence.[106107108]

In Southeast Asia, intensive deforestation and agricultural intensification have heightened the risk of emerging and re-emerging infectious diseases, such as Nipah virus.[109110111] At the same time, water pollution from agricultural runoff and untreated waste impacts freshwater ecosystems, increasing the risk of waterborne diseases, and pollinator declines and invasive alien species, such as the golden apple snail, harm rice production

[103] World Health Organization. (2023). World Malaria Report 2023. Geneva: World Health Organization.

[104] World Health Organization. Water: Factsheet. [Online]. Available from https://www.afro.who.int/health-topics/water [Accessed 4th October, 2024].

[105] World Health Organization, United Nations Children's Fund. (2021) Progress on Household Drinking Water, Sanitation and Hygiene 2000-2020: Five Years into the SDGs. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF).

[106] Epstein, J. H., Hume, E., Field, S.L., Pulliam,J.R.C., Daszak, P. (2006). Nipah Virus: Impact, Origins, and Causes of Emergence. Current Infectious Disease Reports. 8(1): 59-65.

[107] Van den Bosch, M., Sang, Å. O. (2017). Urban Natural Environments As Nature-based Solutions for Improved Public Health–A Systematic Review of Reviews. Environmental Research, 158: 373-384.

[108] Kabisch, N., van den Bosch, M., Lafortezza, R. (2017). The Health Benefits of Nature-based Solutions to Urbanisation Challenges for Children and the Elderly–A Systematic Review. Environmental research, 159, 362-373.

[109] Afelt, A., Frutos, R., Devaux, C. (2018). Bats, Coronaviruses, and Deforestation: toward The Emergence of Novel Infectious Diseases?. Frontiers in Microbiology, 9, 702.

[110] Soman Pillai, V., Krishna, G., Valiya Veettil, M. (2020). Nipah Virus: Past Outbreaks and Future Containment. Viruses, 12(4), 465.

[111] Chua, Kaw Bing, Beng Hui Chua, and Chew Wen Wang. (2002). Anthropogenic Deforestation, El Nino and The Emergence of Nipah Virus in Malaysia. Malaysian Journal of Pathology 24(1): 15-21.

and food security.[112][113][114][115] NbS, such as mangrove restoration, not only protect coastal areas from storms and flooding but also filter pollutants from freshwater systems, reducing health risks associated with polluted water, and can increase food security.[116] Other systematic reviews of NbS applications also show that health benefits of blue spaces, such as rivers and lakes, extend beyond food security and disease regulation. For example, access to coastal areas and rivers can improve mental health and reduce stress,[117] especially in natural environments, and also reduce anxiety and depression.[118] While these health benefits apply broadly, they are also relevant considerations in regions facing displacement due to global environmental changes.

In Small Island Developing States (SIDS) and coastal regions, rising sea levels and coral reef degradation severely impact food security, particularly fisheries.[119] This threat is further amplified by the global decline in wild-caught fish stocks, jeopardizing nutritional security worldwide, especially in regions heavily reliant on fish for micronutrients.[120] Other challenges include saltwater intrusion causing soil salinization and reduced agricultural

[112] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2019). Global Assessment Report on Biodiversity and Ecosystem Services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: IPBES Secretariat.

[113] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2016). Assessment Report on Pollinators, Pollination, and Food Production. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: IPBES Secretariat.

[114] Schneiker, J., Weisser, W.W., Settele, J., Bustamante, J.V., Marquez, L., Villareal, S., Arida, G., Chien, H.V., Heong, K.L., Türke, M.. Is There Hope for Sustainable Management of Golden Apple Snails, A Major Invasive Pest in Irrigated Rice? NJAS-Wageningen Journal of Life Sciences 79 : 11-21.

[115] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2023). Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H. E., Pauchard, A., Stoett, P., Renard Truong, T., Bacher, S., Galil, B. S., Hulme, P. E., Ikeda, T., Sankaran, K. V., McGeoch, M. A., Meyerson, L. A., Nuñez, M. A., Ordonez, A., Rahlao, S. J., Schwindt, E., Seebens, H., Sheppard, A. W., and Vandvik, V. (eds.). IPBES Secretariat. Bonn: Germany.

[116] Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., Geneletti, D., Calfapietra, C. (2017). A Framework for Assessing and Implementing The Co-Benefits of Nature-based Solutions in Urban Areas. Environmental Science & Policy, 77: 15-24.

[117]WHO Regional Office for Europe (2021) Green and blue spaces and mental health: new evidence and perspectives for action. Copenhagen: WHO Regional Office for Europe; 2021. Licence: CC BY-NC-SA 3.0 IGO.

[118]WHO Regional Office for Europe (2021) Green and blue spaces and mental health: new evidence and perspectives for action. Copenhagen: WHO Regional Office for Europe; 2021. Licence: CC BY-NC-SA 3.0 IGO.

[119] Food and Agriculture Organization of the United States. (2020). The State of World Fisheries and Aquaculture 2020: Sustainability in action. Rome: FAO.

[120] Golden, C. D., Allison, E. H., Cheung, W. W., Dey, M. M., Halpern, B. S., McCauley, D. J., Smith, M., Vaitla, B., Myers, S.S. (2016). Nutrition: Fall in Fish Catch Threatens Human Health. Nature, 534(7607), 317-320

yields[121], and the introduction of invasive species further jeopardizing marine ecosystems and biodiversity.[122] These factors exacerbate food insecurity and malnutrition, drive the risk of infectious disease emergence, increase the risk of NCDs such as kidney disease, and disproportionately affect lower-income populations. NbS, such as mangrove restoration, offer benefits including reduced saltwater intrusion, improved water quality, and enhanced food security[123], while also potentially reducing health inequalities and mortality risks.[124] (Mitchell & Popham, 2008).

In Latin America and the Caribbean, environmental degradation and climate change also pose significant threats to health and well-being, with uneven impacts across populations. Based on WHO data, avoidable environmental risks contribute to an estimated 1,016,000 premature deaths annually in the WHO America region (13% in high-income[125], 19% in low- and middle-income countries[126] of the region). [127][128]These disease burdens are driven largely by air pollution (nearly 320,000 deaths yearly from respiratory and cardiovascular diseases), inadequate sanitation and unsafe water (30,000 annual deaths), food insecurity and malnutrition in all its forms, and a persistent prevalence in infectious diseases.[129] Medicinal plants play a vital role in traditional

[121] Parker, S. Y., Parchment, K. F., & Gordon-Strachan, G. M. (2023). The Burden of Water Insecurity: A Review of The Challenges to Water Resource Management and Connected Health Risks Associated with Water Stress in Small Island Developing States. Journal of Water and Climate Change, 14(12), 4404-4423.

[122] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2023). Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H. E., Pauchard, A., Stoett, P., Renard Truong, T., Bacher, S., Galil, B. S., Hulme, P. E., Ikeda, T., Sankaran, K. V., McGeoch, M. A., Meyerson, L. A., Nuñez, M. A., Ordonez, A., Rahlao, S. J., Schwindt, E., Seebens, H., Sheppard, A. W., and Vandvik, V. (eds.). IPBES secretariat, Bonn, Germany.

[123] Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., & Turner, B. (2020). Understanding the Value and Limits of Nature-based Solutions to Climate Change and Other Global Challenges. Philosophical Transactions of the Royal Society B, 375(1794), 20190120.

[124] Mitchell, R., Popham, F. (2008). Effect of Exposure to Natural Environment on Health Inequalities: An Observational Population Study. The Lancet, 372(9650): 1655-1660.

[125] High-income countries: Antigua and Barbuda, Bahamas, Barbados, Canada, Chile, Saint Kitts and Nevis, Trinidad and Tobago, United States of America, Uruguay.

[126] Low- and middle-income countries: Argentina, Belize, Bolivia (Plurinational State of), Brazil, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Venezuela (Bolivarian Republic of).

[127] World Health Organization. (2016). Preventing Disease through Healthy Environments: A Global Assessment of The Burden of Disease from Environmental Risks. Geneva: WHO.

[128] Shaffer, R.M., Sellers, S.P., Baker, M.G., Kalmen, R., Frostad, J., Suter, M.K., Annenberg, S.C., Balbus, J., Basu, N., Bellinger, D.C., Birnbaum, L., Brauer, M., Cohen, A., Ebi, K.L., Fuller, R., Grandjean, P., Hess, J.J., Kogevinas, M., Kumar, P., Landrigan, P.J., Lanphear, B., London, S.J., Rooney, A.A., Stanaway, J.D., Trasande, L., Walker, K., Hu, H. (2019). Improving and expanding estimates of the global burden of disease due to environmental health risk factors. Environmental Health Perspective 127(10):105001

[129] Pan American Health Organization. (2021). Agenda for the Americas on Health, Environment, and Climate Change 2021–2030.

healthcare systems across the Americas, as in other parts of the world,[130][131] with a rich diversity of species used to prevent and treat a wide range of ailments.[132][133][134] In the Americas, these plants represent a significant source of cultural knowledge for Indigenous Peoples, and form an integral part of many communities' healthcare practices.[135] The loss of biodiversity in the Americas directly threatens Indigenous peoples' access to essential medicinal plants, undermining traditional healthcare systems and cultural practices vital to their well-being.[136]

In the WHO European Region, the environmental situation reveals critical challenges for health and biodiversity. While the EU has designated roughly 25% of its land as protected, a significant 39% is used for agriculture, placing considerable stress on water resources. This pressure is particularly acute in southern Europe, where 30% of the population faces permanent water stress. Furthermore, the degradation of wetlands is alarming, with two-thirds lost in the last century and 85% of those remaining in an unfavourable conservation status. This situation highlights the urgent need to protect and restore natural ecosystems, considering the substantial impact of environmental degradation on human health and well-being.[137] Moreover, access to nature and exposure to environmental risks vary significantly based on social status and location. Marginalized and low-income communities often face higher environmental health risks and limited access to beneficial natural areas. Urban green spaces that mitigate heat are typically less available in poorer neighborhoods, while wealthier areas enjoy better-quality environments. Access to natural spaces for recreation is hindered by distance, safety concerns, and resource limitations.[138]

[130] Sen, T., Samanta, S. K. (2015). Medicinal Plants, Human Health and Biodiversity: A Broad Review. Biotechnological Applications of Biodiversity, 59-110.
[131] Tomlinson, T. R., Akerele, O. (Eds.). (2015). Medicinal Plants: Their Role in Health and Biodiversity. University of Pennsylvania Press.
[132] Geck, M. S., Cristians, S., Berger-Gonzalez, M., Casu, L., Heinrich, M., Leonti, M. (2020). Traditional Herbal Medicine in Mesoamerica: Toward its Evidence Base for Improving Universal Health Coverage. Frontiers in Pharmacology, 11, 1160.
[133] Giovannini, P., Howes, M. J. R., & Edwards, S. E. (2016). Medicinal plants used in the traditional management of diabetes and its sequelae in Central America: A review. Journal of ethnopharmacology, 184, 58-71.
[134] Reimers, E., Cusimamani, E., Rodriguez, E., Zepeda del Valle, J., Polesny, Z., Pawera, L. (2018). An Ethnobotanical Study of Medicinal Plants Used in Zacatecas State, Mexico. Acta Societatis Botanicorum Poloniae, 87(2).
[135] Kor, L., Homewood, K., Dawson, T. P., & Diazgranados, M. (2021). Sustainability of Wild Plant Use in The Andean Community of South America. Ambio, 50(9), 1681-1697.
[136] Redvers, N., Aubrey, P., Celidwen, Y., Hill, K. (2023). Indigenous Peoples: Traditional Knowledges, Climate Change, and Health. PLOS Global Public Health, 3(10), e0002474.
[137] WHO, Regional Office for Europe. (2023). Nature, BIodiversity and Health. Link Accessed 14th October, 2024. https://www.who.int/europe/news-room/fact-sheets/item/nature--biodiversity-and-health
[138] World Health Organization. (2021). Nature, Biodiversity and Health: An Overview of Interconnections. World Health Organization. Copenhagen: WHO Regional Office for Europe.

Nature-based Solutions: A Health Imperative

Photo Credit: Bioversity International/Khant Zaw

The intricate interplay of environmental degradation, health risks, and socio-economic disparities within and across regions, countries and communities underscore the urgent need for targeted interventions. NbS offer a key strategy to not only conserve, restore and sustainably manage ecosystems but also to address the health inequities exacerbated by these converging global crises. In this report, NbS are defined in accordance with UNEA Resolution UNEP/EA.5/Res.5 adopted by consensus in 2022 (see Box 1).

Environmental stressors compounded by socio-economic factors like violent conflict, economic instability, and population growth—undermine the resilience of health systems, especially among vulnerable populations. These groups—including children, low-income communities, Indigenous Peoples, and those in rural or coastal regions—often face heightened health risks associated with ecosystem degradation and have more limited access to social protection. Well-designed NbS can enhance community resilience and ensure equitable access to the benefits of nature, including for vulnerable populations disproportionately affected by global environmental changes.

NbS interventions like urban reforestation, wetland restoration, and sustainable agricultural practices, do more than safeguard ecosystems and mitigate climate change. As preceding sections and those to follow demonstrate, well-designed NbS provide tangible health benefits by improving air, water, and soil quality; supporting food security; enhancing mental health; and increasing access to natural medicines. Additionally, they reduce disease risks and vulnerability to natural disasters. By integrating ecological protection with health strategies, NbS foster more resilient health systems capable of adapting to changing environmental and health conditions.[139]

Box 1: Nature-Based Solutions (NbS) Defined

Box 1: Nature-Based Solutions (NbS) defined

NbS are defined as:

...actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits, and recognizes that nature-based solutions:

(a) Respect social and environmental safeguards, in line with the three "Rio conventions" (the Convention on Biological Diversity, the United Nations Convention to Combat Desertification and the United Nations Framework Convention on Climate Change), including such safeguards for local communities and indigenous peoples;

(b) Can be implemented in accordance with local, national and regional circumstances, consistent with the 2030 Agenda for Sustainable Development, and can be managed adaptively;

(c) Are among the actions that play an essential role in the overall global effort to achieve the Sustainable Development Goals, including by effectively and efficiently addressing major social, economic and environmental challenges, such as biodiversity loss, climate change, land degradation, desertification, food security, disaster risks, urban development, water availability, poverty eradication, inequality and unemployment, as well as social development, sustainable economic development, human health and a broad range of ecosystem services;

(d) Can help to stimulate sustainable innovation and scientific research.

Ref: UNEA resolution UNEP/EA.5/Res.5., "Nature-based Solutions"

[139] United Nations Environment Programme. (2021): Making Peace with Nature: A Scientific Blueprint to Tackle the Climate, Biodiversity, and Pollution Emergencies. Nairobi: United Nations Environment Programme.

**Prior to the adoption of the UNEA decision in 2022, to coordinate NbS action, the IUCN developed the IUCN Global Standard for NbS and a self assessment tool featuring eight criteria. As it does not specifically have an indicator or criterion for health, the Global Standard was not used as a focus of this report. An example of how it may be applied, including to assess health co-benefits, can be found in Appendix 1.

At this critical juncture, collaboration across sectors, governments, and communities is essential to fully realize the potential of NbS. A whole-of-government and whole-of-society approach is necessary to tackle the full range of interconnected social economic and environmental challenges we face. Health leadership, in coordination with sectors such as agriculture, urban planning, and environmental management, among others, must play a central role in advancing both human well-being and ecosystem resilience.

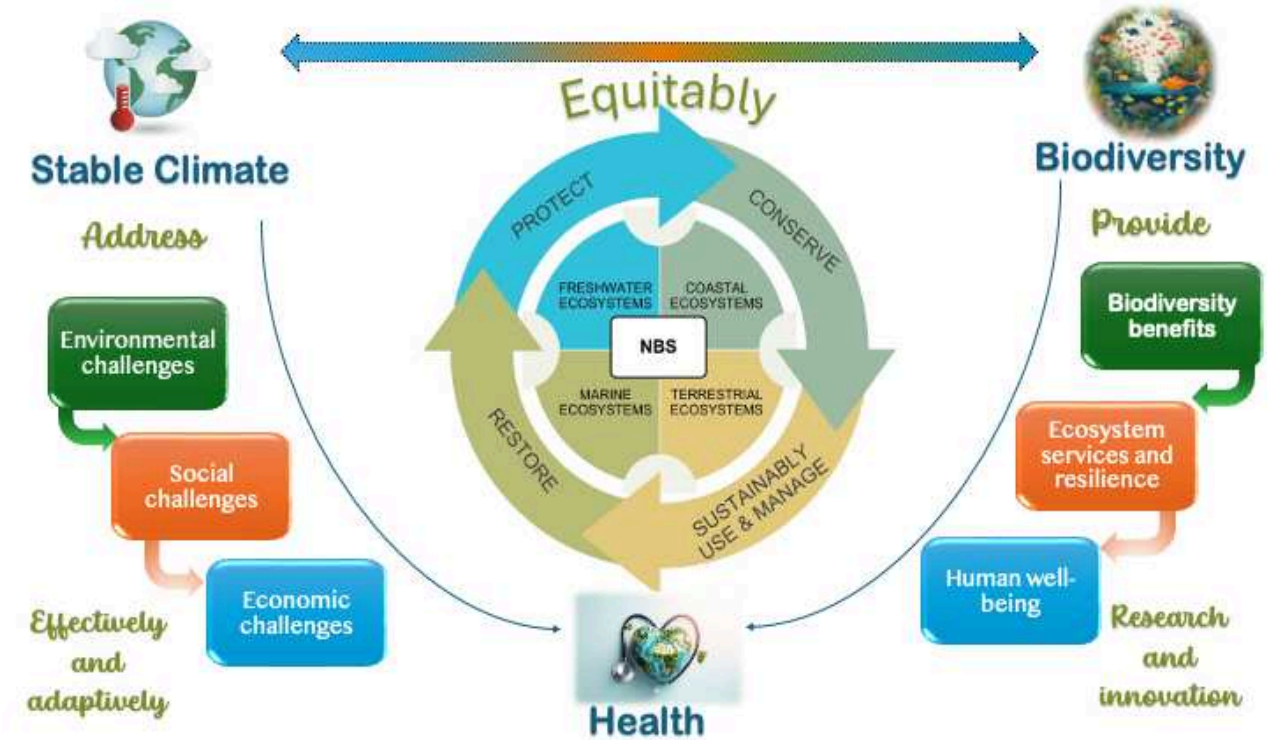
Framing health as a core, purposeful objective of NbS (see Figure 1), rather than an assumed co-benefit, and including health-related sectors in co-benefits and trade-off analyses will yield more robust, context-specific NbS assessments, enhance community acceptance and empower the health sector to scale these solutions.[140] This approach strengthens public health through a more targeted focus on primary prevention,[141] reducing healthcare burdens and enhancing resilience to threats like extreme weather events and zoonotic diseases.

The health sector, in collaboration with other health-determining sectors, must lead the effort to scale up NbS interventions. By leveraging the One Health approach—or similar holistic frameworks—NbS can become a cornerstone of health resilience and environmental sustainability, safeguarding the well-being of people and ecosystems for future generations.

Figure 1: Health in Nature-based Solutions

[140] Giordano, R., Pluchinotta, I., Pagano, A., Scrieciu, A., Nanu, F. (2020). Enhancing Nature-based Solutions Acceptance through Stakeholders' Engagement in Co-benefits Identification and Trade-offs Analysis. Science of the Total Environment, 713, 136552.

[141] Markotter, W.,. Mettenleiter, T.C., Adisasmito, W.B., Almuhairi, S., Barton Behravesh, C., Bilivogui, P., Bukachi, S.A., Casas, N., Cediel Becerra, N., Charron, D.F., Chaudhary, A., Ciacci Zanella, J.R., Cunningham, A.A., Dar, O., Debnath, N., Dungu, B., Farag, E., Gao, G.F., Hayman, D.T.S., Khaitsa, M., Koppmans, M.P.G., Machalaba, C., Mackenzie, J., Morand, S., Smolenskiy, V., Zhou, L. (2023). Prevention of Zoonotic Spillover: From Relying on Response to Reducing The Risk at Source." PLoS Pathogens 19, no. 10 (2023): e1011504.



Strengthening Nature-based Solutions through a One Health Approach

Under the right conditions, NbS leverage natural systems to address a range of societal challenges: enhancing climate resilience, reducing disaster risk, ensuring food and water security, combating biodiversity loss, and improving human health (see Figure 1). However, these co-benefits should not be assumed, nor are they systematically achieved. Effective NbS implementation demands strategic coordination and integration into broader frameworks, with a focus on equity and inclusivity. For example, Indigenous Peoples or surrounding communities, whose cultures, knowledge systems, and livelihoods are deeply interconnected with the ecosystems they steward, must be central to NbS planning. Without their full participation and benefit-sharing (for example through mechanisms such as the Nagoya Protocol) NbS interventions risk compromising community acceptance and perpetuating inequality. In developed and industrialized countries, several local community members also possess valuable stores of traditional ecological knowledge, as a vital element of biocultural diversity – the total variety in natural and cultural systems - which has historically been utilized to address social and environmental challenges. Research has shown that much of this knowledge is in decline, yet holds significant potential for enhancing community resilience.[142]

[142] Molnár, Z., Berkes, F. (2018). Role of Traditional Ecological Knowledge in Linking Cultural and Natural Capital in Cultural Landscapes. Reconnecting Natural and Cultural Capital: Contributions from Science and Policy; Paracchini, ML, Zingari, PC, Blasi, C., Eds, 183-193.

The development and reform of national laws are important for effective NbS implementation and enforcement. Legislative and regulatory instruments should be aligned with the human right to a clean, healthy, and sustainable environment, as this is foundational to the enjoyment of all universally recognized human rights. By embedding the right to a healthy environment within national legal frameworks and incorporating health in NbS approaches, countries can promote coordinated efforts to achieve clean air, a safe and stable climate, access to safe water and sanitation, food security, and thriving biodiversity and ecosystems. Furthermore, the development of related legislative and regulatory instruments can facilitate the adoption of procedural mechanisms to ensure access to information, public participation in decision-making, and access to justice, as applicable, including for vulnerable groups and Indigenous Peoples. The Free Prior and Informed Consent (FPIC) of Indigenous peoples should always be ensured and robust measures should be implemented to ensure transparency, accountability and compliance.

NbS, such as reforestation, wetland restoration, agricultural diversification and other forms of sustainable land management, are recognized for their capacity to contribute to global mitigation efforts. When combined with other strategies, including green-gray infrastructure and technological innovations, NbS can provide over one-third of the cost-effective mitigation needed to achieve global climate targets while also offering co-benefits for biodiversity and human health.[143] However, NbS cannot stand alone; they must be paired with rapid and sustained reductions in greenhouse gas emissions. Moreover, maintaining the provision and effectiveness of some NbS benefits also hinges on achieving global mitigation targets through rapid reductions in fossil fuel use, as climate impacts reduce the capacity of ecosystems to deliver such benefits. As daunting as the impacts already are, climate change is only part of the challenge. Land and sea use changes—including agricultural expansion, intensified land management, and direct exploitation like fishing and logging—are currently the leading drivers of biodiversity loss.[144][145] These combined pressures also significantly heighten health risks, with land use change identified as a leading driver of emerging infectious disease emergence.[146] Addressing biodiversity loss with the same urgency as climate change is essential to safeguarding human and ecosystem health.[147] Integrating both into

[143] Intergovernmental Panel on Climate Climate Change (2022): Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

[144] Jaureguiberry, P., Titeux, N., Wiemers, M., Bowler, D. E., Coscieme, L., Golden, A. S., Guerra, C.A., Jacob, Takahashi, Y., Settele, J., Díaz, Molnár, Z., Purvis, A. (2022). The Direct Drivers of Recent Global Anthropogenic Biodiversity Loss. Science Advances, 8(45), eabm9982

[145] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services. IPBES Secretariat.

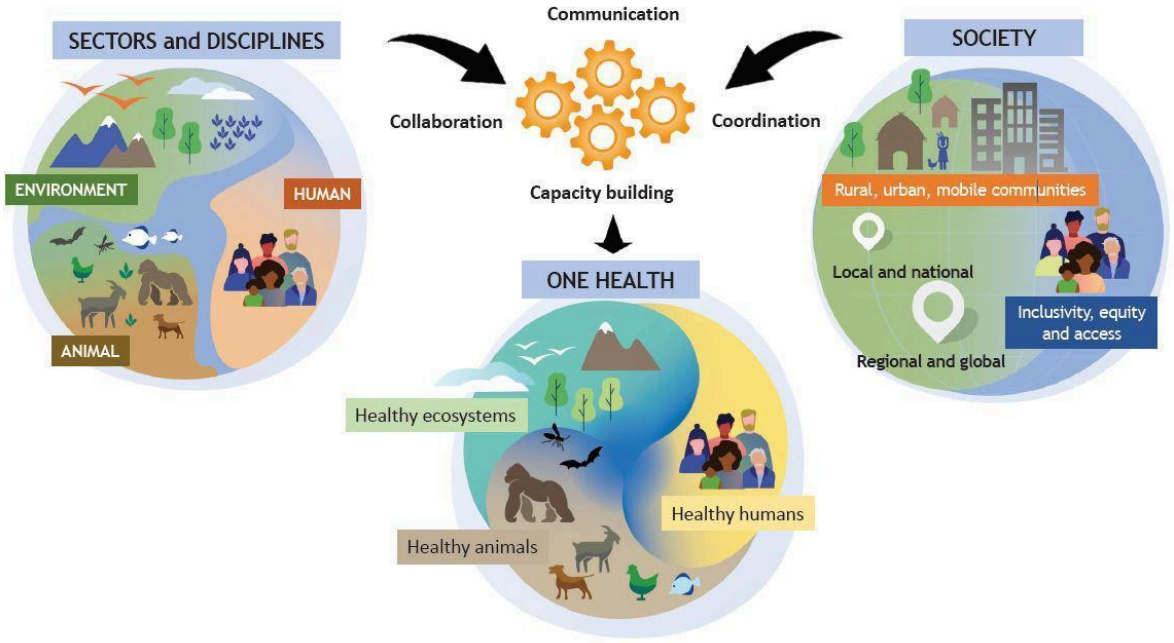
[146] See for example Gottdenker, N. L., Streicker, D. G., Faust, C. L., & Carroll, C. R. (2014). Anthropogenic land use change and infectious diseases: a review of the evidence. EcoHealth, 11, 619-632. It is worth noting that all the leading drivers of biodiversity loss, also identified by the IPBES (2019) including land use change, overexploitation of resources, climate change, invasive alien species and pollution are also leading drivers of disease emergence. See for example WHO & CBD, 2015.

[147] Jaureguiberry, P., Titeux, N., Wiemers, M., Bowler, D. E., Coscieme, L., Golden, A. S., Guerra, C.A., Jacob, Takahashi, Y., Settele, J., Díaz, Molnár, Z., Purvis, A. (2022). The Direct Drivers of Recent Global Anthropogenic Biodiversity Loss. Science Advances, 8(45), eabm9982

broader policy frameworks is essential for comprehensive and sustainable responses to contemporary challenges to human and planetary health.

Complementing NbS are integrated approaches to health such as One Health, defined by the One Health High-Level Expert Panel (OHHLEP)[148] as "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 clean water, energy, and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development".[149]

Figure 2: One Health Approach



Source: OHHLEP 2021

The World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (WOAH) and the United Nations Environment Programme

[148] The One Health High-Level Expert Panel is a multidisciplinary group of international experts established in 2021 to provide scientific and policy advice on One Health issues. The panel was proposed by France and Germany, with the support of the World Health Organization (WHO), the World Organization for Animal Health (WOAH), the United Nations Food and Agriculture Organization (FAO), and the United Nations Environment Programme (UNEP).
[149] See https://www.who.int/news/item/01-12-2021-tripartite-and-unep-support-ohhlep-s-definition-of-one-health

(UNEP) are jointly working to mainstream the One Health approach, acknowledging its essential role in addressing environmental determinants of health. This not only includes through the development of evidence, capacity-building, and awareness raising activities but also a vast number of tools developed by each individual agency. The Quadripartite Alliance for One Health developed a Joint Plan of Action on One Health and related implementation guide to support One Health implementation at national level[150], and also supports regional capacity-building activities. These combined efforts support countries in operationalizing One Health at all levels, enabling them to better address common objectives at the intersection of health and global environmental change. WHO and other implementation partners are also contributing to strengthening national One Health implementation efforts, with a focus on addressing the drivers of biodiversity loss, through the Nature4Health (N4H) Initiative, to strengthen national capacity for primary prevention.

In addition to efforts led by each of these agencies, their vast network of partners, and advisory bodies such as the OHHLEP, many national governments, communities, regions, and other partners are also leading complementary efforts to mainstream and implement holistic approaches in policies, projects and initiatives at the community, national, and regional levels. These national and locally driven initiatives are essential for ensuring that One Health strategies are context-specific and aligned with global frameworks such as the KMGBF. Cross-sectoral multi-stakeholder initiatives have the potential to be more effective, comprehensive and tailored than those carried out by any individual sector, and funding and recognition of their added value must be significantly scaled up.

[150] See the Quadripartite Alliance's guide to implementing the One Health Joint Plan of Action at national level (2023),officially launched at the WHO Health Pavilion at UNFCCC COP 28. Available at: https://www.who.int/publications/i/item/9789240082069

Photo Credit: Bioversity International/Danny Hunter

I. The Added Value of One Health

One Health can enhance NbS strategies by facilitating a whole-of-government, cross-sectoral approach that actively balances trade-offs and amplifies co-benefits across health, biodiversity, and climate outcomes. By promoting collaboration between sectors such as health, agriculture, and the environment, One Health and other holistic approaches enable more coordinated and evidence-based planning. Integrated planning helps to evaluate co-benefits and avoid the unintended consequences of implementing siloed measures that focus only on positive outcomes for one sector (to the potential detriment of others). For example, large-scale afforestation projects aimed solely at sequestering carbon may inadvertently result in the planting of non-native monocultures, undermining local biodiversity and disrupting vital ecosystem services such as water regulation and soil health. Without multi-sectoral input, multi-stakeholder and community engagement from the first stages of development, these interventions may lead to unintended consequences,[151][152] such as reducing public

[151] Giordano, R., Pluchinotta, I., Pagano, A., Scrieciu, A., Nanu, F. (2020). Enhancing Nature-based Solutions Acceptance through Stakeholders' Engagement in Co-benefits Identification and Trade-offs Analysis. Science of the Total Environment, *713*, 136552.

[152] Martín, E. G., Giordano, R., Pagano, A., Van Der Keur, P., & Costa, M. M. (2020). Using A System Thinking Approach To Assess The Contribution of Nature- based Solutions to Sustainable Development Goals. Science of the Total Environment, 738, 139693.

acceptance and uptake, further degrading biodiversity, exacerbating climate risks, introducing new health risks, or deepening existing inequalities.

Similarly, climate actions that fail to consider health and biodiversity outcomes—such as agricultural shifts without assessing impacts on food security, nutrition, water quality, or ecosystem integrity—can inadvertently increase health risks and drive biodiversity loss, particularly for marginalized populations. A whole-of-government One Health approach integrating expertise from health-determining sectors, facilitates the identification of targeted measures to manage potential trade-offs. Combining NbS with One Health enables more resilient solutions better tailored to the local context.

By incorporating knowledge and data from multiple sectors and stakeholder groups, this approach allows for a more careful consideration of environmental and socio-economic determinants of health, as well as cultural preferences that influence how communities interact with their environment and manage health risks. A range of other holistic approaches, such as Ecohealth[153] and Planetary Health[154], can similarly support the design of NbS, ensuring a comprehensive understanding of these intersecting variables. A One Health approach ensures that NbS solutions not only mitigate and adapt to climate change but also conserve biodiversity and promote sustainable resource use, fostering a healthier, more resilient ecological and social systems. In addition to NbS and One Health projects, there are a number of highly complementary initiatives, such as the WHO-led Alliance for Transformative Action on Climate and Health (ATACH)[155] and the Pathfinder Initiative, that contribute to climate resilient and sustainable health systems.[156]

II. Illustrating NbS and One Health Synergies

This report showcases the potential of NbS to address key health and environmental challenges recognizing that effective and sustainable responses to these complex global challenges necessitate a holistic approach that recognizes the interconnectedness of human, animal, plant and ecosystem health. Table 1 categorizes the NbS interventions explored in this report based on their primary focus and highlights synergies between these interventions and the One Health approach. The detailed descriptions of each case study, provided in the following section, further elucidate these synergies and demonstrate the significant and wide-ranging co-benefits resulting from the strategic integration of NbS into a One Health framework.

---

[153]See for example Charron, D. F. (2011). Ecohealth Research in Practice. In Ecohealth Research in Practice: Innovative Applications of an Ecosystem Approach to Health (pp. 255-271). New York, NY: Springer New York.

[154] See for example, Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., de Souza Dias, B. F., et al. (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The lancet*, *386*(10007), 1973-2028.

[155] See https://www.who.int/initiatives/alliance-for-transformative-action-on-climate-and-health

[156] For example, the Pathfinder Initiative highlights the critical need for systemic solutions that integrate health into climate action. By targeting multiple sectors, Pathfinder highlights how reducing emissions can deliver significant health co-benefits, complementing the NbS and One Health approaches emphasized in this report. See https://www.lshtm.ac.uk/research/centres-projects-groups/pathfinder-initiative

Table 1: Enhancing Health Co-Benefits through NbS and OH

NbS Intervention Category	NbS Interventions Implemented	NbS/One Health Synergies	Examples/Case Studies*
Biodiversity Conservation & Protection	Community education, wildlife surveillance, habitat restoration, protection of biodiversity hotspots, sustainable harvesting practices	Reduced zoonotic disease risk, enhanced ecosystem services, Biodiversity protection, Community engagement and education equitable access to resources	Integrating Biodiversity and Health Messaging (Liberia); Community-designed NbS (Madagascar); Pimachiowin Aki Assembly; The Stabilising Land Use Project (PLUS)
Integrating Nature into Healthcare	Nature prescriptions, urban greening, improved access to quality green spaces	Reduced stress, anxiety, and depression; improved overall mental health; enhanced sense of well-being	Park Prescriptions (PaRx); Green Heart Louisville Project; Lahti Health Forest; Active in Nature (Healthy Parks., Healthy People) Connecting Climate Minds
Sustainable Food Systems	Regenerative agriculture, diversified farming, composting, food system profiling	Enhanced food security & nutrition, improved soil health, climate-resilient agriculture, healthier diets, reduced reliance on chemical inputs	The Periodic Table of Food Initiative (PTFI); Naandi Foundation; The Stabilising Land Use Project (PLUS) Meloy Fund for Sustainable Fisheries

Improved Water & Sanitation	Best management practices, sustainable sanitation systems, water purification	Enhanced water quality, reduced waterborne diseases, improved community health, sustainable waste management	New York City Watershed Agricultural Program; Tiger Worm Toilets
Ecosystem Restoration & Resilience	Reforestation, wetland restoration, agroforestry, payments for ecosystem services, parametric insurance	Enhanced ecosystem resilience, enhanced ecosystem connectivity, carbon sequestration, reduced disaster risk, improved human & environmental health	Health Systems Reimagined (Indonesia); Insuring the Mesoamerican Coral Reef; Payments for Ecosystem Services (Costa Rica) The Stabilising Land Use Project (PLUS)
Community Empowerment & Engagement	Radical listening, community-led design & implementation, capacity building, traditional knowledge integration, securing land tenure rights	Improved health outcomes, empowered communities including youth or vulnerable groups, enhanced social justice, sustainable livelihoods, resilient communities	Indigenous Peoples Assistance Facility (IPAF); Årramăt Project; Community-designed NbS (Madagascar); Active in Nature (Healthy Parks, Healthy People) Naandi Foundation Connecting Climate Minds Meloy Fund for Sustainable Fisheries
Stimulating research and innovation	Capacity-building, education, research collaborations to improve NbS design;	Strengthened capacity of stakeholders from different sectors; improved assessment of co-benefits and trade-offs; improved capacity for disease prevention	AFROHUN; Ărramăt Project Connecting Climate Minds

			Ecosystems Protecting Infrastructure and Communities (EPIC) Nepal PTFI;
Disaster Risk Reduction via Green Infrastructure	Bioengineering, community-based disaster risk reduction (Eco-DRR)	Supporting ecosystem health; Strengthening ecosystem service delivery; Enhanced community engagement and acceptance	Ecosystems Protecting Infrastructure and Communities (EPIC) Nepal

* Numerous initiatives cut across several NbS intervention categories, the above are incorporated as examples not an exhaustive list. Similarly, synergies described here are examples of synergies but numerous are cross cutting.

III. The Imperative for (One) Health Leadership

This report arrives at a critical juncture for the health sector, which has a unique responsibility to address the complex and growing impacts of environmental changes on human health. Aligning NbS with the One Health approach offers a powerful framework for developing more integrated, cross-sectoral health interventions that target the underlying ecological, socio-economic and other drivers of poor health outcomes, further strengthening the capacity for primary prevention.[157]

NbS, when aligned with an inclusive application of One Health predicated on the OHHLEP definition and theory of change, can more effectively address the full range of environmental determinants of health, such as habitat destruction, deforestation, and land-use changes, alongside its economic and social determinants, which contribute to zoonotic disease spillover, food insecurity, and a wide range of other health risks to people, animals plants and ecosystems. By fostering healthy ecosystems, we not only improve human health outcomes, but also strengthen the resilience of communities to climate impacts, pandemics, and other environmental shocks. Together, these strategies can advance a vision of health resilience that extends beyond health-related sectors, supporting sustainability and environmental stewardship as key components of well-being.

Health professionals, policymakers, and institutions have an important role to play in championing NbS as critical interventions for reducing health risks and to work alongside all other health-determining sectors. These

[157] For a discussion on primary prevention, see for example this white paper, authored by the members of the One Health High-Level Expert Panel (OHHLEP)
https://cdn.who.int/media/docs/default-source/one-health/ohhlep/ohhlep-prevention-of-zoonotic-spillover.pdf
See also Wanda Markotter, Thomas C. Mettenleiter, Wiku B. Adisasmito, Salama Almuhairi, Casey Barton Behravesh, Pépé Bilivogui et al. "Prevention of zoonotic spillover: From relying on response to reducing the risk at source." PLoS Pathogens 19, no. 10 (2023): e1011504.

strategies can more effectively increase food and nutrition security, improve air and water quality, support mental health, and enhance community resilience to environmental crises. The One Health approach complements these efforts by providing a multisectoral framework that addresses health risks at their source, ensuring that nature-based interventions are evidence-based, equitable, inclusive, and protective of vulnerable populations. Aligning NbS and One Health also facilitates coordinated actions that mitigate climate change, preserve biodiversity, and strengthen public health systems, leading to sustainable, long-term solutions for both human and planetary health.

Risk Mitigation Strategies

NbS offer a powerful approach to addressing interconnected global challenges, as outlined in this report. However, it's crucial to acknowledge that, like any intervention, NbS projects can have unintended negative consequences if not carefully planned and implemented. A robust NbS approach necessitates the proactive identification and mitigation of potential risks to ensure long-term ecological, social, and economic sustainability. This section will outline potential risks associated with NbS and propose strategies for their mitigation.

I. Ecological Risks and Mitigation

While NbS aim to enhance biodiversity and ecosystem services, poorly designed interventions can have the opposite effect[158]. Monoculture planting, for example, can reduce species diversity and ecosystem resilience. The introduction of non-native species can disrupt existing ecological communities and lead to invasive species proliferation. Furthermore, poorly planned NbS projects may inadvertently alter natural hydrological cycles, nutrient flows, or sediment transport, with detrimental effects on water quality and downstream ecosystems. Habitat fragmentation, resulting from NbS implementation, can also negatively affect biodiversity and ecosystem processes. To mitigate ecological risks (and avert trade offs), NbS projects must incorporate rigorous environmental impact assessments that consider both biodiversity and ecosystem-level processes, and should also consider these results alongside health impact assessments. The use of diverse native species, promoting habitat connectivity, and implementing adaptive management strategies are crucial for enhancing ecosystem resilience. Regular monitoring is necessary to detect and address unintended ecological consequences. Careful site selection, avoiding sensitive habitats, and implementing restoration plans can also reduce risks.

II. Socio-Economic Risks and Mitigation

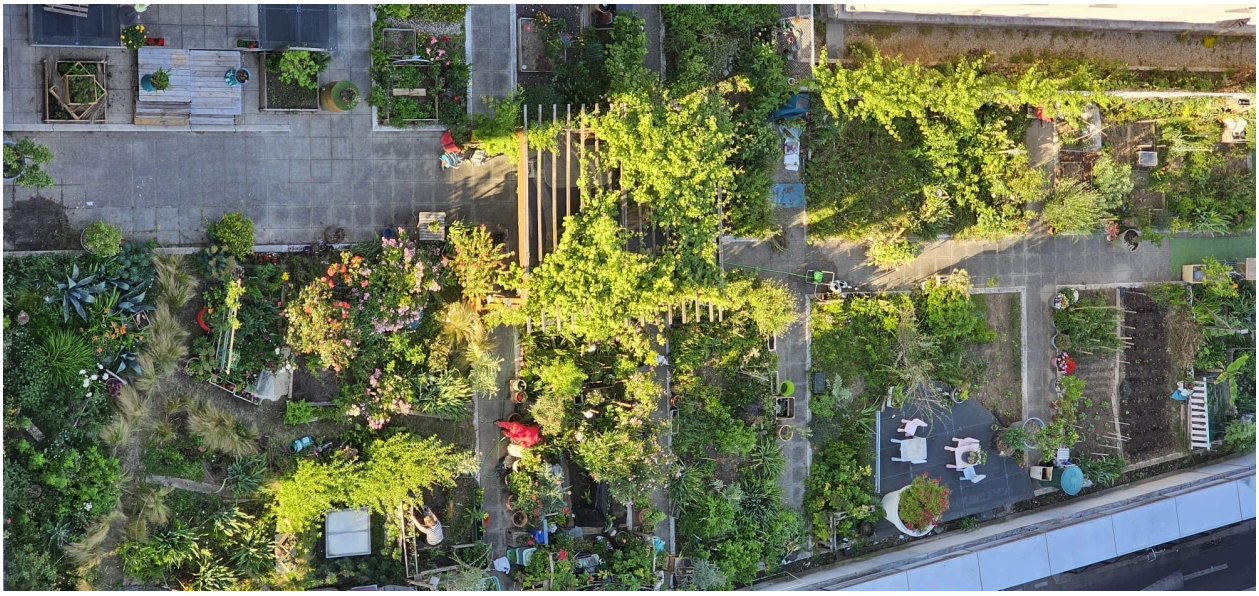
NbS implementation can sometimes lead to social inequities if not carefully managed.[159] Land-use changes associated with NbS (e.g., afforestation or wetland restoration) may displace or marginalize communities

[158] Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., House, J. Srivastava, Turner, B. (2021). Getting the Message Right on Nature-based Solutions to Climate Change. Global Change Biology, 27(8), 1518-1546.

[159] Bremer, L. L., Keeler, B., Pascua, P., Walker, R., Sterling, E. (2021). Nature-based Solutions, Sustainable Development, and Equity. In Nature-based Solutions and Water Security (pp. 81-105). Elsevier.

dependent on existing land uses. Unequal distribution of benefits from NbS can exacerbate existing social inequalities and undermine community acceptance of projects.[160] Lack of meaningful community engagement in the planning and implementation phases can also lead to conflict and resentment.[161] Conflicts over resource access can also arise, especially in areas with overlapping land claims or competing interests. Strategies to mitigate social risks include participatory planning that actively engages affected communities. Ensuring FPIC from Indigenous Peoples is essential, and should be accompanied by meaningful consultations with affected communities. Transparency and accountability in benefit-sharing practices are also critical and establishing community-based mechanisms for addressing grievances. Robust conflict resolution mechanisms should also be implemented to address any potential disputes that may arise.

Economic mitigation strategies should also be carefully developed. Poorly designed projects may fail to deliver anticipated economic benefits, hindering both local development and broader NbS uptake. Over-reliance on external funding can also create dependency and vulnerability. Mitigating economic risks requires a diversified and sustainable funding strategy. This could involve blended finance that combines public, private, and philanthropic funding sources. Long-term planning and monitoring of financial and economic outcomes are vital to ensure project sustainability and attract further investment. Developing innovative financial instruments, such as payments for ecosystem services or carbon credits, can enhance economic viability.



Source[162]: CEKretsch/ Cohab, 2024.

[160] Wolch, J. R., Byrne, J., Newell, J. P. (2014). Urban Green Space, Public Health, and Environmental Justice: The Challenge of Making Cities 'Just Green Enough'. Landscape and Urban Planning, 125, 234-244.

[161] Borelli, S., Conigliaro, M., Salbitano, F. (2021). The Social Impacts of NBS: Access to and Accessibility of Green Spaces as a Measure of Social Inclusiveness and Environmental Justice. In Nature-Based Solutions for More Sustainable Cities–A Framework Approach for Planning and Evaluation (pp. 211-224). Emerald Publishing Limited.

[162] Photo of a Rooftop Community gardening in Paris, supporting pollinators, food diversity and nutrition, mental and physical fitness and urban greening for climate mitigation.

Implementing NbS for Health: Key Recommendations

The report presents ten actionable recommendations, presented below, each addressing how nature-health linkages and One Health can be leveraged to improve health outcomes in NbS. A *Highlights Brief* summarizing these ten recommendations (see Figure 3) was launched in December 2023 at the UNFCCC COP 28, providing a concise overview of the report's key messages and strategies for integrating NbS into public health frameworks.[163]

These case studies, which reflect varied stages of implementation across diverse regions and sectors, not only demonstrate the feasibility of scaling up NbS but also serve as concrete examples of how integrating health and nature can yield transformative outcomes. The following recommendations build on this foundation, starting with the critical role of biodiversity, healthy ecosystems, and climate stability in achieving better health outcomes.

Figure 3: 10 Recommendations

[163] World Health Organization and International Union on the Conservation of Nature (2023): Highlights Brief on WHO-IUCN Report on Designing Nature-Based Solutions for Human Health. WHO & IUCN. Link.

To begin, **biodiversity, healthy ecosystems, and a stable climate** are foundational to achieving positive health outcomes. Key ecosystem services, including clean air and freshwater, food provision, and disease regulation form the backbone of human health and strengthen resilience in the face of global environmental changes. It is essential to ensure that the sustainable management, restoration and use of biodiversity and conservation of healthy ecosystems is meaningfully embedded in NbS. International agreements, such as the KMGBF, align ecosystem health and human development, reinforced by local action to protect health-benefiting ecological functions and services (See Recommendation I and related case studies).

Secondly, the report emphasizes the need to **educate and empower health professionals to engage directly with NbS, and nature**. By equipping health professionals with the knowledge and tools to integrate ecological health into clinical and public health practice, they can become essential advocates and supporters of NbS. Initiatives like Nature Rx and PaRx, which prescribe time in nature as part of healthcare, showcase the tangible mental and physical health benefits of nature-based interventions (See Recommendation II and related case studies). These programs demonstrate how bridging healthcare with nature can improve overall well-being, making the case for scaling such initiatives.

Third, an indispensable component of improving health outcomes is to **transform food systems to be both nature-positive and resilient**. Sustainable food systems not only bolster climate resilience but also reduce waste and promote equitable access to nutritious diets.[164] By supporting agroecology, regenerative agriculture, and traditional food systems, these approaches contribute to enhanced food security, improved nutrition, and

[164] EAT-Lancet Commission (2023): Summary Report: Healthy Diets From Sustainable Food Systems. EAT-Lancet Commission. Available at: https://eatforum.org/eat-lancet-commission/eat-lancet-commission-summary-report/

overall environmental health (See Recommendation III and related case studies).[165] Transforming food systems is not just an option or "nice to have" — it is an irrevocable necessity to ensure that all people, within planetary boundaries, have access to healthy, nutritious diets that support both human and planetary health.

The report also emphasizes the need to **use NbS to improve access to safe water, sanitation, hygiene, and waste management (WASH)**. Natural systems such as watersheds, wetlands along with sustainable sanitation facilities like the Tiger Worm Toilet, play an instrumental role in water supply management, reducing contamination, and enhancing access to and the resilience of WASH services (See Recommendation IV and related case studies).[166] By harnessing the natural filtration and resilience of ecosystems, these interventions directly address critical public health challenges, ensuring access to clean water, effective sanitation, and sustainable hygiene systems that are vital for reducing disease and promoting long-term health outcomes.

Fifth, **integrating urban ecosystems into public health planning** is essential for building healthier, more resilient cities. Urban green and blue spaces support physical activity, mental health, flood resilience, air purification and can reduce the heat-island effect, making them indispensable to the development of health-promoting environments. Initiatives such as Cities with Nature exemplify how green infrastructure can enhance health-promoting opportunities and sustainability in urban areas, offering a variety of models for developing sustainable cities globally (See Recommendation V and related case studies). As urban populations increase, the need for accessible, health-promoting environments becomes increasingly critical.

Sixth, the report emphasizes the urgent need to **redesign energy and transport systems** to reduce the detrimental impacts of fossil fuels on both public health and ecosystems. Fossil-fuel-based energy systems are major contributors to air pollution, a leading risk factor for non-communicable diseases, resulting in millions of premature deaths worldwide. Integrating green-gray infrastructure provides a transformative solution by combining natural ecosystems with engineered systems to manage environmental challenges, reduce emissions, enhance biodiversity, and support sustainable development. For instance, Nepal's Eco-Safe Roads Project showcases how incorporating ecological elements into transport infrastructure can mitigate pollution, prevent landslides, and promote healthier, more resilient communities. Similarly, transitioning away from fossil fuel-dependent systems toward greener alternatives can significantly lower the health risks associated with air pollution, such as respiratory and cardiovascular diseases (See Recommendation VI and related case studies). These examples highlight the potential of green-gray infrastructure to reshape energy and transport systems, reducing pollution, protecting ecosystems, and fostering healthier, more equitable living environments.

The seventh recommendation advocates for **placing equity at the centre of NbS design, governance, and implementation,** a central consideration for the success of NbS. Ensuring that Indigenous Peoples, local

[165] FAO, IFAD, UNICEF, WFP, and WHO (2021): The State of Food Security and Nutrition in the World 2021. Transforming Food Systems for Food Security, Improved Nutrition and Affordable Healthy Diets for All. Food and Agriculture Organization of the United Nations (FAO).
[166] Famiglietti, J. (2019): A Map of the Future of Water. The Pew Charitable Trusts. Link.

communities, and marginalized populations are actively included in decision-making processes is essential for developing NbS that are not only socially acceptable but also culturally relevant and effective in addressing health disparities. These groups, often disproportionately impacted by environmental degradation and health inequities, bring invaluable knowledge and practices that enhance the sustainability and success of NbS initiatives. For example, the Indigenous Peoples Assistance Facility (IPAF), empowers Indigenous Peoples in Africa, Asia, and Latin America to manage natural resources and protect biodiversity, contributing to improved health outcomes through the recovery of traditional seeds and medicinal herbs (See Recommendation VII and related case studies). By integrating their perspectives, NbS can foster healthier ecosystems and communities while advancing social justice and health equity.

Eighth, the report emphasizes the importance of **empowering Indigenous Peoples and under-resourced communities** to play a central role in the development and implementation of Nature-based Solutions (NbS). Indigenous knowledge is indispensable for effective ecosystem management, as Indigenous-led initiatives have demonstrated enhanced community and ecosystem resilience across various regions. For instance, the Health in Harmony programs in Gunung Palung, Indonesia, and the Manombo Special Reserve, Madagascar, illustrate how Indigenous stewardship not only conserves biodiversity but also fosters healthier, more resilient communities by integrating traditional practices with modern NbS approaches (See Recommendation VIII and related case studies). Indigenous Peoples' territories harbour 80% of the world's biodiversity, and their conservation practices, rooted in deep cultural and ecological traditions, have proven vital for climate stability and biodiversity protection. By ensuring Indigenous Peoples have the resources and platforms to co-design and lead NbS projects, we can better safeguard both planetary and human health, while advancing equity and resilience in the face of global environmental challenges.

Ninth, the report underscores the transformative potential of **youth leadership and innovation** in addressing the complex challenges at the intersection of nature and health. Young people are not only catalysts for global climate movements, like Fridays for Future and Zero Hour, but also key drivers of innovative solutions that challenge the status quo. Initiatives such as the One Health Young Leaders program and Connecting Climate Minds showcase how youth-led efforts are redefining the way we approach planetary health, mental well-being, and ecosystem resilience. These programs prove that youth voices are not just vital for shaping future policies—they are already creating new pathways for integrating NbS into mental health care, climate adaptation, and sustainable development. By empowering young leaders, we can ensure that the next generation’s vision for a healthier, more sustainable world is realized, turning today's challenges into tomorrow's opportunities. The involvement of youth in NbS, particularly in addressing the mental health impacts of climate change, underscores their critical role in driving holistic, inclusive solutions that leave no one behind (See Recommendation IX and related case studies).

Tenth, the report highlights the urgent need for **financing inclusive NbS that prioritize health outcomes**, and to close the US$700 billion annual finance gap for NbS that prioritize health outcomes.[167] Current investments fall short, requiring innovative financial tools such as green bonds, blended finance, and natural asset insurance to attract both public and private capital. The health sector plays a critical role, as NbS offer significant public health benefits, from improving air and water quality to enhancing food security and reducing disease risks. The Meloy Fund for Sustainable Community Fisheries exemplifies how NbS financing can protect ecosystems while improving nutrition, livelihoods, and overall community resilience (See Recommendation X and related case studies). By scaling up targeted investments in NbS that support health, we can simultaneously safeguard ecosystems and address pressing global health challenges, ensuring sustainable development for vulnerable populations that rely heavily on natural resources.

These ten recommendations provide a clear roadmap for making both improved health outcomes and health-nature linkages explicit co-benefits within NbS, while combining these efforts with integrated approaches such as One Health. By drawing on real-world evidence-based examples, the recommendations that follow offer actionable strategies to jointly address biodiversity loss, climate change, and public health risks together. These recommendations, supported by case studies from diverse regions, highlight how integrating health and environmental goals can create transformative solutions that benefit both people and the planet. This comprehensive strategy underscores the need for cross-sectoral collaboration, fostering integrated approaches that prioritize equity, sustainability, and long-term health resilience.

Scope, Purpose, and Methodology

I. Scope

This report addresses the complex interconnections between climate change, biodiversity loss, pollution, and health, focusing on how Nature-based Solutions (NbS) can be strategically leveraged to mitigate these intertwined crises. It offers a dedicated focus on nature-health linkages.

WHO's long-standing efforts to tackle the health impacts of climate change[168] are exemplified through its ongoing promotion of climate-resilient health systems, building capacity and monitoring science and evidence on climate and health, supporting countries to protect human health from climate change, and advocacy for the recognition of health co-benefits in climate action[169]. These efforts are also exemplified in WHO leadership in

[167] Finance Earth. (2021). A Market Review of Nature-Based Solutions: An Emerging Institutional Asset Class. Green Purpose Company, Finance Earth.

[168] See https://www.who.int/health-topics/climate-change#tab=tab_1

[169] Numerous tools and partnerships have been established by WHO on climate and health. For example, the WHO-WMO Joint Climate and Health programme promotes the integration of climate data into health decision-making, including early warning systems for extreme heat, air quality, and infectious diseases. See, https://wmo.int/activities/who-wmo-joint-climate-and-health-programme

integrating health and environmental determinants (including biodiversity and climate change) into frameworks such as One Health, by supporting country implementation, and Health in All Policies,[170] in collaboration with a vast network of partners.[171]

Building on WHO's significant body of work at the intersection of climate and health, this report adds value by placing a central focus on biodiversity, nature, and NbS. It emphasizes how protecting and restoring ecosystems can enhance health outcomes, strengthen climate and health resilience, and deliver essential services like water purification and disease regulation. By prioritizing NbS, this report complements WHO's efforts, offers nature-centered solutions that further align with an inclusive One Health approach, and other holistic approaches, and provides integrated benefits for both environmental and public health challenges, with a strong focus on vulnerable populations.[172]

While climate remains a critical factor in this study, the report expands beyond climate action to purposely consider the often-overlooked links between nature and health. NbS are presented as an essential - albeit not exclusive - tool for addressing health challenges, such as improving air and water quality, ensuring food security, supporting mental health, and preventing infectious diseases. By tackling broader drivers of biodiversity loss—such as deforestation, unsustainable land use, and habitat degradation—the report advocates for an integrated, equitable, and socially just approach to climate and biodiversity challenges.

At its core, the report emphasizes the essential role that healthy ecosystems play in sustaining human health and well-being, underscoring the reciprocal relationship between health and nature. It highlights the need for NbS to be embedded within broader holistic frameworks, such as One Health, to maximize their effectiveness. One Health promotes the interconnectedness of human, animal, plant, and ecosystem health, calling for coordinated, cross-sectoral responses to address today's pressing environmental and health challenges. By situating NbS within this broader vision, the report aligns with global efforts to address planetary and health crises together.

The report links ten key recommendations to case studies that illustrate how NbS can address a variety of health challenges in both rural and urban contexts. These case studies offer actionable insights for addressing major environmental and health challenges—such as deforestation, unsustainable land use, and habitat degradation — illustrating health benefits that can be derived from NbS. They demonstrate how integrated, nature-based approaches can generate co-benefits for human, animal, plant, and ecosystem health, and highlight the potential

---

[170] See WHO Response to Biodiversity and Health Challenges https://www.who.int/teams/environment-climate-change-and-health/climate-change-and-health/biodiversity. See also Nature4Health Initiative, https://nature4health.org/

[171] https://www.who.int/europe/news-room/fact-sheets/item/nature--biodiversity-and-health

[172] For example, the large number of activities carried out under the CBD-WHO Joint work Programme on biodiversity and health. See https://www.who.int/news/item/01-01-2020-biodiversity-and-health-the-who-cbd-joint-work-programme . The work of the WHO-IUCN Expert working group is also an extension of that work as it builds on activities of the CBD-WHO Joint work programme and its Interagency-Liaison Group on Biodiversity and Health. https://www.who.int/news/item/30-03-2021-who-iucn-expert-working-group-biodiversity

for biodiversity protection, restoration, and sustainable use to deliver both immediate and long-term health outcomes.

The report aims to inspire policymakers and key stakeholders to integrate NbS into public health strategies, ensuring that health considerations are embedded in the development and implementation of NbS. Although health has not yet been fully integrated as a co-benefit of NbS, the report seeks to catalyze transformative change by laying the foundation for scaling up efforts. Through a One Health lens, NbS can enhance health outcomes, build resilience to climate impacts, and safeguard ecosystems, while fostering policy coherence and maximizing co-benefits.

The report also emphasizes the importance of equity, inclusion, and rights-based governance in scaling up NbS, with special attention to marginalized communities, women, and Indigenous Peoples. It highlights the critical role that Indigenous Peoples' traditional knowledge and stewardship play in the success of NbS initiatives.

Finally, the report calls for leadership across all sectors to integrate health more robustly into NbS strategies. Cross-sectoral collaboration, interdisciplinary knowledge sharing, and stronger partnerships are essential to achieving joint health and environmental goals. Sustained collaboration, through a whole-of-government approach, will ensure that NbS deliver equitable and sustainable outcomes for both people and nature.

II. Purpose

The primary purpose of this report is to provide policymakers with evidence-based recommendations for integrating NbS into public health policy, planning, and practice, while also mainstreaming health into NbS strategies. The report emphasizes the need to make the integration and identification of health co-benefits more explicit, ensuring that health is recognized as a core component of NbS. By doing so, it seeks to catalyse leadership from policy makers, health professionals and stakeholders from health-determining sectors, encouraging them to take a more proactive and coordinated role in supporting NbS efforts.

In addition to guiding decision-makers in adopting NbS as effective public health interventions through ten targeted recommendations, the report demonstrates how NbS can deliver multiple benefits—from biodiversity conservation to improved health outcomes— through a series of case studies, and through integrated approaches such as One Health. The convergence of these efforts can strengthen collaboration and policy coherence across sectors, ensuring that health remains a central focus in NbS strategies.The report highlights the vital links between nature and health, emphasizing that NbS are essential not only for addressing immediate health challenges—such as water security, food safety, and disease prevention—but also for contributing to broader environmental goals through a One Health lens. Through its focus on equity and inclusion, the report prioritizes the needs of vulnerable populations, including Indigenous Peoples, women, and marginalized communities, in the design and implementation of NbS.

III. Methodology

The development of this report involved a comprehensive methodology that combined stakeholder consultations, case study analysis, and a focused literature review. This multifaceted approach was designed to ensure that the recommendations are informed by diverse perspectives and grounded in practical, real-world applications. The process integrated experiences from various sectors, regions, and knowledge systems, with particular emphasis on the health co-benefits of NbS.

Consultations with youth,[173]and Indigenous Peoples,[174] together with engagement at key international forums, collectively shaped this report and its ten recommendations, first launched at CBD COP 28 in 2023. Direct input was obtained from these groups through targeted events, while additional evidence-based perspectives was gathered at dedicated events held at the margins of UNFCCC COP 27, COP 28, CBD COP 15, intersessional meetings of the CBD SBSTTA (SBSTTA 24, SBSTTA 25, and SBSTTA 26), and the Prince Mahidol Award Conference 2023 (PMAC 2023).[175] Contributions from the WHO-IUCN Expert Working Group on Biodiversity, Climate Change, and Nature-based Solutions further ensured that the recommendations are grounded in scientific expertise and practical insights. This collaborative process enriched the report by integrating a wide range of experiences and knowledge systems, enhancing the relevance and applicability of the recommendations across various contexts.

The selection of case studies was guided by submissions from the open consultation processes, as well as submissions from the IUCN Health and Well-Being Specialist Group and the WHO-IUCN Expert Working Group on Biodiversity, Climate Change, and NbSs. These experts provided critical reviews, practical insights, and submitted relevant case studies, which ensured that the recommendations reflect real-world applications of NbS across different contexts and stages of implementation. The case studies were specifically chosen for their relevance to health outcomes, scalability, and adaptability, highlighting successful NbS implementations across various regions and ecosystems.

The report also draws upon a focused review of scientific research, policy documents, and international frameworks. This review aligned the recommendations with best practices and global policy agendas, ensuring they are evidence-based, varied and forward-looking. Peer review by additional subject matter experts validated their accuracy and policy relevance.

As we transition to the forthcoming recommendations and case studies, it becomes evident that the leadership of health-related and health-determining sectors is essential to unlocking the full potential of NbS. The following

[173] The initial online intergenerational dialogue on NbS and health was held on 15 September 2021. https://www.who.int/news-room/events/detail/2021/09/15/default-calendar/nature-climate-and-health-catalyzing-an-intergenerational-response

[174] The initial online consultation with Indigenous Peoples, chaired by Mukaro Borero, was held on 25 July 2022. https://www.who.int/news-room/events/detail/2022/07/25/default-calendar/virtual-indigenous-peoples-panel-discussion--inputs-to-the-report-on-health-and-nature-based-solutions

[175] The full session on NbS for health at PMAC 2023 is available from https://pmac2023.com/activity/14/session/detail

sections provide detailed descriptions of each recommendation and highlight practical examples of how integrated nature-based approaches are transforming communities, building resilience, and safeguarding the future of both people and ecosystems. The case studies provide a diverse portfolio of actionable blueprints for scaling up NbS across all levels of governance and society. Collectively, these recommendations illustrate that addressing concurrent environmental and global health crises is not only achievable but timely and necessary.

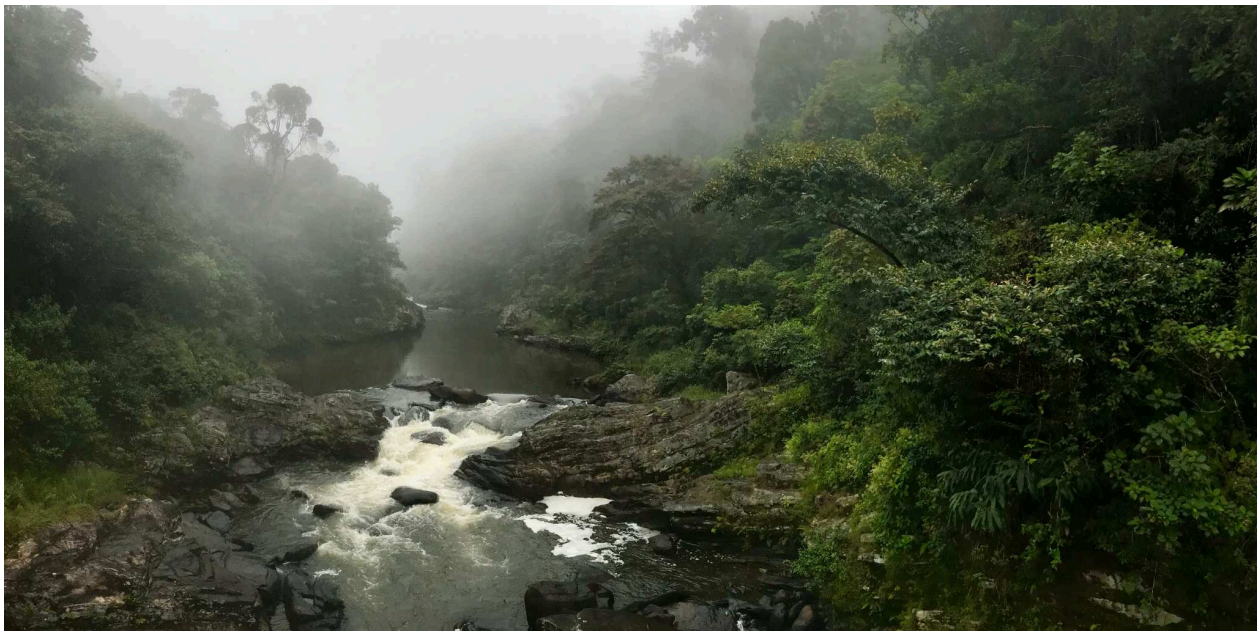


Photo Credit: Amy Krzyzek

Recommendation I: Biodiversity, Healthy Ecosystems and a Stable Climate Are Essential to Achieving Good Health Outcomes

Human activities are responsible for the warming of the planet by approximately 1°C above pre-industrial levels[176] with predictions that the mean surface temperature will increase by 1.4°C to 5.8°C by the end of the century.[177] Associated sea-level rise is estimated to be 0.09 to 0.88m with precipitation rates increasing in equatorial and high-latitude areas.[178] Current warming is leading to a wide range of responses from plants and animals: plants are blooming and leafing earlier, migratory birds are migrating sooner, and many species are shifting their ranges towards higher altitudes and the poles,[179] and according to the IUCN Red List there are over 13,741 species at threat from climate change and severe weather events.

---

[176] Intergovernmental Panel on Climate Change. (2018). Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24. https://doi.org/10.1017/9781009157940.001.

[177] Intergovernmental Panel on Climate Change. (2002). Climate Change and Biodiversity. Gitay, H., Suárez, A., Dokken, D.J., Watson, R.T (eds.).

[178] Intergovernmental Panel on Climate Change. (2002). Climate Change and Biodiversity. Gitay, H., Suárez, A., Dokken, D.J., Watson, R.T (eds.).

[179] Chivian, E., (ed.) (2003). Biodiversity: Its Importance to Human Health, Interim Executive Summary, A Project of the Center for Health and the Global Environment Harvard Medical School under the Auspices of the World Health Organization, the United Nations Development Programme, and the United Nations Environment Programme. Center for Health and Global Environment Harvard Medical School.

Other human activities have induced biodiversity loss via air pollution; diversion of water to intensively managed ecosystems and urban areas; habitat fragmentation; introduction of invasive species; land-use and land-cover change; selective exploitation of species; soil and water degradation and pollution; and stratospheric ozone depletion.[180] Due to such pressures, the years 1970 to 2018 witnessed an estimated 69% drop-off in the relative abundance of monitored wildlife populations[181] and the IUCN Red List has documented over 45,300 species threatened with extinction.

Plants, animals, microbes, and the chemical and physical environment with which they interact make up an ecosystem.[182] Examples of ecosystems are alpine meadows, arctic tundra, cloud forests, and coral reefs[183] and the species that live in these regions are particularly vulnerable to these increased temperatures. Healthy ecosystems support the conditions necessary to human life as they provide food and medicine, purify air and water, neutralize toxins, decompose waste, control floods, moderate storm surges, stabilize landscapes, and regulate the climate and diseases.[184][185] These benefits to people, known as ecosystem services, contribute to human well-being as they supply basic material for a good life, freedom of choice and action, good social relations, security, and last but not least, health.[186][187]

[180] Intergovernmental Panel on Climate Change (2002). Climate Change and Biodiversity. Gitay, H., Suárez, A., Dokken, D.J., Watson, R.T (eds.).
[181] World Wildlife Fund (2022). Living Planet Report 2022- Building a Nature-Positive Society. Almond, R.E.A., Grooten, M., Juffe Bignoli, D. & Petersen, T. (Eds). WWF, Gland, Switzerland.
[182] Chivian, E., (ed.) (2003). Biodiversity: Its Importance to Human Health, Interim Executive Summary, A Project of the Center for Health and the Global Environment Harvard Medical School under the Auspices of the World Health Organization, the United Nations Development Programme, and the United Nations Environment Programme. Center for Health and Global Environment Harvard Medical School.
[183] For a complete list of ecosystems, please see the IUCN Global Ecosystem Typology.
[184] Chivian, E., (ed.) (2003). Biodiversity: Its Importance to Human Health, Interim Executive Summary, A Project of the Center for Health and the Global Environment Harvard Medical School under the Auspices of the World Health Organization, the United Nations Development Programme, and the United Nations Environment Programme. Center for Health and Global Environment Harvard Medical School.
[185] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review.
[186] Millennium Ecosystem Assessment (2005). Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.
[187] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2019). Global Assessment Report on Biodiversity and Ecosystem Services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: IPBES Secretariat.

Several recent assessment reports from the IPBES, IPCC[188][189]and the joint IPBES-IPCC workshop[190] provide compelling evidence of worsening climate change, the impacts of biodiversity loss, ecosystem degradation, and invasive alien species, underscoring the importance of biodiversity conservation, and its sustainable management and use for health and well-being. The COVID-19 pandemic brought to the forefront the interconnectedness between humans, animals, plants and their shared environment, and prompted greater policy attention to zoonosis and disease spillover. Emerging infectious diseases originate from microbes in animal reservoirs, but their occurrence is primarily driven by the same human activities that drive biodiversity loss and climate change, and drive health risk.[191]

Transformative approaches across health-determining sectors are needed to foster solutions that support healthy and biodiverse ecosystems, a stable climate and positive health outcomes. Potential synergies include NbS to promote ecosystem health, human well-being, and mitigate the adverse impacts of climate change.[192] As elaborated in earlier sections of this report, it is also important to establish appropriate safeguards within a rights-based framework, acknowledging the right to a clean, healthy, and sustainable environment as a basic human right.[193] This also means ensuring all stakeholders, especially the most vulnerable and disadvantaged populations- are included at all levels of the decision-making processes in the development of NbS, and ensuring accountability.[194][195][196] It is also important to maintain ecosystem integrity, as fragmentation can lead to ecosystem dysfunction, the disruption of food webs, reduced access to freshwater, and loss of pollination services, among other consequences.[197] As of 2022, only 10% of the world's terrestrial protected areas were connected,[198] and approximately two-thirds of key connectivity areas linking these protected regions remained unprotected. To address habitat fragmentation and enhance climate resilience, connectivity conservation- to

[188] Intergovernmental Panel on Climate Change. (2022). Climate Change 2022. Impacts, Adaptation and Vulnerability. Summary for Policymakers. Intergovernmental Panel on Climate Change.
[189] Intergovernmental Panel on Climate Change. (2022). Climate Change 2022. Mitigation of Climate Change. Summary for Policymakers. Intergovernmental Panel on Climate Change.
[190] Pörtner et al. (2021). IPBES-IPCC Co-Sponsored Workshop: Biodiversity and Climate Change Workshop Report.
[191] Marselle, M.R., Stadler, J., Korn, H., Irvine, K.N., Bonn, A. (2019) Biodiversity and Health in the Face of Climate Change: Challenges, Opportunities and Evidence Gaps.
[192] Marselle, M.R., Stadler, J., Korn, H., Irvine, K.N., Bonn, A. (2019) Biodiversity and Health in the Face of Climate Change: Challenges, Opportunities and Evidence Gaps.
[193] UN General Assembly. (2022). The Human Right to a Clean, Healthy and Sustainable Environment. A/RES/76/300.
[194] World Wildlife Fund (2022). Living Planet Report 2022- Building a Nature-Positive Society. Almond, R.E.A., Grooten, M., Juffe Bignoli, D. & Petersen, T. (Eds). WWF, Gland, Switzerland.
[195] UN Special Rapporteur on Human Rights and the Environment. (2022). The Right to a Clean, Healthy and Sustainable Environment: Non-Toxic Environment (A/ HRC/49/53)
[196] UN Special Rapporteur on Human Rights and the Environment. (2019). Issue of Human Rights Obligations Relating to The Enjoyment of A Safe, Clean, Healthy and Sustainable Environment (A/HRC/40/55)
[197] World Wildlife Fund (2022). Living Planet Report 2022- Building a Nature-Positive Society. Almond, R.E.A., Grooten, M., Juffe Bignoli, D. & Petersen, T. (Eds). WWF, Gland, Switzerland.
[198] Ward, M., Saura, S., Williams, B., Ramírez-Delgado, J. P., Arafeh-Dalmau, N., Allan, J. R., Venter, O., Dubois, G. & Watson, J. E. M. (2020). Just ten percent of the global terrestrial protected area network is structurally connected via intact land. Nature Communications, 11(1), 4563.

protect and restore ecological links across landscapes and waterways through ecological corridors, linkage areas, and wildlife crossings- should also be considered as an effective strategy[199] to improve health outcomes.[200][201]

The following case studies illustrate practical strategies for addressing the interconnected challenges of biodiversity loss, climate change, and their impacts on human health. The Liberia case utilizes a One Health approach to reduce zoonotic disease risks through wildlife surveillance and community engagement, while Madagascar showcases community-led efforts that connect mobile health clinics with sustainable agriculture and reforestation in a biodiversity hotspot. The third case study, PLUS highlights a landscape-scale intervention that integrates biodiversity conservation with One Health principles. Together, these examples emphasize the importance of zoonotic spillover prevention, rights-based approaches, and connectivity conservation in fostering resilience for both ecosystems and public health.

CASE STUDY 1

Community-Designed NbS for Health, Biodiversity and Climate in Madagascar

Madagascar

Photo Credit: Aina Eric Andrianarisata

[199] Keeley, A. T. H., Beier, P., Creech, T., Jones, K., Jongman, R. H., Stonecipher, G. & Tabor, G. M. (2019). Thirty Years of Connectivity Conservation Planning: An Assessment of Factors Influencing Plan Implementation. Environmental Research Letters, 14(10), 103001.

[200] For more information on Connectivity Conservation, see the IUCN Guidelines for Conserving Connectivity.

[201] To learn about the IUCN Green List of Protected and Conserved Areas, a global certification program that recognises well-managed, effectively governed protected areas that achieve successful conservation outcomes for nature and people, see the IUCN Green List.

Overview

Madagascar is a biodiversity hotspot: at least 80% of its plant and animal species are found nowhere else on Earth. The Manombo region of southeastern Madagascar encompasses 5000 hectares of lowland coastal rainforest and stores more than 1 million tonnes of aboveground carbon, providing freshwater, forest products, and weather-regulation for a population of approximately 12,260 people living across 34 villages. However, Madagascar faces serious environmental and health issues: two-thirds of Madagascar's forests have been lost; the island's endemic primates, the lemurs, are at risk of extinction; and Madagascar suffers some of the highest rates of poverty and hunger of any non-conflict zone in the world.

In 2020, Health in Harmony (HIH) began using a "Radical Listening" methodology to ask communities what global support they needed to thrive and protect their tropical rainforests. Communities designed a system solution that links mobile health clinics (which regularly visit 12 community-selected locations) with improved water and sanitation infrastructure, strategic reforestation, and an agricultural extension program that provides each village with training in climate-smart farming, including intensified rice production and diversified vegetable cultivation.

Successes

In close cooperation with national health authorities, HIH has conducted more than 25,000 patient consultations in mobile clinics, including a community-managed severe acute malnutrition program and cervical cancer screenings. As of September 2024, the Health Guardians (a community-designed program drawing upon local expertise for health monitoring) conducted 6700 household visits to collect data and provide education on immunizations, family planning, insecticide-treated bed nets, sanitation, and acute malnutrition. They supported the installation of nearly 1000 latrines and found that 82% of households actively use them for the majority of their sanitation needs.

Agricultural training reached 2600 people in the first four years of project implementation, reaching nearly every household. A University of Vermont study found a 90% increase in farmers using System of Rice Intensification techniques, with female farmers reporting significantly improved confidence in their ability to practice intensified rice cultivation. [202]

Forest Guardians (like Health Guardians) have reported 268 detections of forest-degrading activities such as tree-cutting, charcoal production, and trapping wildlife. To quantify the impact of community-designed solutions on biodiversity, HIH deployed eDNA and bioacoustic monitoring to describe the baseline situation: a total of 113 vertebrate species were detected. Among them were 15 fish, frog, lemur, and carnivore species of

[202] Moore, M, Razafindrina, K., Méndez, V.E & Niles, M.T (2024). An Analysis of the Adoption of the "System of Rice Intensification" (SRI): Why a Homegrown Technique Has Yet to Take Seed among Rice Farmers in Madagascar. Cogent Food & Agriculture 10(1).

significant conservation concern. Seven lemur species were recorded, including the critically-endangered Manombo sportive, white-collared, and black-and-white ruffed lemurs. Many threatened species were found in forest fragments near villages and farms. To protect and reconnect the specialized bamboo, fruit, and hardwood habitat required by endemic wildlife, communities reforested 178 hectares and conducted agroforestry on another 38 hectares since 2020. The saplings and woven pots used for this were provided by patients as non-cash payments inside the project's healthcare services. In 2023, HIH partnered with Médecins sans Frontières and Ny Tanintsika to conduct Radical Listening with 164 villages surrounding the Vondrozo Forest Corridor in Ikongo District. The partners are implementing community-designed NbS for forest health, serving 40,000 people who protect 50,600 hectares of tropical rainforest.

One Health in Action: A Comprehensive Approach to Biodiversity, Climate and Health

This case study addresses both biodiversity, climate and health via reforestation, sustainable agriculture, and mobile health clinics. Reducing reliance on forest resources and minimizing zoonotic spillover risks, the project demonstrates how protecting biodiversity and ecosystems can simultaneously improve health outcomes and climate resilience. In addition, this program has been cited in Emerging Infectious Diseases**,** PLOS Climate, and by WHO as a potential model for reducing zoonotic spillover risk.[203] It maintains intact wildlife habitat (wet-rice farming as an alternative to swidden), reduces human-wildlife contact (supports legume, poultry, and fish production as alternatives to bushmeat hunting), and provides early detection and treatment for disease in the human population. The combination of mobile health clinics, improved sanitation, and agricultural training enhances health, while community-led forest monitoring and reforestation protect biodiversity and reduce harmful activities like wildlife trapping. Via reforestation efforts and climate-smart agricultural practices, the project also enhances climate resilience.[204]

Further Opportunities for Nature-Health Linkages

Future projects working in a similar vein could:

- Commit to trust- and reciprocity-based, community-led approaches: Local communities know best how their own health needs and outcomes link to the health of the ecosystems they inhabit. Where local communities lead in design and implementation of projects, solutions are impactful across the OH landscape, are culturally relevant and widely accepted. Utilizing methodologies like Radical

[203] The level of spillover risk reduction is being quantified through a 10-year, One Health (OH) research partnership involving several US and Malagasy research institutions.

[204] In November 2024, HIH will conduct a five-year follow up on its 2020 baseline census. All 2,250 households will be interviewed about their health, livelihoods, food security, and forest practices. Biodiversity will be inventoried again. Baseline and five-year results will be compared to quantify the impact of the agricultural training,mobile clinics and reforestation on human health, economic status, food security, deforestation, and biodiversity. Then at year 10, as it did at its Indonesian program described in Recommendation VIII, HIH will publish the 10-year impact analysis of these community-designed solutions on human thriving, biodiversity, forest cover, and carbon.

Listening allows communities to voice their needs, define their priorities, and centre their own nature-based design expertise.

- Integrate health and conservation silos, because human health and ecosystem health are interdependent.
- Implement alternative livelihood training programs focused on sustainable and climate-smart agriculture, such as agroforestry and crop diversification, to reduce reliance on forest resources and improve food security, helping biodiversity while building community resilience to climate change.

Case Study Sources

BBC News (2023). Paying for Healthcare with Tree Seeds. [Online], Available at: https://www.bbc.com/news/av/world-africa-66022969

Chen, C., Flyn, K., (2023). They Set out to Save Rainforests- and Could Help Prevent the Next Pandemic. [Online] ProPublica. Available from: https://www.propublica.org/article/pandemic-spillover-madagascar-health-in-harmony

Health in Harmony (2019). Radical Listening in the Rainforests of Madagascar: A Letter from Our Founder [Online]. Available from: https://healthinharmony.org/2019/10/24/radical-listening-in-the-rainforests-of-madagascar-a-letter-from-our-founder/

Huntignton, H., Steven, C., Seybolt, C., Carlson, S., Tobiason, A., Daut, E., Bouvier, I. (2024). Applications of Implementation Science in Integrated Conservation and Health Programs: Improved Learning to Achieve Environmental and Health Objectives. PLoS, 3(5).

Vora, N. M., Hannah, L., Walzer, C., Vale, M. M., Lieberman, S., Emerson, A....Epstein, J. H. (2023). Interventions to Reduce Risk for Pathogen Spillover and Early Disease Spread to Prevent Outbreaks, Epidemics, and Pandemics. Emerging Infectious Diseases, 29(3), 1-9.

World Health Organization (2021). Regenerating Rainforests in Madagascar by Listening to Communities: Case Study on Climate Change and Health. [Online]. Available at: https://www.who.int/news-room/feature-stories/detail/regenerating-rainforests-madagascar-listening-communities

---

CASE STUDY 2

The Stabilising Land Use Project (PLUS)

Democratic Republic of Congo, Ghana, Tanzania and Uganda

Overview

The Stabilising Land Use Project (PLUS) worked in six landscapes across four African countries- the DRC, Ghana, Tanzania, and Uganda- from 2017 to 2023 to enhance biodiversity in agricultural land, improve ecological connectivity, and reduce emissions from deforestation and forest degradation. It targeted areas of high biodiversity value where deforestation and land degradation persist as ongoing threats, but where conventional exclusionary measures are neither socially acceptable nor operationally viable. Ecological connectivity between

protected areas was achieved by expanding the role of protected area categories V (protected landscape or seascape) and VI (protected areas with sustainable use of natural resources), as well as employing the full IUCN Protected Area Matrix of governance types, to ensure more flexible conservation strategies. PLUS promoted sustainable agricultural practices that not only enhanced biodiversity, but also helped stabilize ecosystems that are essential for food security and community resilience. Healthy ecosystems, through better ecological connectivity and reduced deforestation, provide cleaner air and water, lower disease transmission, and mitigate climate change impacts. Additionally, by preserving biodiversity and improving sustainable land use management, PLUS diminished risks related to environmental degradation and supported healthier living conditions for people.

Successes

The project's key successes include the protection and sustainable management of approximately 4 million hectares of land and the direct involvement of over 10,000 individuals in conservation efforts, with over 40% being women. The achievements reflect a strong emphasis on both ecosystem conservation and community well-being, aligning with the One Health approach. In all project countries workshops and stakeholder engagements were organized to promote the adoption of One Health principles and enhance the capacity of local communities, government agencies and conservation practitioners. In the DRC, the project facilitated multisectoral collaboration to address disease transmission and deforestation, it engaged stakeholders via trainings and workshops which enhanced the integration of One Health and Landscape Approaches in the Mangaï landscape; while Ghana saw One Health integrated into national and landscape management strategies, benefiting 537 individuals, 80% of whom were women, and national and landscape-level workshops promoted the mainstreaming of One Health while providing livelihood support to beneficiaries. Tanzania on the other hand, focused on operationalizing the National One Health Strategic Plan and creating regional platforms for stakeholder engagement, and launched a One Health Platform in the Kilombero Landscape; and Uganda's efforts centered on capacity building, training, and the revision of the One Health Training Manual to include ecosystem health. Across all countries, livelihood training, stakeholder consultations, and financial pathway development were integral to achieving conservation and health outcomes.

Role of Area- based Conservation for One Health

Although area-based conservation is fundamental to both global and national biodiversity conservation initiatives, their role in endemic and pandemic prevention, detection, response, and recovery, is not fully recognized even though it holds significant potential.[205]Neither are their provision of essential ecosystem services, such as clean air and water,carbon sequestration, and medicinal plants to the same degree as biodiversity conservation.[206] The PLUS project, however, realizes the untapped potential of area-based conservation in

[205] International Union for the Conservation of Nature, EcoHealth Alliance (2022). Healthy People and Wildlife through Nature Protection: Guidelines for Prevention, Detection, Response, and Recovery from Disease Risks in and around Protected and Conserved aAreas. Gland, Switzerland: IUCN, and New York, USA: EcoHealth Alliance.

[206] Ramagosa, F., Eagles, P.F.J., Lemiuex, C.J. (2015). From the Inside out to the Outside in: Exploring the Role of Parks and Protected Areas as Providers of Human Health and Well-being. Journal of Outdoor Recreation and Tourism. 10:70-77.

biodiversity and public health and integrated the One Health framework which not only addressed disease transmission risks and deforestation, but also highlighted the essential ecosystem services provided by PAs. In the DRC, PLUS worked to address both disease transmission risks and deforestation by facilitating cross-sectoral collaboration between health and environmental authorities, and in Ghana and Tanzania, PLUS focused on embedding One Health principles into national and landscape-level policies. The efforts to include One Health underscored the critical role of ecosystems for One Health and laid the groundwork for future multi-sectoral collaboration.

Further Opportunities for Nature-Health Linkages

Other projects can adopt similar approaches as the PLUS project by:

- Creating partnerships among health, agriculture, and environmental sectors, like establishing a joint task force to address both health and ecological issues.
- Advocating and supporting the development of One Health frameworks in their regions- expanding from the national to the regional. Projects can implement similar community engagement strategies by conducting training programmes that educate locals and sustainable land-use practices and the importance of biodiversity.
- Monitoring ecosystem health and impact. PLUS implemented monitoring initiatives to track the impacts of their conservation efforts on both ecosystems and community well-being. Future projects could engage local residents in data collection about wildlife populations, habitat conditions, and health indicators, thereby providing valuable insights into the links between ecosystem health and human health.

Case Study Sources

International Union for the Conservation of Nature (2018). Inclusivity across 4 African Landscapes. IUCN [Online]. Available at: https://iucn.org/news/forests/201805/inclusivity-across-4-african-landscapes [Accessed 28th September, 2024].

Moore, E. (2020). Three Landscape Conservation Projects Converge in the Kilombero Valley. IUCN. [Online]. Available at: https://iucn.org/news/forests/202009/three-landscape-conservation-projects-converge-kilombero-valley [Accessed 28th September, 2024].

Pokhrel, P.R., Kante, A., Poe, K., Kuman, C. (2024). Integrating Health into Landscape Conservation: Conservation, Biodiversity, and Health Are inextricably Linked. [Online]. Available at: https://storymaps.arcgis.com/stories/29d47cd7021a4e8e8462f3912e1895fe [Accessed 28th September, 2024].

CASE STUDY 3

Integrating Biodiversity and Health Messaging to Protect Wildlife and People in Liberia

Liberia

Overview

Liberia is a culturally and ecologically diverse country where the majority of its people depend upon forest resources for their livelihoods. Human interactions with wildlife, however, particularly the hunting and consumption of animals such as bats, pose significant zoonotic disease risks. Following the devastating 2014-2016 Ebola epidemic in West Africa, it became clear that there was an urgent need to reduce the risk of Ebola virus and other related filoviruses in Liberia. It was also deemed necessary to improve disease risk awareness, as there was a widespread cultural belief in the supernatural causes of zoonotic diseases which hindered disease prevention and control, as well as complicating efforts to implement evidence-based public health interventions.

The project aimed to address these challenges through wildlife surveillance, community engagement, and a One Health Approach. The One Health approach was adopted in order to promote the coexistence of communities and wildlife; strengthen Liberia's capacity for wildlife surveillance and disease detection through local workforce training; reduce ecologically-detrimental practices like bat hunting and consumption, and support biodiversity protection and ecosystem services by educating communities about the ecological importance of wildlife and risk reduction measure that emphasize protection of bats and people.

Successes

Liberian scientists developed their capacity to safely sample wildlife, including bats and domestic animals, in order to detect zoonotic pathogens. This work led to the detection of genetic fragments of the Zaire ebolavirus in the greater long-fingered bat (Miniopterus inflatus), providing critical evidence of the Ebola virus reservoir in West Africa for the first time, and boosting the scientific community's understanding of the pathogen circulation in wildlife populations and the spillover risks to humans. Importantly, in line with NbS the project conducted outreach in 13 communities using the "Living Safely with Bats" book, a visual and interactive educational tool, which integrated biodiversity protection with public health messages.[207] The outreach, which was met with participation of community members of all ages, building on prior engagement with village leaders, emphasized the ecological roles of bats (e.g seed dispersal, pollination, pest control) and taught communities how to coexist with wildlife, while reducing the risk of disease transmission. The education efforts aimed to dispel the aforementioned superstition about disease origins, replacing them with science-based

[207] Martinez, S., Sullivan, A., Hagan, E., Goley, J., Epstein, J.H., Olival, K.J., Saylors, K., Euren, J., Bangura, J., Zikankuba, S., Mouiche, M., Camara, A.O Desmond, J., Islam, I., Hughes, T., Wacharplusadee, S., Duong, V., Nga, N. T.T., Bird, B., Goldstein, T., Wolking, D., Johnson, C.K., Mazet, J. AK., Olson, S.H., Fine, A.E Valitutto, M., Karesh, W.B., Daszak, P., Francisco, L., the PREDICT Consortium (2022). Living Safely with Bats: Lessons in Developing and Sharing a Global One Health Education Resources. Global Health: Science and Practice, 10(6).

understanding of zoonotic diseases and promoting bat protection, rather than bat extirpation that could result from fear around bat-associated disease risks, empowering communities with constructive practices that can keep bat and human populations healthy. By doing so, it created a space for community awareness and dialogue about the risks associated with bat hunting and consumption practices, as well as discussion on the reasons for protecting bat habitat. Trust was built through sustained engagement with community leaders and members, ensuring that scientific findings were shared and discussed openly to encourage application of local norms and governance for uptake in complement to governmental laws and regulations.

Linking Wildlife Health with Human Health

By identifying wildlife reservoirs of pathogens such as Ebola virus in wildlife (which itself could be a form of NbS through sentinel detection that can inform human disease screening and detection strategies and preparedness initiatives), as well as educating communities on safe interactions with wildlife, the project addressed the risk of zoonotic disease transmission and informed integrated biodiversity-public health messaging. Protecting habitats and species within functioning ecosystems and landscapes play a crucial role in preserving predator-prey dynamics, which in turn supports essential functions like disease regulation,[208]thereby positively impacting human health. Importantly, the findings have enabled national authorities and Liberian scientists to communicate the risks of zoonotic disease spillovers in ways that also support upstream prevention and promote biodiversity, potentially averting future outbreaks and encouraging biodiversity and ecosystem protection. Climate change is indirectly addressed by emphasizing ecosystem protection, wildlife conservation, and biodiversity preservation- key factors in climate resilience. Noting that disease responses and perceptions can in some cases inappropriately villainize wildlife, this project demonstrates the role of One Health-informed messaging that increases awareness about the protection of biodiversity and ecosystem services.

Further Opportunities for Nature-Health Linkages

Future projects working in a similar vein could:

- Engage in community education and outreach via public health messaging linked to biodiversity conservation, enlightening communities about the ecological importance of species like bats, which contribute to seed dispersal, pollination and pest control, while also understanding how to reduce disease transmission risks.
- Foster local governance and trust through sustained community engagement. By working with village leaders and involving local norms and values in decision-making, projects build community trust and increase the uptake of scientific and policy recommendations.
- Highlight the importance of policy advocacy and cross-sectoral collaboration and share scientific findings with national authorities which can contribute to national strategies reinforcing the interconnectedness of biodiversity, climate, and human health. Encouraging policy makers to adopt

[208] International Union for the Conservation of Nature, EcoHealth Alliance (2022). Healthy People and Wildlife through Nature Protection: Guidelines for Prevention, Detection, Response, and Recovery from Disease Risks in and around Protected and Conserved aAreas. Gland, Switzerland: IUCN, and New York, USA: EcoHealth Alliance.

solutions based on nature into national health and environmental plans can lead to the recognition that healthy ecosystems are vital for human health, biodiversity protection and climate resilience at a national level.

Case Study Sources

Francisco, L., Sullivan, A., Goley, J., Martinez, S., (2018). Living with Bats. Available at: https://www.ecohealthalliance.org/living-safely-with-bats Accessed 28th September, 2024.

Machalaba, C., and Society for the Conservation of Nature of Liberia (2022). Integrating Biodiversity and Health Messaging and Tackling Superstition with Communities in Liberia. Available at: https://panorama.solutions/en/solution/integrating-biodiversity-and-health-messaging-and-tackling-superstition-communities Accessed 28th September, 2024.

Martinez, S., Sullivan, A., Hagan, E., Goley, J., Epstein, J.H., Olival, K.J., Saylors, K., Euren, J., Bangura, J., Zikankuba, S., Mouiche, M., Camara, A.O Desmond, J., Islam, I., Hughes, T., Wacharplusadee, S., Duong, V., Nga, N. T.T., Bird, B., Goldstein, T., Wolking, D., Johnson, C.K., Mazet, J. AK., Olson, S.H., Fine, A.E Valitutto, M., Karesh, W.B., Daszak, P., Francisco, L., the PREDICT Consortium (2022). Living Safely with Bats: Lessons in Developing and Sharing a Global One Health Education Resources. Global Health: Science and Practice, 10 (6).

USAID. Predict Liberia: One Health in Action (2016-2020). Available at: USAID, Predict Liberia: One Health in Action Accessed 28th September, 2024.

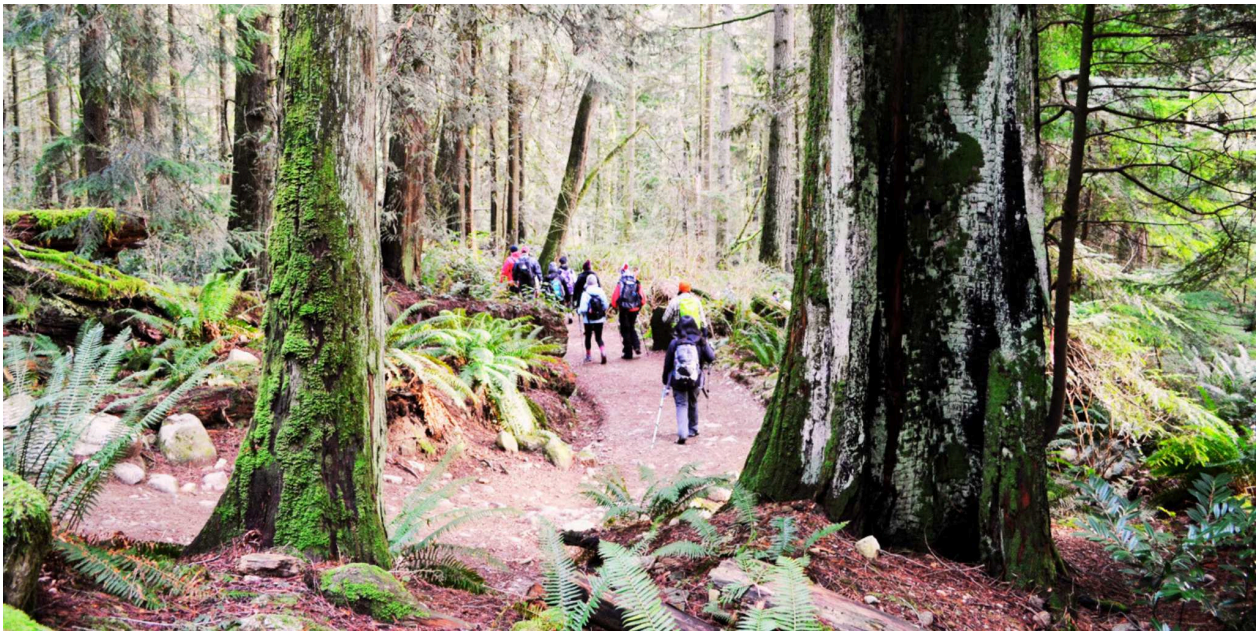


Photo Credit: Melissa Lim

Recommendation II: Educate and Empower Health Professionals to Engage in Nature-based Solutions

Protecting and restoring natural ecosystems is essential for reducing zoonotic disease risks and serves as a core principle of NbS. By leveraging the protective functions of healthy ecosystems—such as wetlands, forests, and biodiversity—NbS can mitigate health risks by enhancing the ecosystem services that help regulate disease transmission.

To maximize the effectiveness of NbS, it is important to incorporate training on the protective benefits of nature in health curricula, including through One Health education.[209] Interdisciplinary education provides an opportunity for understanding the protective benefits of nature, enabling health professionals to support strategies that address zoonotic disease risks through NbS. The integration of NbS into academic curricula should cover various topics such as the health benefits of green spaces, the ecological determinants of health, and the role nature plays in disease prevention and management, amongst others. Implementing case-based learning that showcases practical applications of NbS in healthcare settings can significantly enhance public knowledge.

With an interdisciplinary foundation in environment, ecology and health, health professionals are better equipped to understand and support interventions that restore ecosystem health and the pathways to prevent disease transmission —such as reducing deforestation, supporting conservation, reforestation and habitat

[209] Kumar, K., Pokhrel, P.R. (2024). A Case for Intersectoral Health- Conservation Collaboration: Barriers and Opportunities. IUCN.

conservation. WHO defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Achieving this comprehensive understanding of health entails integrating ecosystem protection into health strategies and working to reconnect individuals with nature, a connection often strained by urbanization and changing lifestyles.

.

Incorporating nature into healthcare can positively influence physical and mental health.[210] Programmes that encourage positive interactions with the natural world,[211] such as increased access to green spaces (i.e covered by vegetation) and blue spaces (i.e. bodies of water) have been shown to improve health outcomes.[212] For example, exercising in green space has been found to reduce anxiety, depression and improve general mood regardless of exercise type or intensity (e.g. walking, cycling, fishing).[213][214][215] Greater access to green and blue spaces has been linked to reductions in various health risks, including a 31% decrease in all-cause mortality; a 16% drop in cardiovascular-related death; a 28% lower risk of developing type 2 diabetes, and a 12% increase in self-reported well-being.[216]

Nature prescriptions, defined as recommendations prescribed by healthcare professionals to spend time in nature,[217]are emerging as an effective approach to addressing physical and mental health challenges.. Over time, healthcare professionals are becoming better versed in incorporating nature into healthcare, with nature prescriptions being adopted in countries such as Canada, Finland, Scotland, and the US. These nature prescriptions not promote health, but also support pro-environmental behaviours.[218]

As environmental degradation stems largely from human activities, encouraging environmentally conscious behaviors and sustainable lifestyles becomes imperative.[219] The disconnection from nature has emerged as a

[210] Shanahan, D.F, Bush, R., Gaston, K.J., Lin, B.B., Dean, J. Barber, E., Fuller, R.A. (2016). Health Benefits from Nature Experiences Depend on Dose. Scientific Reports, 6:28551.

[211] Cox, D.T.C., Shanahan, D.F., Hudson, H.L., Fuller, R.A., Anderson, K., Hancock, S., Gaston, K.J (2017). Doses of Nearby Nature Simultaneously Associated with Multiple Health Benefits. International Journal of Environmental Research and Public Health. 14(2):172.

[212] Hunter, R.F, Nieuwenhuijsen, M., Fabian, C., Murphy, N., O'Hara, K., Rappe, E., Fleming Sallis, J., Lambert, E.V., Sarmiento Duenas, O.L., Sugiyama, T., Kahlmeier, S (2023). Advancing Urban Green and Blue Space Contributions to Public Health. The Lancet Public Health 8(1): E735-E742.

[213] Barton, J., Pretty, J.N (2010). What is the Best Dose of Nature and Green Exercise for Improving Mental Health? A Multi-Study Analysis. Environmental Science and Technology 44(10):3947-55.

[214] Hartig, T., Mitchell, R., de Vries, S., Frumkin, H. (2014). Nature and Health. Annual Review of Public Health, 35:207-228.

[215] World Health Organization (2021). Green and Blue Spaces and Mental Health: New Evidence and Perspectives for Action. Copenhagen: WHO Regional Office for Europe.

[216] Twohigh-Bennet, C., Jones, A. (2018). The Health Benefits of the Great Outdoors: A Systematic Review and Meta-Analysis of Greenspace Exposure and Health Outcomes. Environmental Research 166:628-637.

[217] James,J.J., Christiana, R.W, Battista, R.A (2019). A Historical and Critical Analysis of Park Prescriptions. Journal of Leisure Research. 50(4):311-329.

[218] Whitburn, J., Linklater, W., Abrahamse, W. (2019). Meta-Analysis of Human Connection to Nature and Proenvironmnetal Behavior. Conservation Biology 34(1):180-193.

[219] Ehrlich, P.R., Kennedy, D. (2005) Millennium Assessment of Human Behavior. Science, 309(5734): 562- 563.

significant reason for people's indifference toward environmental challenges.[220]Although conservation science has successfully highlighted the impacts of human activities on ecosystems, behavior change is essential to bolster conservation efforts.[221] Nature prescriptions have the potential to generate health benefits while also inspiring individuals to engage in conservation efforts, cultivating a shift in values that supports both human well-being and environmental sustainability.

The following case studies illustrate how integrating nature into healthcare can improve health outcomes and can have positive co-benefits for nature and human health.

CASE STUDY 1

African One Health University Network (AFROHUN)

Cameroon, Côte d'Ivoire, Democratic Republic of the Congo, Ethiopia, Kenya, Liberia, Senegal, Tanzania, Uganda, Rwanda

Overview

The African One Health University Network operates throughout Africa, engaging 18 universities across 9 countries, with a focus on building a One Health workforce that addresses pressing health challenges, such as infectious disease outbreaks, food safety, zoonotic diseases, and global health security. Africa's vulnerability to such health challenges, compounded by factors like biodiversity loss, deforestation, and human-animal contact, underpins the need for One Health. Through programs like the Mentored Experiential Learning and Training (MELT), AFROHUN builds capacity to tackle zoonotic diseases, promotes cross-disciplinary research and collaboration, and trains students and professionals to understand and address the impact of ecosystem changes, such as deforestation and wildlife habitat disruption- on the emergence of infectious diseases.

Successes

Over 10,000 students and professionals have been empowered through capacity-building programs in public health, veterinary medicine, and environmental sciences. It includes scholarships, fellowships, and research grants, fostering advancements in health science research and increased workforce skills in One Health approaches. The MELT program has bolstered the capacity of local professionals to prevent, detect, and respond to infectious disease outbreak, focusing on experiential learning and mentoring. In Uganda, AFROHUN has contributed to the development of the Uganda One Health Strategic Plan, fostering collaboration between

[220] Pyle, R.M. (2003). Nature Matrix: Reconnecting People and Nature. Oryx, 37(2): 206-214.
[221] Pyle, R.M. (2003). Nature Matrix: Reconnecting People and Nature. Oryx, 37(2): 206-214.

multiple government sectors such as health, agriculture, wildlife, and the environment. AFROHUN Cameroon has strengthened the country's Risk Communication and Community Engagement strategies, and played a role in both fortifying e-learning, as well as in the development of a Master's training program in Wildlife and other programs focused on antimicrobial resistance and One Health. The initiative supported Côte d'Ivoire's COVID-19 vaccination programs, and multiple universities across Côte d'Ivoire have put together Student One Health Innovation Clubs which have become platforms for promoting interdisciplinary collaboration among students from diverse fields who have organized workshops, participated in national conferences, and conducted awareness campaigns on global health topics, like COVID-19 and rabies.

Connecting Environment and Pandemic Prevention

The premise of AFROHUN is "to drive transformational change for continuous improvement of health and well-being of humans, animals, and environment through One Health principles and approach to research, training and community service".[222] As such, it considers One Health as more than just an approach targeted at biosecurity interventions alone, but as a paradigm that views health by a continuum of causes and effects which span animal and human populations, as well as ecosystems.[223] Viewing the matter holistically, the OH approach examines the combined synergistic and negative mitigation efforts which increases the likelihood of promoting long-term solutions that are effective, fair, and sustainable.

Though the network is not an initiative that directly focuses on NbS per se, by educating healthcare professionals about the dangers of environmental loss and degradation, it can open the door to exploring NbS as an important approach to preventing future pandemics. It offers opportunities for fostering leadership as students become more aware of the dangers of environmental loss and the importance of conservation, and may become advocates for NbS as part of a larger movement toward sustainability, climate action, and health. Though this is a purely aspirational statement, future projects may be able to prove this with quantifiable evidence. Recognizing the significance of One Health in relation to emerging infections and pandemics is an initial step; fostering collaboration across disciplines and institutions is a second; and adopting NbS as an effective tool in managing both current and future pandemics is the next.

Future Opportunities for Nature-based Linkages

Educating and empowering health professionals to engage in NbS is in its nascent stages. However, future projects can use the AFROHUN and similar case studies, as a springboard to make headway on this topic.
Future projects working in a similar vein could:

- Develop interdisciplinary curricula that integrate One Health principles with environmental science, public health, and veterinary medicine and develop training modules to incorporate more directly NbS

[222] AFROHUN Secretariat (2023). Africa One Health University Network, 2022-23 One Health Workforce- Next Generation AFROHUN Secretariat Kampala, Uganda
[223] Evans, B.R., Leighton, F.A. (2014). A History of One Health. Rev.sci.tech.Off.int.Epiz., 33(2):413-420

into existing curricula. This can involve education on how to leverage natural ecosystems to mitigate health risks, such as green spaces.

- Prompt health professionals to explore NbS as proactive, preventive measures for reducing the risk of zoonotic diseases, pandemics, and noncommunicable diseases linked to environmental factors.
- Encourage OH students to create NbS groups across academic institutions to advance their knowledge on the subject and its relevance to OH.

Case Study Sources

AFROHUN Secretariat (2023). Africa One Health University Network, 2022-23 One Health Workforce- Next Generation AFROHUN Secretariat Kampala, Uganda .

CASE STUDY 2
Park Prescriptions (PaRx)
Canada

Overview

Launched in all ten Canadian provinces, PaRx is an initiative implemented by BC Parks Foundation which aims to connect patients to the health benefits of the natural environment by having healthcare professionals prescribe time in nature as a preventive and therapeutic measure. Specifically, it seeks to improve patient health through nature-based therapies; to increase awareness and policy change around nature, health and sustainability; to provide equitable access to nature, especially for marginalized populations; and to foster pro-nature values and stewardship.

Successes

PaRx has been widely adopted by healthcare professionals across Canada with over 15,000 healthcare providers (including 7% of all physicians) registered to prescribe nature. As of 2024, over 1,000,000 nature prescriptions have been issued, with the majority targeting mental health issues. In addition, by collaborating with parks, healthcare systems, and transportation providers, PaRx has facilitated patients' access to nature. This has been partly due to having been able to reduce the cost of nature access by more than $200,000 for patients in need, helping to remove financial barriers and promoting equitable access to green spaces. Furthermore, PaRx is a key partner in international projects worth over $10 million in funding that support research on nature-based therapies, further validating its scientific approach and helping expand evidence-based practices in the field of healthcare. Guided and self-guided activities produced by the BC Parks Foundation are deeply involved in biodiversity conservation and land projection, in partnership with governments, Indigenous Peoples and the

private sector. These activities expand nature access, help health practitioners issue nature prescriptions, and boost people's confidence to spend time outdoors for their health.

Photo Credit: Delta Management/ Clean50

Cultivating Nature Connectedness for Environment and Health Benefits

The project's holistic approach manages to straddle the silos of both health care and biodiversity conservation, resulting in the amelioration of public health while simultaneously promoting a sustainable relationship with the natural environment. By encouraging people to spend more time in green and blue spaces, the initiative aids in raising awareness of the importance of conserving biodiversity and protecting ecosystems, while promoting related actions. Key to the project's rationale is nature connectedness (NC) which is the extent to which people view nature as integral to their identity and feel at one with the natural world.[224] NC has been associated with higher levels of happiness, deeper care for living beings, stronger sense of community and responsibility toward future generations, as well as greater ecological awareness, attitudes and behaviours.[225]Research also indicates

[224] Lemieux, C.J., Groulx, M.W., Buxton, R.T., Reining, C.E., Blye, C.J., Hassen, N., Harding, S.L., Halpenny, E.A., Lem, M., Jakubec, S.L., Wright, P., Maklettzoff, T., Kerry, M, Keenleyside, van der Leest, P.S, Bueddefeld, J., Lemelin, R., Carruthers den Hoed, D, Steinberg, B., Moon, R., Scott, J., Grant, J., Khan, Z., Carr, D., McLaughlin, L., Krehbiel, R. (2022). The "Healthy Parks-Healthy People" Movement in Canada: Progress, Challenges, and an Emerging Knowledge and Action Agenda. International Journal of Protected Areas and Conservation. 21(1).

[225] Martin, L., White, M.P., Hunt, A., Richardson, M., Pahl, S., Burt, J. (2020). Nature Contact, Nature Connectedness and Associations with Health, Well-being, and Pro-Environmental Behaviours. Journal of Environmental Psychology 68:101389. .

that deliberate interactions with nature, such as hiking in a park, are essential for cultivating NC.[226]. Due to growing urbanization, people are prone to lose contact with nature, yet the research does demonstrates that health and well-being are positively related to nature contact, and that connectedness to nature tends to lead to pro-environmental behaviours and actions that protect the health of the planet. The PaRx initiative actively promotes access to nature through its natural prescriptions, potentially fostering environmental stewardship, while strengthening human health. Leveraging nature as a health resource for all presents certain challenges, though initiatives like PaRx are leading the way forward.

Further Opportunities for Nature-Health Linkages

Future projects in a similar vein could:

- Seek cross-sectoral partnerships to widen impact and interact with community-based programs that promote biodiversity, such as community gardens or urban greening projects, in addition to expanding partnerships with mental health organizations which could enhance awareness of the therapeutic benefits of nature.
- Strengthen collaborations with public health ministries which would unlock financial and human resources.
- Conduct and disseminate research that tracks the efficacy of nature-based therapies in improving health outcomes and building robust evidence base that supports the integration of NbS into healthcare practices, providing healthcare professional concrete data to inform their approaches.
- Perform ecosystem service evaluations to quantify cost savings to the healthcare system to show to decision-makers.

Case Study Sources

Association Médical Canadienne, Canadian Medical Association. Environmentally Sustainable Health Systems in Canada. [Online] Available at: https://policybase.cma.ca/link/policy14489 [Accessed 13th October, 2024].

PaRx: A Prescription for Nature [Online] Available at: https://www.parkprescriptions.ca/ [Accessed 28th September, 2024).

Clean50. (2023). BC Parks Foundation Brings the great Outdoors to a Prescription Pad Near You. Clean50. [Online]. Available at: https://clean50.com/projects/bc-parks-foundation-brings-the-great-outdoors-to-a-prescription-pad-near-you/ [Accessed 13th October, 2024].

Forster, V. (2022) Canadian Physicians Can Now Prescribe Nature to Patients. Forbes. [Online]. Available at: https://www.forbes.com/sites/victoriaforster/2022/02/08/canadian-physicians-can-now-prescribe-nature-to-patients/?sh=373b9c726f20 [Accessed 13th October, 2024].

Prescri- Nature (2024). Prescri-Nature de Temps Passé en Nature. [Online]. Available at: https://www.prescri-nature.ca/ [Accessed 2nd October, 2024].

[226] Wright, P.A., Matthews, C. (2015). Building a Culture of Conservation: Research Findings and Research Priorities on Connecting People to Nature in Parks. PARKS. 21(2):11-24.

Vancouver Sun (2022). Canadian Medical Association Endorses B.C. Parks Foundation Plan to Prescribe Nature. [Online] Available at: https://vancouversun.com/news/local-news/cma-endorses-nature-prescription [Accessed 13th October, 2024].

Photo Credit: Graeme Williams

Recommendation III: Redesign Food Systems to Be Nature-Positive, Resilient, and to Sustain Healthy Communities.

Contemporary food systems face a complex array of challenges which have profound implications for nature and public health. Food insecurity remains a persistent issue which causes under- and mal- nutrition, particularly amongst the most vulnerable populations. The global food system today fails more than 800 million individuals who go hungry and 2.4 billion people face significant difficulties in accessing sufficient and proper nutrition.[227] Inaccessible capital and social resources to nutritious food options can exacerbate health inequities and economic disparities in the food system, causing detrimental effects on diet and nutrition of the most vulnerable.[228]

[227] Food and Agriculture Organization of the United Nations (2022). The State of the World's Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome.

[228] High Level Panel of Experts on Food Security and Nutrition (2019). Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems that Enhance Food Security and Nutrition. A Report by the High Level World Health Organization (2020). Guidance on Mainstreaming Biodiversity for Nutrition and Health. Geneva.Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome.

Outbreaks of food-borne illnesses and contamination issues can have severe health consequences, underscoring the need for robust food safety measures.

By 2050 our food systems will need to be able to feed nearly 10 billion people and if consumption trends continue, food production will need to be upped by more than 50%.[229] Our current food systems are responsible for approximately 21 to 37% of global greenhouse gas emissions due to agriculture and land use, storage, transport, packaging, processing, retail and consumption.[230] Over one third of global landmass is used to produce food which continues to expand, driving deforestation and impacting negatively on biodiversity.[231] Livestock production is the main cause of global habitat loss[232] and the driving force behind tropical deforestation,[233] with the potential devastating effect of speeding up vector-borne diseases. Native vegetation and soils contain vast quantities of carbon, and conversion to agricultural land causes the loss of nearly all of it.[234] Contaminated soils can have detrimental effects on food safety and human health, arising from the presence of harmful chemicals, heavy metals, and other contaminants in the soil which can be taken up by plants, and, when consumed, pose health risks to humans.[235] Agriculture is also the primary cause of nutrient runoff, giving birth to toxic algae blooms and dead zones in marine ecosystems.[236]

Fisheries and aquaculture play a significant role in both current and prospective food supplies, especially in specific regional coastal economies such as Small Island Developing States (SIDS). Blue foods are key sources of animal protein, essential fatty acids and critical micronutrients, with wild capture fisheries representing the largest source of wild food for human consumption, which are incredibly difficult to replace.[237]Human

---

[229] Searchinger, T., Waite, R., Hanson, C., Ranganathan, J., Dumas, P., Matthews, E., Klirs, C. (2019). Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050. Final Report.

[230]Mbow,C.,C.Rosenzweig,L.G.Barioni,T.G.Benton,M.Herrero,M.Krishnapillai,E.Liwenga,P.Pradhan,M.G.Rivera-Ferre, T. Sapkota, F.N. Tubiello, Y. Xu, 2019: Food Security. In: Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. Cambridge: University Press.

[231] Millennium Ecosystem Assessment (2015). Ecosystems and Human Well-Being: Synthesis. Washington D.C.: Island.

[232] Machovina, B., Feeley, K.J, Ripple, W.J. (2015). Biodiversity Conservation: The Key is Reducing Meat Consumption. Science of the Total Environment 536:419-431.

[233] Geist, H.J., Lambin, E.F. (2002). Proximate Cause and Underlying Driving Forces of Tropical Forests Are Disappearing as the Result of Many Pressures, Both Local and Regional, Acting in Various Combinations in Different Geographical Locations. Bioscience 52:143-150.

[234] Searchinger. T.D., Wirsenius, S., Beringer, B., Dumas, P. (2018). Assessing the Efficiency of Changes in Land Use for Mitigating Climate Change. Nature 564:249-253.

[235] Kabata- Pendias, A., Mukherjee, A.B. (2007). Trace Elements from Soil to Human. Geophysical Research Abstracts 9:11054.

[236] Selman, M., Greenhalgh, S. (2009). Eutrophication: Sources and Drivers of Nutrient Pollution. WRI Policy Note. Washington D.C: World Resources Institute.

[237] Tigchelaar, M., Leape, J., Micheli, F., Allison, E.H., Basurto, X., Bennett, A., Bush, S.R., Cao, L., Cheung, W.W.L, Crona, B., DeClerck, D., Fanzo J., Gelcich, S., Gephart, J.A, Golden, C.D., Halpern, B.S, Hicks, C.C., Jonell, M., Kishore, A., Koehn, J.Z., Littel, D.C., Naylor, R.L., Phillips, M.J., Selig, E.R., Short, R.E., Rashid Sumaila, U., Thilsted, S.H.,

pressures, especially anthropogenic climate change significantly impact marine ecosystems with one of the most critical, detrimental consequences being rising, and irreversible, atmospheric carbon dioxide[238] and ocean acidity. Climate change causes increasing ocean temperatures[239] which leads to higher sea levels, greater ocean stratification, reduced sea-ice extent, shifts in ocean circulation, precipitation and freshwater input[240] and deoxygenation.[241] These changes affect the oceans' ability to provide food by altering the abundance and distribution of fisheries. The loss of marine food sources due to climate change and biodiversity loss leads to dietary shifts that increase demands on agriculture and negatively impact the food security and nutrition of coastal communities.

The loss of biodiversity in food production systems is increasingly worrying and the homogenization of agricultural practices can reduce the diversity of food sources available to people. Out of the countless plant and animal species beneficial to human food security, just 80 crop plants and 50 animal species supply most of the world's food.[242] There are numerous overlooked, underutilized, indigenous crop species, totaling several hundred, that hold substantial promise in facilitating diversification, enhancing adaptability to changing conditions and fortifying resilience.[243] However, food species, both plant and animal, rely heavily on the contributions of a myriad of others, including insects, bats, and birds that pollinate crops or help to control pests and diseases that threaten food production, as well as microbial species that are abundant in the soil and live on plants and animals.[244] As such, protecting biodiversity helps to ensure the long-term productivity of soils and the

---

Troell, M., Wabnitz, C.C.C.(2022). The Vital Roles of Blue Foods in the Global Food System. Global Food Security 33:100637.

[238] Natl. Res. Counc (2011). Climate Stabilization Targets: Emissions, Concentrations and Impacts over Decades to Millennia. Washington D.C: Natl. Res. Counc.

[239] Bindoff, N.L, Willebrand, J., Artale, V., Cazenave, A., Gregory, J.M, Guleve, S., Hanawa, K., Le Quere, C.,Levitus, S, Nojiri, Y., Shum, C.K., Talley, L.D., Unnikrishnan, A.S, Josey, S.A., Tamisa, M, Tsimplis, M., Woodworth, P. (2007). Observations: Oceans Climate Change and Sea Level In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M. Averyt, K.B., Tignor, M, Miller, H.L (eds.) Climate Change 2007: the Physical Science Basis: Contribution of Working Group I. Cambridge, Cambridge University Press, 385-428.

[240] Doney, S.C, Ruckelshaus, M., Emmett Duffy, J., Barry, J.P, Chan, F., English, C.A., Galindo, H.M, Grebmeier, J.M, Hollowed, A.B., Knowlton, N., Polovina, J., Rabelais, N.N., Sydeman, W.J., Talley, L.D. (2011). Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science 4.

[241] Laffoley, D., Baxter, J.M (eds.) (2019). Ocean Deoxygenation: Everyone's Problem- Causes, Impacts, Consequences and Solution. Full Report. Gland.

[242] Chivian, E., (ed.) (2003). Biodiversity: Its Importance to Human Health, Interim Executive Summary, A Project of the Center for Health and the Global Environment Harvard Medical School under the Auspices of the World Health Organization, the United Nations Development Programme, and the United Nations Environment Programme. Center for Health and Global Environment Harvard Medical School.

[243] Kahane, R., Hodgkin, T., Jaenicke, H., Hoogendoorn, C., Hermann, M., Keatinge, J.D.H., d'Arros Hughes, J., Padulosi, S., Looney, N.E (2013). Agrobiodiversity for Food Security, Health and Income. Agronomy for Sustainable Development. 33(4):671-693.

[244] Chivian, E., (ed.) (2003). Biodiversity: Its Importance to Human Health, Interim Executive Summary, A Project of the Center for Health and the Global Environment Harvard Medical School under the Auspices of the World Health Organization, the United Nations Development Programme, and the United Nations Environment Programme. Center for Health and Global Environment Harvard Medical School.

genetic resources for all crops, livestock, and marine species harvested for food, and the adoption of underutilized crops can rectify dietary diversity paucity, as well as preserve biodiversity in food systems.. All in all, a move towards transformative changes in the way food is produced, distributed, and consumed is vital,[245] which brought the EAT-Lancet 2.0 to conclude that feeding 10 billion people a healthy diet and avoiding severe environmental degradation is possible, as long as food systems restore planetary health.

CASE STUDY 1

The Periodic Table of Food Initiative (PTFI)
Global

Overview

Led by The Rockefeller Foundation, co-managed by the American Heart Association and the Alliance of Biodiversity and CIAT, and supported by a global ecosystem of funders and Centers of Excellence on each continent, The Periodic Table of Food Initiative (PTFI) is a science-to-action effort with three key lines of investigation: assessing the impacts of climate change on food quality to enhance food security and resilience; generating evidence to scale regenerative agriculture and agroecology to foster biodiversity and ecosystem services; and informing nutrition assistance programs, procurement, food formulation, meal planning, and dietary guidelines to improve dietary quality and mitigate diet-related chronic diseases. The PTFI, along with its capacity strengthening arm Food EDU, seeks to engage a wide spectrum of scientists, practitioners, consumers, and policymakers in leveraging food composition data and supporting food systems metadata. It has established standardized analytical protocols that can be utilized by laboratories worldwide to profile the composition and associated metadata attributes of locally-relevant foods to tackle context-specific food system challenges. Its overarching goal is to inform evidence-based solutions across food systems, from crop breeding to national dietary guidelines and public health initiatives.

Success

The PTFI has made strides towards applying its standardized analytical protocols to identify the biomolecular composition of foods, addressing the knowledge gap related to the thousands of components that comprise the planet's edible biodiversity. Each serves a role in the functioning of ecosystem dynamics and human health. Food composition data on the first 500 foods from approximately 250 species analyzed from PTFI protocols and associated food systems metadata can currently be accessed in the PTFI data interface as a global public good. In order to expand the number of edible species and food types, the PTFI embarked upon a global consultation process to compile a list of 1750 minimally processed, single-species foods that are vital for nutrition and cultural

[245] World Wildlife Fund (2023). Food Systems Transformation: Ensuring Regenerative and Resilient Production and Consumption. World Wildlife Fund.

significance, bringing attention to underexplored foods and their biomolecular attributes. The initiative is further empowering its global partners including Centers of Excellence and national labs to profile their local food and contribute data to PTFI's database. The initiative is also integrating its standardized analytical protocols in research projects to investigate the effects of climate change on food composition and the potential of regenerative agriculture to enhance food quality based on food composition to support environmental and human health. Researchers across the PTFI ecosystem are examining the effects of regenerative farming practices on crops such as almonds, apples, beans, buckwheat, cacao, coffee, and wheat comparing the quantities and presence of food biomolecules based on agricultural production practices, inputs, and outcomes. Another example of fostering nature-positive food systems is an integrative project supported by the Seerave Foundation connecting soil health, food quality, and human health outcomes being led by PTFI Centers of Excellence in Ethiopia and Ghana, including the Ethiopia Public Health Institute and the Kwame Nkrumah University of Science and Technology, as a study of traditional food systems in the DRC.

Harnessing Edible Biodiversity for Health and Sustainability

PTFI's focus on profiling food quality of the planet's edible biodiversity highlights the importance of preserving natural ecosystems including wild food environments, nature-positive agricultural systems such as regenerative agriculture, and the diverse biomolecules and organisms within them that are dependent on complex ecosystem dynamics. The PTFI endeavours to democratize access to data, tools, training, and other knowledge assets to empower both communities and policymakers to make informed decisions that benefit public health, the environment, and agricultural sustainability. In addition to standardized protocols for profiling food composition, the PTFI has also developed standardized tools to profile human serum. Application of these resources to food grown from different types of agricultural systems such as regenerative agriculture, as well as to human serum from consumers of these foods, will enable identifying the biomolecular mechanisms connecting ecosystems, food, and human health. Facilitating food access more wildly and incorporating higher-quality foods into our diets can enable more people to lead healthier lives; choosing regenerative agricultural systems that mimic nature can protect ecosystems and biodiversity, which are severely threatened by climate and land-use changes.

Further Opportunities for Nature-Health Linkages

The initiative is steamrolling ahead to fill in the *"black hole of nutritional knowledge"* and to reach its long-term goal of an equity-centered evidence-based system to prevent or treat diet-related diseases while enhancing planetary health.[246]

Future projects in a similar vein could:

[246] Rockefeller Foundation. https://www.rockefellerfoundation.org/insights/grantee-impact-story/periodic-table-of-food-lays-the-ground-for-a-healthcare-revolution/ Accessed 1st October, 2024.

- Integrate food system and health data to understand the link between diet, human health and environmental sustainability, and inform policymakers about the health benefits of sustainable diets and nature-positive farming systems.
- Focus on adopting underutilized crops and indigenous crops which may be more resilient to climate change, require fewer inputs, enhance food security, support ecosystem health, and diversify diets.
- Encourage regenerative agriculture to ameliorate soil health, promote healthier diets, and strengthen food systems' resilience in the face of climate change.

Case Study Sources

Ahmed, S., de la Parra, J., Elouafi, I., German, B., Jarvis, A., Lal, V., Lartey, A. Longvah, T., Malpica, C., Vázquez-Manjarrez, N., Prenni, J., Aguilar-Salinas, C.A., Srichamnong, W., Rajasekharan, M., Shafizadeh, T., Bloomfields Siegel, J., Steiner, R., Tohme, J., Watkins, S. (2022). Foodnomics: A Data- Driven Approach to Revolutionize Nutrition and Sustainable Diets. Front. Nutri. 9:874312.

Ahmed, S., Chien., C.M., de la Parra, J., German, J.B., Jarvis, A., Lal, V., Lartey, A., McDade, M., Morgan, K., Prenni, J., Rajasekharan, M., Shafizadeh, T., Vázquez- Manjarrez, N., Watkins, S. (2023). What Is in A Tomato? Mapping The Building Blocks of Food. Front. Young Minds 11:1038318.

Ewing- Chow, D. (2024). Converting Food Tradition into Science with The Periodic Table of Food. Forbes. [Online]. Available at: Converting Food Tradition Into Science With The Periodic Table Of Food [Accessed 3rd October, 2024].

Jarvis, A., Gallo-Franco, J., Portilla, J., German, B., Debouck, D., Rajasekharan, M., Khoury, C., Herforth, A., et al.., (2024). Periodic Table of Food Initiative for Generating Biomolecular Knowledge of Edible Biodiversity. Nature Food. 5:189-193.

Nierenberg, D. (2024). The Global Effort to Map Biomolecules in Food to Health Outcomes. Forbes. [Online]. Available at:
The Global Effort To Map Biomolecules In Food To Health Outcomes. [Accessed 3rd October, 2024].

Periodic Table of Food Initiative. Discover. [Online] Available at: https://foodperiodictable.org/discover/

What's in your food? A new research effort intends to find out [Accessed 3rd October, 2024].

The Rockefeller Foundation (2024). The Periodic Table of Food Initiative (PTFI). [Online]. Available at: https://www.rockefellerfoundation.org/initiative/periodic-table-of-food/. [Accessed 21st October, 2024].

CASE STUDY 2

Naandi Foundation

India

Photo Credit: Graeme Williams

Overview

India has a vast population of around 1.43 billion people with 12.9% of inhabitants living in poverty.[247] Agriculture makes up a significant portion of the country's GDP and employs an estimated 43% of the total workforce.[248] Soil degradation due to conventional farming is a major issue, with 35% of the world's soils already degraded and 90% predicted to be degraded by 2050 if unsustainable practices continue.[249] Soil degradation in India is estimated to affect 147 million hectares of land due to myriad of reasons amongst them, water erosion, acidification, flooding, wind erosion, salinity which is alarming as India is home to 18% of the global human population, 15% of the world's livestock, yet accounts for only 2.4% of the Earth's total land area.[250] As an agrarian country, India generates a large quantity of agricultural wastes which to dispose of is a great challenge, but a common solution is to burn it, emitting significant amounts of CO2, NsO, CH4, other air pollutants, volatile and semivolatile organic compounds, and particulate matter.[251] Large scale burning of crop residues risks pollution, health hazards and loss of nutrients. The Naandi Foundation's goal is to address these issues by promoting regenerative agriculture which focuses on restoring soil health. Improved soil health increases crop yields. resulting in better nutritional quality of food and bolsters the resilience and sustainability of farmers'

[247] World Bank Group Data. India https://data.worldbank.org/country/india Accessed 1st October, 2024.

[248] International Labour Organization https://ilostat.ilo.org/data/country-profiles/ Accessed 1st October, 2024.

[249] United Nations (2022). FAO Warns 90 Percent of Earth's Topsoil at Risk by 2050 https://news.un.org/en/story/2022/07/1123462 Accessed 26th September, 2024.

[250] Bhattacharyya, R., Ghosh, B.N, Mishra, P.K., Mandal, B., Rao, C.S., Sarkar, D., Das, K., Anil, K.S., Lalitha, M., Hati, K.M et al. (2015). Soil Degradation in India: Challenges and Potential Solutions. Sustainability 4:3528-3570.

[251] Jani, N., Bhatia, A., Pathak, H. (2014). Emission of Air Pollutants from Crop Residue Burning in India. Aerosol and Air Quality Research 14:422-430.

livelihoods.. Naandi's regenerative farming practices center upon using organic compost made from locally sourced material such as crop residue, cow dung, and biodiverse plant matter, which enriches depleted soils while simultaneously reducing air pollution, as crop residue is composted, rather than burnt.

Successes

The Naandi Foundation has managed to create centralized composting hubs where organic fertiliser is produced and then distributed to farms, alongside other crucial elements such as seeds, saplings, and technical knowledge. This has had the positive effects of facilitating farmers' access to high-quality organic fertilizers and speeding up the rate of adoption of regenerative agriculture. The Foundation has also promoted the use of cover crops to prevent soil erosion and improve nutrient cycling, as well as no-till farming to maintain soil structure. Thanks to Naandi's aforementioned organic compost, cover crops, and no-till farming practices, soil health has improved, resulting in enhanced soil biodiversity, greater crop yields and reduced reliance on chemical fertilizers. Furthermore, Naandi's work includes afforestation efforts, particularly in tribal areas, which has involved the planting of over 49 million trees in order to restore forest ecosystems, providing a healthier environment for biodiversity, and increasing carbon sequestration. By doing so, it has also revitalized coffee, such as the Araku Coffee, which won the prestigious Prix Epicure gold medal in 2018. Aside from these successes, the project also includes market linkages activities, assisting farmers in the sale of their produce to large supermarkets and online markets which have boosted farmers' incomes, making sustainable farming practices more attractive and viable in the long term. The project's community-driven approach has also built trust and collaboration between Naandi and local farmers, further ensuring the project's success in scaling sustainable agriculture across various regions in India.

Empowering Communities through Sustainable Agriculture

By promoting practices like cover cropping, afforestation, and biodiversity-enhancing farming techniques, Naandi has helped protect and restore natural ecosystems, such as forests and farmlands essential for climate resilience and carbon sequestration. The foundation's focus on improving farmers' livelihoods by making agriculture profitable while looking after the health of the environment supports the health of communities, particularly in tribal and rural areas, and fosters socio-economic resilience alongside ecological preservation. Additionally, in tribal areas, Naandi's work on afforestation and supporting coffee farmers has led to reforestation, carbon sequestration, and enhanced biodiversity. Naandi's holistic approach has integrated economic viability with ecosystem restoration, thereby empowering communities to adopt sustainable farming practices that improve both biodiversity and human well-being.

Further Opportunities for Nature-Health Linkages

By restoring soil health using organic compost and promoting sustainable farming techniques, like cover cropping and no-till farming, Naandi enriches soil biodiversity, increases crop yields, and improves the nutritional quality of food.

Future projects in a similar vein could:

- Advocate for regenerative farming techniques such as organic composting, cover cropping and non-till-farming to restore soil health, improve biodiversity and reduce reliance on chemical fertilizers. Compost crop residues instead of burning them.
- Scale-up to different geographies, keeping in mind the importance of collaborating with local leaders and organizations to achieve positive results.
- Demonstrate to farmers considering the transition from conventional to sustainable practices, the financial benefits of regenerative agriculture which can be done via incentives, such as subsidies for organic compost and access to low-interest loans for initial investments, as well as showcasing successful case studies where farmers have benefited economically.

Case Study Sources

Hamilton, M. (2022). Supporting India's Farmers to Regenerate the Soil. The Rockefeller Foundation. [Online]. Available at: https://www.rockefellerfoundation.org/insights/grantee-impact-story/supporting-indias-farmers-to-regenerate-the-soil/ [Accessed 28th September, 2024].

Naandi. [Online]. Available at: https://naandi.org/[Accessed 28th September, 2024].

Photo Credit: New York City Department of Environmental Protection

Recommendation IV: Use Nature-based Solutions to Support Access to Safe Water, Sanitation, Hygiene and Waste Management.

Water, sanitation, hygiene (WASH) and waste management are fundamental pillars of public health, representing essential components of a thriving society. Access to safe and clean water, proper sanitation facilities, and effective waste management systems is not only a matter of convenience, but a matter of life and death. Estimates show that globally up to 1.5 billion people do not have access to toilets or latrines and of these 419 million are forced to defecate in the open;[252] 2 billion people drink water that is faecally contaminated;[253] and diarrhoea, though largely preventable, is a predominant cause of death.[254] However, better water, sanitation and hygiene could prevent a massive amount of health fatalities, including avoiding the deaths of approximately 395,000 children under the age of 5 (2019 data).[255]

The global challenge lies in achieving universal access to WASH and sustainable waste management.[256] Improper waste management poses significant environmental and health risks, from pollution of water sources to the

[252] World Health Organization (2024). Sanitation https://www.who.int/news-room/fact-sheets/detail/sanitation Accessed 29th September, 2024.
[253] World Health Organization (2019a). WHO Global Water, Sanitation and Hygiene Annual Report 2018. Geneva.
[254] World Health Organization (2019b). Safe Water, Better Health 2091 Update. World Health Organization, Geneva.
[255] World Health Organization (2024). Sanitation https://www.who.int/news-room/fact-sheets/detail/sanitation Accessed 29th September, 2024.
[256] World Health Organization & UNICEF (2021). Progress on Drinking Water, Sanitation and Hygiene: 2000-2020. Geneva.

proliferation of vector-borne diseases.[257] Diseases include cholera, typhoid, and dysentery, and chemical pollutants such as heavy metals and pesticides which enter water supplies can lead to long-term health concerns once consumed.[258] Poor sanitation and inadequate waste management practices contribute to the faecal contamination of water sources, exacerbating the potential for disease transmission.[259]

Plastic pollution, stemming from poor waste management, frequently finds its way into aquatic ecosystems and wildlife.[260] This pollution poses a significant health threat to humans as plastics break down into microplastics that can be ingested by aquatic organisms and ultimately, enter the human food chain. The toxins associated with plastics can accumulate within the food web, presenting health risks for those who consume contaminated seafood.[261]

Addressing plastic pollution is critical to safeguarding aquatic systems and ensuring water security, however major sources of water pollution are agriculture, human settlements, and industries, with farms discharging agrochemicals, organic matter, sediments and saline drainage[262]which harms ecosystems, and consequently also biodiversity and human health.[263]Over the past 20 years, a new type of agricultural pollutant in the form of veterinary medicines, such as antibiotics, vaccines, and growth promoters like hormones, enter water streams from farms, affecting ecosystems and contaminating drinking water sources.[264] Legal instruments to manage agricultural runoff are needed and if used in conjunction with NbS, water pollution caused by agricultural runoff can be improved. Wetlands for instance, can modify numerous pollutants via physio-chemical and biological procedures, recycling wastewater and ameliorating water quality,[265]demonstrating one method in which NbS can be used in WASH and waste management.

These already urgent WASH and waste management challenges are further exacerbated by the effects of climate change in the form of extremely severe weather events. Drought depletes drinking water sources and causes

[257] UN Environment (2019). Global Environmental Outlook- GEO-6: Health Planet, Health People. Nairobi.
[258] World Health Organization & UNICEF (2021). Progress on Drinking Water, Sanitation and Hygiene: 2000-2020. Geneva.
[259] World Health Organization & UNICEF (2021). Progress on Drinking Water, Sanitation and Hygiene: 2000-2020. Geneva.
[260] United Nations Environment Programme (2018). Single-Use Plastics: A Roadmap for Sustainability.
[261] United Nations Environment Programme (2018). Single-Use Plastics: A Roadmap for Sustainability..
[262] Mateo- Sagasta, J., Zadeh, S.M., Turral, H., Burke, J. (2017). Water Pollution from Agriculture: A Global Review. Executive Summary. Rome: FAO; Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE).
[263] United Nations Environment Programme (2016). A Snapshot of the World's Water Quality: towards a Global Assessment. Nairobi, United National Environment Programme (UNEP).
[264] Mateo- Sagasta, J., Zadeh, S.M., Turral, H., Burke, J. (2017). Water Pollution from Agriculture: A Global Review. Executive Summary. Rome: FAO; Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE).
[265] Stefanakis, A.I., Tsihrintzis, V.A. (2014). Effects of Loading, Resting Period, Temperature, Porous Media, Vegetation and Aeration on Performance of Pilot-Scale Vertical Flow Constructed Wetlands. Chemical Engineering Journal. 181-1812: 416-430.

inadequate water for flushing toilets or managing personal hygiene; flooding hinders access to toilets or makes them unusable and floodwaters can introduce contaminants from pits and septic tanks into drinking water sources; cyclones result in strong winds which damage or demolish latrine structures and debris carried by wind clogs intake pipes at water sources; and lastly sea level rise risks drinking water sources becoming contaminated with saltwater and coastal erosion can lead to the collapse of sanitation infrastructure.[266]

These pressing climate change problems can cause forced migration, particularly rural, and worsens other socio-economic drivers of migration, such as food insecurity. [267] In the period 2008-2015, it was recorded that approximately 26.4 million people per year were displaced by natural-hazard induced and climate-related disasters.[268] This is predicted to rise to over 400 million by 2050.[269]Refugee camps will find additional influxes exceptionally strenuous, especially as they typically struggle with WASH due to overcrowding and inhabitants are particularly at risk of communicable diseases.[270]

Finding innovative ways to ensure WASH for everyone, especially for those compelled to the direst of situations, is needed and NbS may be adopted on a variety of occasions to help support access to safe water, sanitation, hygiene and waste management. which is not only a matter of convenience, but of human dignity.

CASE STUDY 1

New York City Watershed Agricultural Program
United States

Overview

During the latter half of the 20th century, New York faced a growing concern over water source pollution due to deforestation, agricultural expansion, and farm runoff. In an attempt to combat this, the Watershed Agricultural

[266] Megaw, T., Kohlitz, J., Gero, A., Chong, J. (2020). Understanding and Responding to Climate Change Impacts in Inclusive WASH Programs- A Conceptual Framework- Learning Paper. Institute for Sustainable Futures, University of Technology Sydney.

[267] Food and Agriculture Organization of the United Nations (2017). Migration, Agriculture and Climate Change: Reducing Vulnerabilities and Enhancing Resilience. Rome.

[268] Internal Displacement Monitoring Centre and Norwegian Refugee Council (2015). People Displaced by Disasters. Geneva.

[269] Food and Agriculture Organization of the United Nations (2016). The Future of Food and Agriculture- Trends and Challenges. Rome

[270] Philips, R.M., Vujic, J., Boscoe, A., Handzel, T., Aninyasi, M., Cookson, S.T., Blanton, C., Blum, L.S., Ram, P.K. (2015). Soap Is Not Enough: Handwashing Practices and Knowledge in Refugee Camps, Maban County, South Sudan. Conflict and Health 9(39).

Program (WAP) was established in 1992, targeting the Croton and Catskill/ Delaware watersheds, implementing strategies to mitigate pollution while also promoting the economic stability of local farms and forests. The New York City Watershed now supplies unfiltered drinking water to 9.5 million residents and it does so by using best management practices (BMPs) on farms that reduce pollutants, supporting local farmers with education and economic programs, and preserving agricultural and forest lands from development through conservation easements. The Watershed Agricultural Council (WAC) collaborates with the New York City Department of Environmental Protection (NYCDEP) to manage agricultural and forestry practices that could potentially harm water quality.

Photo Credit: New York City Department of Environmental Protection

Successes

Interdisciplinary environmental assessments of farms known as Whole Farm Plans have been conducted to identify potential pollution sources and develop tailored strategies to address issues pertinent to each farm's specific environmental and operational conditions, ensuring customized solutions for water quality protection. Best management practices such as manure management, covered barnyards and fencing have been used to reduce agricultural pollutants like pathogens, nutrients, and sediment from entering the water supply. Farms have adopted precision feed management to reduce excess nutrient imports and optimize manure management, which in turn reduces runoff. Covered facilities have been constructed to prevent pollutants like animal waste from being washed into streams by rain, and separate facilities for young animals have also been built to manage the higher pathogen risk associated with calves, keeping them separate from mature cattle. Fences have also been erected to keep livestock out of water courses, and cover crops have been adopted to reduce soil erosion and nutrient runoff during periods when the land is not used for main crops. Additionally, many farmers have adopted no-till farming methods to minimize soil disturbance.

The program has also supported an educational program which provides farmers with knowledge on how to operate and maintain their farm. This includes training on animal health, nutrient management, and other best practices through workshops, farm tours and pasture walks. The program promotes local food systems and provides financial and marketing support to watershed farmers, encouraging sustainable agriculture that is also economically viable for local producers. Microgrant programs of up to US$5,000 have been set up for farmers to improve their businesses and grow more sustainably, and such financial incentives and support for transition plans have helped farmers adopt regenerative agricultural practices that improve ecosystem health while maintaining, or enhancing, farm productivity. Via nutrient management credit programs, farmers have been incentivized to reduce nutrient imports and improve nutrient cycling on their farms.

Linking Biodiversity and WASH: Sustainable Practices for Community Well-being

The program is an example of how harnessing nature can aid in the access of WASH. By using BMPs like manure management, covered barnyards and fencing to prevent pollutants (pathogens, nutrients, and sediment) from entering the water supply. This reduces agricultural runoff and contamination of drinking water, supports ecosystem and human health. The program links biodiversity and human health by incentivizing practices that conserve forests and farmlands and the preservation of agricultural and forest lands through conservation easements that conserves biodiversity by protecting habitats and preventing development. By integrating sustainable agricultural practices, the program has also fostered soil health, reduced erosion, and promoted the long-term viability of local food systems, which are essential for community health.

Further Opportunities for Nature-Health Linkages

As climate conditions change with more extreme weather patterns and altered precipitation, watersheds and other projects are in danger of facing increased runoff and sedimentation which will require adaptive management practices.

Future projects in a similar vein could:

- Implement similar best management practices for water protection such as buffer zones, cover crops, no-till farming, and precision nutrient management. These BMPs help prevent contaminants from agricultural runoff (like excess nutrients, pathogens, and sediments) from water sources, ensuring cleaner water supplies and healthier ecosystems.
- Promote wetland restoration and conservation. Wetlands naturally filter pollutants and regulate water flow, reducing the risk of flooding and contamination in drinking water sources. Projects can restore degraded wetlands or protect existing ones as nature-based infrastructure to enhance water purification, mitigate the effects of flooding, and support wastewater management.
- Engage and educate communities in sustainable practices. Provide training and education to local communities, farmers, and stakeholders on NbS for water safety and hygiene. Raising awareness about

the importance of conserving natural ecosystems and integrating them into water management strategies is key to long-term success.

Case Study Sources

Watershed Agricultural Council. [Online]. Available at: https://www.nycwatershed.org/. [Accessed 3rd October, 2024].
New York State. New York City Watershed Program. [Online]. Available at: https://dos.ny.gov/new-york-city-watershed-program [Accessed 3rd October, 2024].

CASE STUDY 2

Tiger Worm Toilets

Ethiopia, India, Liberia, Myanmar, Sierra Leone

Overview

Tiger Worm Toilets (TWTs) are a sanitation system employed to efficiently treat human waste. A specialized type of composting worm, known as the Tiger Worm, resides in a bedding material and feeds on the faeces deposited in the toilet, breaking down the faecal matter. The worms consume and digest the waste, and the resulting effluent passes through a layer of sand and gravel, undergoing a natural filtration process. A key outcome of the Tiger Worm Toilet system is the production of vermicompost, a nutrient-rich organic material generated through the digestion of faeces by the resident Tiger Worms. This process significantly reduces the volume of faecal matter by approximately 70% to 80%. Tiger Worms can thrive solely on a diet of faeces and do not require additional organic inputs, a distinction from other composting worms, and with proper maintenance, a worm colony can inhabit the Tiger Worm Toilet indefinitely as long as the appropriate environment conditions are maintained. Developed through research and trials by Oxfam and its partners, the projects have been implemented in Ethiopia India (partnered with PriMove), Liberia, Myanmar and Sierra Leone where conventional pit latrines faced logical and environmental constraints.

Successes

In Liberia, TWTs were installed in slums prone to flooding and areas with high water tables, which provided a more durable alternative to traditional latrines. These installations significantly reduced the frequency of emptying, as the composting worms processed waste into vermicompost, lowering maintenance costs and extending the toilets' lifespan. In Ethiopia and Myanmar, TWTs were introduced into refugee camps where they addressed both space limitations and health risks associated with crowded sanitation facilities. The trials demonstrated that TWTs can be used for years without desludging, making them ideal for long-term use in resource-constrained settings. It was estimated that one site used around 13,500 litres of diesel each year for

desludging tractors, and approximately 2500 litres of petrol for pumps, resulting in the emission of ~40 tonnes of CO^2 per year. If IWTs had been used throughout the project duration, these emissions could have been avoided. TWTs contributed to improved public health by reducing odours, flies, and disease vectors, encouraging higher rates of toilet use and decreasing open defecation.

Transforming Waste: the Eco-Positive Power of Worms in Sanitation

TWTs are NbS as they leverage the natural digestive process of composting worms to treat human waste in a sustainable and efficient way. By using the worms to break down faecal matter into nutrient-rich vermicompost, the system mimics natural decomposition, reducing waste volume by up to 80% and eliminating the need for chemical or mechanical waste treatment methods. This biological process not only treats waste, but also prevents untreated effluent from contaminating local water sources, particularly in areas with high water tables or prone to flooding. The project further enhances environmental health by producing vermicompost, which can be reused as a natural fertilizer, supporting agriculture and promoting a circular waste-to-resource system. This is an eco-friendly sanitation method which reduces the carbon footprint of waste management by minimizing the need for desludging and transport, and can benefit human health.

Further Opportunities for Nature-Health Linkages

After many years of implementing TWTs Oxfam no longer recommends them for refugee camp settings unless they are able to have individual family latrines which is rare but does happen, for example in Uganda. This is because user group numbers can vary massively due to other latrines becoming unusable because they are full, damaged or uncleaned and therefore the worms cannot keep up with the increase in food and become inundated by sludge. Though TWTs can have strong positive outcomes, future projects should consider context before adopting them as an NbS.

Future projects in a similar vein could:

- Address cultural taboos and resistance to using human waste for composting by investing in comprehensive community engagement and education campaigns. A key challenge during the trials was a lack of understanding about the safety of vermicomposting. Efforts should focus on building local understanding of vermicomposting's safety and benefits for health, hygiene, and agriculture. Tailored messaging can help overcome cultural barriers and increase acceptance.
- Invest in local wormeries to ensure a reliable and sustainable supply of composting worms which will not only support the project, but also create local economic opportunities and ensure that the worm supply is readily available for future maintenance or expansions.
- Implement ongoing training programmes for local communities and maintenance personnel to ensure proper operation and upkeep of the TWTs. Training should cover key aspects such as maintaining the right moisture levels and environmental conditions for the worms, preventing pests, and ensuring overall system sustainability.

- Ensure high construction standards to avoid issues like gaps that allow pests to enter, and adapt designs to local conditions. Customizing TWTs to suit the specific environmental and cultural needs of each location will help maximize efficiency, ensure durability, and enhance user satisfaction.

Case Study Sources

Furlong, C., Lamb, Bastable, A., (2017). Learning from Oxfam's Tiger Worm Toilets Projects. [Online]. Available at: https://wedc-knowledge.lboro.ac.uk/resources/conference/40/Furlong-2835.pdf [Accessed 28th September, 2024].

Snoad, C., (2018). Tiger Worm Toilet Manual: Globally Relevant Learnings from Myanmar. Oxfam.

Oxfam Wash. Tiger Worm Toilets. [Online]. Available at: https://www.oxfamwash.org/en/sanitation/tiger-worm-toilets [Accessed 28th September, 2024].

Watako, D., Mougabe, K., Heath, T. (2016). Tiger Worm Toilets: Lessons Learned from Constructing Household Vermicomposting Toilets in Liberia. Waterlines, 35(2): 136-147.

Photo Credit: Mike Wilkinson

Recommendation V: Integrate Urban Ecosystems with Public Health Planning.

The majority of the world's population resides in urban areas, with 56% recorded in 2021, a number which is estimated to rise to 68% in 2050.[271] Urban ecosystems are a primary source of global emissions attributed mainly to the concentration of transport, communities, business and industries; the consumption of natural resources; and land and ecosystem transformation.[272] Cities, especially megacities, can influence local weather patterns in significant ways, mostly by enhancing high-impact weather hazards due to their alteration of surface and atmospheric properties.[273] Many cities suffer from the "urban heat island effect" (UHI)- a microclimate phenomenon linked to substantial rises in temperature with the potential to intensify heatwaves[274]- with asphalt, metal roofs and brick pavements contributing to the heat island potential.[275] The UHI effect exacerbates existing risks to human health within urban ecosystems: around 80% of the people living in cities are exposed to levels higher than the World Health Organization's Air Quality Guidelines;[276] approximately 7 million deaths are

[271] United Nations Human Settlements Programme (2022). World Cities Report 22. Nairobi.
[272] Lal, R. (2012). Urban Ecosystems and Climate Change. In Lal, R., Augustin, B. (eds.) Carbon Sequestration in Urban Ecosystems. Springer, Dordrecht.
[273] Oke, T.R., Mills, G., Christen, A., Voogt, J. (2017). Urban Climate. Cambridge, UK. Cambridge University Press.
[274] Leal Filho, W., Wolf, F., Castro-Díaz, R. Li, C., Ojeh, V.N, Gutiérrez, N., Nagy, G.J, Savic, S., Natenzon, C.E Quasem Al-Amin, A., Maruna, M, Bonecke, J. (2021). Addressing the Urban Heat Islands EffectÇ A Cross-Country Assessment of the Role of Green Infrastructure. Sustainability 13(2), 753.
[275] Razzaghmanesh, M., Beecham, S., Salemi, T. (2016). The Role of Green Roofs in Mitigating Urban Heat Island Effects in the Metropolitan areas of Adelaide, South Australia. Urban Forestry & Urban Greening 15: 89-102.
[276] World Health Organization (2006). Air Quality Guidelines: Global Update 2005. Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide. Copenhagen.

caused by ambient and household air pollution;[277] road trafficking injuries account for 1.3 million deaths per year;[278] and physical inactivity (which previous estimates showed roughly 3 million deaths) has now been updated to 5 million.[279] Both high and low income countries are affected by urban health problems. Despite medical advances, high-income countries are seeing a rise in the rates of noncommunicable diseases, while both communicable and noncommunicable diseases are increasing in low income countries, particularly among inhabitants of informal settlements, in part due to inadequate urban and territorial planning regulation and practice.[280]

Growing urbanization, warmer temperatures, increased pollution, extreme weather conditions contribute to cardiovascular disease being the leading cause of death worldwide with rates continuing to rise globally.[281] Urban inhabitants tend to have less access to green space, which can be associated with higher probabilities of insulin resistance,[282] diabetes[283], stroke,[284] cancer,[285] cardiovascular mortality,[286] and a lower life expectancy .[287]

Biodiversity loss in urban ecosystems has a negative knock-on effect on human health. The "biodiversity hypothesis" demonstrates how biodiversity positively impacts human health, demonstrating that symbiotic microbes present in the human microbiome, which are essential for the healthy development of the immune system[288][289] and the proper functioning of the digestive system, are associated with exposure to natural

[277] World Health Organization (2018a). Burden of Disease from Ambient Air Pollution for 2016, versions 2. Geneva.
[278] World Health Organization (2018b). Global Status Report on Road Safety 2018. Geneva.
[279] World Health Organization (2022). Global Status Report on Physical Activity 2022. Geneva.
[280] UN-HABITAT & World Health Organization (2020). Integrating Health in Urban and Territorial Planning: A Sourcebook. Geneva.
[281] Lozano, R., Naghavi, M., Foreman, K., Lim, S., Shibuya, K., Aboyans, V., et al. (2010). Global and Regional Mortality from 235 Causes of Death for 20 Age Groups in 1990 and 2010. Lancet 380(9859): 2095-128.
[282] Jimenez, M.P, Oken, E., Gold, D.R., Luttmann-Gibson, H., Requia, W.J., Rifas- Shiman, S.L., Gingras, V., Hivert, MF., Rimm, E.B, James P. (2020). Early Life Exposure to Green Space and Insulin Resistance: An Assessment from Infancy to Early Adolescence. Environment International 142:105849.
[283] Ccami-Bernal, F., Soriano-Moreno, D.R, Fernandez- Guzman, D., Tuco, K.G., Castro-Díaz, S.D., Esparza- Varaz, A.L., Medina- Ramirez, S.A, Caira- Chuquineyra, B., Cortez- Soto, A.G., Yovera-Aldana, M, Rojas- Rueda, D. (2023). Green Space Exposure and Type 2 Diabetes Meliitus Incidence: A Systematic Review. Health & Place 82: 103045.
[284] Paul, L.A., Hystad, P., Burnett, R.T., Kwong, J.C., Crouse, D.L., van Donkelaar, A., Tu, K., Lavigne, E., Copes, R., Martin, R.V., Cheng, H. (2020). Urban Green Space and The Risks of Dementia and Stroke. Environmental Research.
[285] Iyer, H.S., James, P., Valeri, L., Pernar, C.H., Mucci, L.A., Holmes, M.D., Laden, F., Rebbeck, T.R. (2020). Environmental Epidemiology. 4(2): e091.
[286] Liu, X.X., Ma, X.L., Huang, W.Z., Luo, Y.N., He, C.J., Zhong, X.M., Dadvand, P., Browning, M.H.E.M., Li, L., Zou, X.G., Dong, G.H., Yang, B.Y. (2022). Green Space and Cardiovascular Disease: A Systematic Review with Meta-Analysis. Environment Pollution 15(301):118990.
[287] Rojas-Rueda D., Nieuwenhuijsen M., Gascon M., Perez-Leon D., Mudu P. (2019). Green Spaces and Mortality: A Systematic Review and Meta-analysis of Cohort sStudies. Lancet Planet. Heal. 19:e469–e477
[288] Ruokolainen L, Lehtimäki J, Karkman A, Haahtela T, von Hertzen L, Fyhrquist N. (2017). Holistic View on Health: Two Protective Layers of Biodiversity. Ann Zool Fenn. 24:39–49
[289] Rook GA. Regulation of the immune system by biodiversity from the natural environment: an ecosystem service essential to health. Proc Natl Acad Sci U S A. 2013.

environments.[290] The diversity of a person's microbiome is influenced by their lifestyle, environment, and exposure patterns,[291] and individuals living in urban ecosystems generally have fewer opportunities to interact with beneficial microorganisms, whether through diet, respiratory exposure or skin contact.[292] Microorganisms are prevalent in soils, comprising the second-largest global biomass on Earth after plants, and play a vital role in connecting the health of plants, animals, and humans, bridging various ecosystems.[293] Decreased exposure to a biodiverse range of environmental microbes is linked to an increase in noncommunicable diseases, such as asthma and inflammatory disorders, which have become increasingly prevalent in industrialized countries, potentially in part due to this decreased exposure.[294][295][296] Exposure to environmental microbes that support our immune system and health more broadly may be achieved via the restoration of biodiverse urban green spaces.[297][298] Local biodiversity aids public health due to the diversity and abundance of plants, animals and microbes which can affect urban agriculture, pest management, and the transmission of diseases .[299] [300]Trees play an important role in removing air pollutants via dry deposition, but may also contribute to the reduction of ground-level ozone.[301] Urban biodiversity contributes to cleaner air by filtering the air via the trapping of particulate matter and absorbing pollutants[302] and by generating oxygen via photosynthesis, also supplying the

[290] Renz H, Holt PG, Inouye M, Logan AC, Prescott SL, Sly PD. An Exposome Perspective: Early-Life Events and Immune Development in a Changing World. J Allergy Clin Immunol. 2017;140:24–40.

[291] Ruokolainen L, Lehtimäki J, Karkman A, Haahtela T, von Hertzen L, Fyhrquist N. (2017). Holistic view on health: two protective layers of biodiversity. Ann Zool Fenn. 24:39–49

[292] Ruokolainen L, Lehtimäki J, Karkman A, Haahtela T, von Hertzen L, Fyhrquist N. (2017). Holistic view on health: two protective layers of biodiversity. Ann Zool Fenn. 24:39–49

[293] Banerjee, S., Van der Hejiden, M.G.A (2023). Soil Microbes and One Health. Nature: 21.

[294] Von Hertzen, L., Hanski, I., Haahtela, T. (2011). Natural Immunity. Biodiversity Loss and Inflammatory Diseases are Two Global Megatrends that Might be Related. EMBO Reports, 12 (11), 1089-1093.

[295] Rook, G.A.W, Bloomfield, S.F. (2021). Microbial Exposures the Establish Immunoregulation are Compatible with Targeted Hygiene. The Journal of Allergy and Clinical Immunology 148:1:33-39.

[296] Roslund, M.I, Puhakka, R., Gronroos, M., Murmienen, N., Oikarinen, S., Gazali, A.M, Cinek, O., Kramná, L., Siter, N., Vari, H.K., Soininen, L., Parajuli, A., Rajaniemi, J., Kinnunen, T., Laitinen, O.H, Hyoty, H., Sinkkonen, A., ADELE Research Group, (2020). Biodiversity Intervention Enhances Immune Regulation and Health-Associated Commensal Microbiota among Daycare Children. Science Advances, 6(42).

[297] Mills, J.G, Weinstein, P., Gellie, N.J.C., Wetrich, L.S., Lowe, A.J., Breed, M.F., (2017). Urban Habitat Restoration Provides a Human Health Benefit through Microbiome Rewilding: the Microbiome Rewilding Hypothesis. Restoration Ecology 25:6:866-872.

[298] Robinson, J.M, Aronson, J., Daniels, C.B., Goodwin, N., Liddicoat, C., Orlando, L., Philips, D., Stanhope, J., Weinstein, P., Cross A.T., Breed, M.F. (2022). Ecosystem Restoration is Integral to Humanity's Recovery from COVID-19. The Lancet Planetary Health 6:9:E769-E773.

[299] Marselle, M. R., Lindley, S.J., Cook, P.A., Bonn, A., (2021). Biodiversity and Health in the Urban Environment, Current Environmental Health Reports, 8:146-156.

[300] Robinson, J.M, Breed, A.C., Camargo, A., Redvers, N., Breed, M.F. (2024). Biodiversity and Human Health: A Scoping Review and Examples of Underrepresented Linkages. Environmental Research 246:118115.

[301] Fitzky, A.C., Sandén, Karl, T., Fares, S., Calfapietra, C., Grote, R., Saunier, A., Rewald, B., (2019). The Interplay between Ozone and Urban Vegetation -BVOC Emissions, Ozone Deposition, and Tree Ecophysiology. Frontiers for Global Change 2.

[302] Escobedo, F. J., Kroeger, T., Wagner, J.E. (2011). Urban Forests and Pollution Mitigation: Analyzing Ecosystem Services and Disservices. Environmental Pollution, 159 (8-9), 2078-2087.

air with health promoting bioaerosols, including diverse microbiota and phytoncides.[303] Aquatic plants and microorganisms in ponds and wetlands can absorb excess nutrients like nitrogen and phosphorus from water bodies, avoiding nutrient pollution and water degradation, and vegetation along water bodies stabilizes soil, preventing erosion and ensuring that fewer sediments and pollutants enter urban rivers and streams.[304]Introducing green infrastructure into the city can lower the temperature, providing cooling effects through shade and the release of water vapor during transpiration,[305] and reducing the formatting of ground-level ozone and smog.[306]

Consequently, being in biodiverse urban green spaces can enhance health by boosting our exposure to microbial diversity and influencing the composition of human microbiota upon exposure. Both the cities of Lahti and Louisville aim to target the greening of the urban environment to improve physical and mental health, while co-benefitting nature.

CASE STUDY 1

Green Heart Louisville Project

United States

Overview

The Green Heart Project aims to address two critical issues that plague the residents of Louisville, Kentucky: air pollution and chronic disease. The city is cited as having the worst air quality in Kentucky and possesses a tree canopy of currently only 37% which is being lost at a rate of about 54,000 trees per year.[307] The initiative builds upon observational studies which suggest that living in areas with low levels of greenness is associated with higher risk of diabetes, stroke, cancer and cardiovascular mortality.[308] The Green Heart project was designed to test the hypothesis that exposure to neighbourhood greenery diminishes the risk of cardiovascular disease by decreasing the levels of air pollution. It is hoped that the results of the project will help determine how increasing greenness affects neighbourhood characteristics such as noise and air pollution, ambient heat and biodiversity, as well as the sense of well-being and social cohesion among area residents.

---

[303] Robinson, J.M, Breed, M.F (2023). The Aerobiome-Health Axis: A Paradigm Shift in Bioaerosol Thinking. Trends in Microbiology 31:7.

[304] Paul, M.J., Meyer, J.L (2001). Streams in the Urban Landscape. Annual Review of Ecology and Systematics, 32:333-65.

[305] Gunawardena, K.R., Wells, M.J., Kershaw, T. (2017). Utilizing Green and Bluespace to Mitigate Urban Heat Island Intensity. Science of the Total Environment 584-585: 1040-1065.

[306] Oke, T.R. (1982). The Energetic Basis of the Urban Heat Islands. Quarterly Journal of the Royal Meteorological Society. Vol 108(455), 1-24.

[307] Green Heart Louisville https://greenheartlouisville.com/ Accessed 29th September, 2024.

[308] Keith, R.J, Hart, J.L, Bhatnagar, A., (2024). Greenspaces and Cardiovascular Health. Circulation Research, 134(9), 1179-1196.

Successes

The project examined the effect of a neighbourhood greening intervention on cardiovascular disease risk and inflammation among residents ages 25-75 years in Louisville, Kentucky. Within a group of low-to-middle income neighborhoods, the project identified 16 demographically- and environmentally- matched clusters and split these clusters into target or control neighborhoods. Between 2018 and 2021, the study enrolled 500-700 residents from target and control areas and collected their health information via in-person exams. In 2022, over 8000 mature trees and shrubs were planted within the target areas, and the levels of air pollution in the area and the health of area residents was examined post-greening in 2022 and 2023. Cardiovascular disease risk was evaluated by measuring arterial stiffness, blood pressure and blood lipids, as well as markers of inflammation and pollutant exposure. Data on mental health and well-being were collected via questionnaires.

Prior to planting trees, demographic characteristics were comparable among participants in target and control areas. However, after planting, participants living in the target areas had approximately on average 22% lower levels of C-reactive protein (CRP), a sensitive biomarker of inflammation. In addition, over 5 years, there was a 20% decrease in CRP levels per 0.1 unit increase in the Normalized Difference Vegetation Index (NDVI), a satellite-derived index of greenness. Given that inflammation is the underlying driver of many chronic diseases, these findings suggest that increasing levels of urban greenness could lead to a decrease in the risk of chronic diseases such as cardiovascular disease.

Nature-positive Interventions for a Healthier City

The Green Heart Project tests the effects of nature-positive interventions on specific health impacts to promote community-level health and resilience in urban residents facing degraded environmental conditions such as increased levels of air pollution and ambient heat. Through community-driven efforts and community engagement, the project advances science to pilot, test, and implement-at-scale NbS aimed at improving human health. It is a prime example of greening the urban environment to enhance human health, improve urban environments, and create new models of healthy, urban living that could be replicated worldwide.

Further Opportunities for Nature-Health Linkages

Future projects in a similar vein could:

- Probe the mechanisms underlying the health benefits of greenspaces and examine whether they are related to improvements in environmental conditions, biodiversity and mental health and physical activity as well as greater phytoncide exposures; all of which can lower inflammation and lead to better cardiovascular health.
- Scale up the research strategy to additional ecosystems and biomes which is needed to test the generalizability of the findings and to generate region-specific implementation approaches and guidance to maximize nature-based solutions as a viable public health strategy.
- Encourage the integration of findings from such nature-based interventions into public health policy and urban planning. By highlighting the health benefits of greenspaces, stakeholders can advocate for

policies that support the development of greenspaces as an effective means of mitigating the impact of climate change in urban locales and decreasing the burden of air pollution and cardiovascular disease worldwide.

Case Study Sources

ClinicalTrials.gov. Health, Environment and Action in Louisville 9HEAL) Green Heart Louisville Project (Heal). [Online]. Available at: https://clinicaltrials.gov/study/NCT03670524?term=HEAL&locStr=Louisville,%20KY,%20USA&country=United%20States&state=Kentucky&city=Louisville&rank=1 [Accessed 28th September, 2024].
Greenheart Louisville. [Online]. Available at: https://greenheartlouisville.com/ [Accessed 28th September, 2024].
The Nature Conservancy, (2018). The Green Heart Louisville Project. [Online]. Available: https://www.nature.org/en-us/about-us/where-we-work/united-states/kentucky/stories-in-kentucky/green-heart-project/ [Accessed 28th September, 2024).
Today (2024). Does Planting Trees Help Improve the Health of Communities? [Online]. Today.com. Available at: https://www.today.com/video/does-planting-trees-help-improve-the-health-of-communities-218060357885. [Accessed 28th September, 2024].

CASE STUDY 2
Lahti Health Forest
Finland

Overview

The Lahti Health Forest, part of the broader H2020 EU project, is one of six cities in the GoGreenRoutes consortium which looks at advancing mental and physical health in tandem with fostering environmental awareness and pro-environmental behaviour. The initiative promotes outdoor recreation, offering opportunities for residents to engage in physical activities which can enhance their overall health and well-being. Lahti's Health Forest is located next to the Päijät-Häme Central Hospital, 6 km from the city center, and has accessible routes for hospital staff, patients, and the general public to support their well-being by connecting to the forest. Small interventions such as yoga platforms, picnic spots and signage have been deployed in the health forest and guided tours are also conducted to make the population aware of the importance of human-nature connections.

Successes

The Lahti Health Forest is a place where people can experience and learn about nature-health benefits. The forest has various routes, places to rest, a yoga platform, board decks, shelter, and instruction boards to inform

people about nature health benefits and guide them to observe nature. The project has worked on extensive communication to raise awareness of nature's health benefits in the forms of videos, brochures and being in the news. In addition, the municipality has distributed health forest education material for all the schools in the city to encourage teachers to organize outdoor education. Currently, the city is organizing a Health Forest Guide with training for 20 participants from the city and local well-being services country, and the Lahti region health services has appointed Finland's first Planetary Health Physician. Lahti has also experimented with Planetary Prescriptions to see whether a smaller carbon footprint has positive human health results, which included activities such as building insect habitats in backyards, barefoot forest walks, and altering diets. The Health Forest has been used by the hospital staff, particularly by people on the psychiatric ward.

Photo Credit: Shreya Utkarsh

Lahti's Nature-based Solution

The city of Lahti, which was named the European Green Capital in 2021, is leading the way in raising awareness about Planetary/One Health among city residents and encouraging them to adopt healthy lifestyles. The Lahti Health Forest is a nature-based solution which supports the well-being of citizens and the environment which has resulted in activities to ameliorate mental and physical health; launched educational initiatives; and showcased planetary health as an approach to improve the lives of people, ecosystems, and the planet. It also encourages public participation in environmental stewardship, empowering communities to contribute to ecosystem preservation and restoration efforts. The Health Forest serves as a biodiverse environment which has the potential to improve air quality; enhance resident's exposure to beneficial microorganisms; and support mental health. The project's multi-sectoral leadership is essential to breaking nature-health silos and increasing internal co-operation, involving the public sector, civil society, research and academia and the private sector, and

Lahti is a strong example of a city implementing NbS in order to address societal challenges, while providing environmental, social and economic benefits, and helping to build resilience.

Further Opportunities for Nature-Health Linkages

Future projects in a similar vein could:

- Adopt health initiatives based in nature such as nature/planetary prescriptions.
- Raise awareness including in schools of the value of greenspaces on human health, biodiversity, and climate regulation, inspiring a new generation to value and protect natural spaces.
- Incorporate conservation activities in the greenspaces in order to support biodiversity such as the planting of native species; creating habitats for wildlife; monitoring wildlife numbers, all which could involve local schools.
- Contribute to the literature on linkages between biodiversity and mental health by tracking mental health impacts on park visitors in a comprehensive study which can be later disseminated.

Case Study Sources

Go Green Routes. Lahti Health Forest Information Brochure. [Online]. Available at: https://gogreenroutes.eu/publication?t=Lahti%20Health%20 Forest%20 Informational%20Brochure [Accessed 28th September, 2024].

Green Lahti. [Online]. Available ate: https://greenlahti.fi/en [Accessed 28th September, 2024].

Photo Credit: Charlotte Fraiberg

Recommendation VI: Redesign Energy and Transport Systems to Integrate Green-Gray Infrastructure to Support Health

Though our modern-day energy and transport systems are the lifeblood of daily life in the twenty-first century, they often come at a significant cost to public health and the environment. One key detrimental consequence of these systems is air pollution which is the second highest risk factor for non-communicable disease with 6.7 million premature deaths attributed to ambient pollution in 2019 alone.[309] Of that number it is estimated that 37% of all outdoor air pollution deaths were caused by ischaemic heart disease and stroke; 18% by chronic obstructive pulmonary disease; 23% by acute lower respiratory infections; and 11% by cancer within the respiratory tract.[310]

Fossil-fuel-based energy systems contribute significantly to indoor air pollution as well, especially in low-income countries where solid fuels such as wood, dung, and crop residues are commonly used for cooking and heating.[311] The indoor burning of these fuels releases harmful pollutants like carbon monoxide and particulate matter, making household air pollution a major risk factor for acute respiratory infections, particularly in women and

[309] World Health Organization (2024). Ambient (Outdoor) Air Pollution. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health Accessed 29th September, 2024.
[310] World Health Organization (2024). Ambient (Outdoor) Air Pollution. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health Accessed 29th September, 2024..
[311] World Health Organization (2023). Household Air Pollution. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health Accessed 29th September, 2024.

young children who spend more time indoors, worsening respiratory disease and contributing to high morbidity and mortality in many parts of the world.[312][313]It is estimated that were clean cookstoves used ubiquitously, there would be a reduction of 1,279 years of life lost/year, and that in the transport sector were there more active travel, there would be a reduction of 60.[314]

In addition to the impacts of energy and transportation systems on air quality, there are also dramatic socio-environmental consequences of energy resource extraction, such as coal, oil, and natural gas, as well as the minerals needed for renewable energy. Mining and fossil fuel extraction have been responsible for soil and water contamination; the displacement of local communities; and the destruction of critical ecosystems. In many regions, especially in low-income countries, communities near extraction sites face higher rates of respiratory diseases, waterborne illnesses, and mental health issues due to environmental degradation and the loss of traditional livelihoods. An example is the Niger Delta in Nigeria, one of the most affected areas by oil extraction. Oil spills and gas flaring have severely contaminated soil and water bodies, affecting fishing and agriculture, and exposing local communities to higher rates of respiratory and gastrointestinal diseases. Benzene and other chemicals have been linked to increased cancer cases.[315] Similarly, in the Jharkhand region of India, open-pit coal mining has caused severe water contamination, increasing rates of respiratory and gastrointestinal diseases among local populations who depend on these resources.[316] Furthermore, water pollution from oil spills or the release of toxic chemicals during mining can lead to serious public health problems, such as gastrointestinal diseases, neurological conditions, and ailments related to exposure to heavy metals like mercury and arsenic. Artisanal gold mining in Ghana, where mercury use has contaminated rivers, caused severe neurological effects in local fishing communities, particularly affecting children and pregnant women.[317]. In Cerro de Pasco, Peru, copper mining has released toxic dust into the air, increasing chronic respiratory diseases, particularly among children.[318]

These issues also affect biodiversity. Lithium extraction in the Salar de Atacama, Chile, has reduced groundwater sources, severely affecting Indigenous Peoples who rely on this water for agriculture, worsening food

[312] World Health Organization (2023). Household Air Pollution. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health Accessed 29th September, 2024..

[313] Whitmee, S., Green, R., Belesova, K., Hassan, S., Cuevas, S., Murage, P., et al. (2024). Pathways to a healthy net-zero future: report of the Lancet Pathfinder Commission. The Lancet, 403(10421), 67-110.

[314] GBD 2017 Risk Factor Collaborators (2017). Global, Regional, and National Comparative Risk Assessment of 84 Behavioral, Environmental and Occupational, and Metabolic Risks or Clusters of Risks for 195 Countries and Territories, 1990-2017: A Systematic Analysis for the Global Burden of Disease Study. Lancet 392:1923-94.

[315] Nanadeinboemi, O. A., Uju, M. L., Christopher, C. N., Hakeem, O. O., David, D. S. (2024). Environmental and Health Influences of Crude Oil Spills in Niger Delta, Nigeria: Case Study Oporoma Community. Journal of Health and Environmental Research, 10(2), 29-40. https://doi.org/10.11648/j.jher.20241002.11

[316] Ghose, M.K., & Majee, S.R. (2001). Environmental Impact of Coal Mining on Water Regime and Its Management. Water, Air, and Soil Pollution.

[317] Hilson, G. (2002). The Environmental Impact of Small-Scale Gold Mining in Ghana: Identifying Problems and Possible Solutions. The Geographical Journal.

[318] James B. Molloy, Donald T. Rodbell, David P. Gillikin, Kurt T. Hollocher (2020); Citizen Science Campaign Reveals Widespread Fallout of Contaminated Dust from Mining Activities in the Central Peruvian Andes. Geology ; 48 (7): 678–682. doi: https://doi.org/10.1130/G47096.1

insecurity.[319] Moreover, unplanned or poorly managed resource extraction increases the risk of natural disasters such as floods and landslides, endangering both infrastructure and human lives. In Colombia, at the Cerrejón coal mine, deforestation and excessive water use have triggered landslides and droughts, affecting Wayuu Indigenous Peoples, who suffer from high rates of child malnutrition and lack of potable water.[320]

Transport systems are also responsible for non- pollution-related deaths as an estimated 1.3 million people die each year in road accidents.[321] Rural roads, if unplanned and non-engineered, can result in catastrophic disasters such as landslides[322] which can be the direct cause of death and injuries from rapidly flowing water and debris, trauma, and suffocation from entrapment.[323] Damaged power, water, gas, and/or sewage lines can lead to injuries or illnesses in affected populations, including risks like waterborne diseases, electrocution or cuts from falling debris, in addition to short and long term mental health issues due to the loss of loved ones, homes, livestock and/or crops.[324] Crucially, landslides can cut off access to essential services such as healthcare, water supply, electricity and communication, and can also involve loss of livestock and crops indirectly harming human health.[325] As such, preventing landslides falls under disaster risk reduction (DRR) which has a key role for public health actors. They are recognized as key contributors to the Sendai Framework for Disaster Risk Reduction 2015-2030[326]as are NbS in order to reduce disaster risk, adapt to climate change, and enhance community resilience.[327]

Addressing the environmental and health impacts of energy and transport systems requires not only cleaner practices, but innovative approaches, such as green-gray infrastructure that combines the strengths of both natural (green) and engineered (gray) systems. Green infrastructure involves the use of natural elements, such as vegetation, soils, wetlands, and water bodies to manage environmental challenges. It is associated with low environmental impact and offers various ecosystem services,[328] which can also be designed via NbS. By integrating green-gray infrastructure into energy and transport systems, biodiversity, climate, and health can be supported.

---

[319] Liu, W., & Agusdinata, D.B. (2020). Interdependencies of Lithium Mining and Community Livelihoods in the Salar de Atacama, Chile. Journal of Cleaner Production

[320] Owen, J.R. (2013). Social License and Mining: A Critical Perspective. Resources Policy.

[321] World Health Organization (2023). Road Traffic Injuries. https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries Accessed 29th September, 2024.

[322] Devkota, S., Shakya, N.M, Sudmeier-Rieux (2019). Framework for Assessments of Eco-Safe Rural Roads in Panchase Geographic Region in Central- Western Nepal Hills. Environments 6(6),59.

[323] World Health Organization. Landslides. https://www.who.int/health-topics/landslides/#tab=tab_1

[324] World Health Organization. Landslides. https://www.who.int/health-topics/landslides/#tab=tab_1

[325] Highland, L., Geertsema (2019). Human Health Effects of Landslides (ed.) Nriagu, J.O, Encyclopedia of Environmental Health 2nd Edition,, Elsevier.

[326] Banwell, N, Rutherford, S., Mackey, B., Chu, C. (2018). Towards Improved Linkage of Disaster Risk Reduction and Climate Change Adaptation in Health: A Review. International Journal of Disaster Risk Science. 15(4), 793.

[327] Arce-Mojica, T., Nehren, U., Sudmeier-Rieux, K., Miranda, P.J., Anhuf, D., (2019). International Journal of Disaster Risk 41:101293.

[328] Browder, G.S., Ozment, S., Rehberger Bescos, I., Gartner, T., Lange, G.M (2019). Integrating Green and Gray: Creating Next Generation Infrastructure. Washington D.C. World Bank and World Resources Institute.

CASE STUDY 1

Payments for Ecosystem Services to Support Hydropower Operations in Costa Rica

Costa Rica

Overview

Prior to the second half of the 20th century, Costa Rica had been a heavily forested country. Yet by late 1980s, the country was experiencing dramatic deforestation rates with forest cover plummeting to just 20% from approximately 70% due to agricultural expansion and infrastructure development.[329] Not only did this harm biodiversity, it also hindered Costa Rica's reliance on a critical energy source, hydropower, as soil erosion and sedimentation were putting hydropower reservoirs at risk. Hydropower serves as a renewable energy source which contributes to cleaner air quality than conventional energy systems, reducing respiratory and cardiovascular diseases associated with pollution. It marks a transition that lessens the negative health impacts associated with climate change, and avoids the adverse health consequences of mining and fossil fuel extraction. In order to combat the risks to the hydropower reservoirs, the country established a national Payment for Ecosystem Services (PES) program through Forestry Law 757 in 1996 which was implemented via the national Fund for Forest Financing (FONAFIFO) and incentivized landowners to conserve and restore forests, enhancing carbon sequestration, as well as the health of both biodiversity and critical watersheds that supply drinking water and hydropower facilities. Thus, via improving the health of the watersheds, supported by sustainable forest management, the local community could reap the public health benefits of good quality drinking water and access to efficiently run hydropower operations.

Successes

By 2017, The Costa Rican PES program had successfully managed to reverse deforestation trends and improve the health of critical ecosystems by enrolling over 280,000 hectares of land into forest conservation. Forest cover had rebounded to around 50%. As upstream forest conservation had been incentivized, soil erosion and sedimentation in reservoirs improved which directly benefited downstream hydropower facilities due to the improved health of the watershed, and enhanced the resilience of Costa Rica's hydropower sector, which generates around 75% of the country's electricity. Improved hydropower reliability directly translates to better energy security for communities, reducing health risks associated with energy shortages. Since its inception, more

[329] Buckingham, K., Hanson, C. (2015). The Restoration Diagnostic Case Example: Costa Rica Case Study. The Restoration Diagnostic. Washington D.C: World Resources Institute.

than 17,000 contracts have been signed with landowners to conserve or restore forests, helping farmers' incomes, and making environmental conservation an economically viable option for landowners. The program has helped Costa Rica advance its climate goals and progress towards its Nationally Determined Contributions under the Paris Agreement as the forests absorb carbon dioxide and mitigate greenhouse gas emissions. It has also garnered finance from organizations such as the Global Environmental Facility and German Development Bank and influenced national policies on sustainable land management and environmental services.

Integrating Green-Gray Infrastructure to Support Sustainable Energy and Public Health

The PES program in Costa Rica exemplifies how a country can successfully integrate natural (green) and engineered (gray) infrastructure to attain positive public health and environmental outcomes, by providing financial incentives to landowners for activities such as forest conservation, reforestation, agroforestry, and sustainable forest management. Preventing soil erosion and sedimentation assisted forests in maintaining the efficiency of hydropower plants, demonstrating a synergy between natural ecosystems and hydropower facilities which as a renewable energy source reduces the need for fossil fuels which are significant contributors to air pollution and related health problems, such as respiratory and cardiovascular diseases. The forest cover can significantly impact water availability, forests protect soil and act as sponges, absorbing water during rainy seasons and slowly releasing during dry period, thereby mitigating extreme weather events like floods and droughts,[330] and as such protecting humans from these adverse effects. They sequester carbon and reduce the frequency and intensity of forest fires as well.

Further Opportunities for Nature-Health Linkages

NbS can offer ways to tackle water security while delivering lasting benefits and future projects can likewise prioritize ecosystem health alongside energy production. The energy sector can be encouraged to adopt green infrastructure and NbS to ameliorate both nature and human health.

- The PES program connects forest conservation to public health by addressing air and water quality. Future projects could similarly seek to make explicit connections between ecological preservation and health outcomes in the energy sector.
- Financial incentives helped align environmental conservation with economic benefits and knock-on positive effects on health. Future projects could likewise use similar mechanisms to encourage sustainable practices that positively impact health.
- Projects can design systems that leverage natural ecosystems to prevent health issues, such as combining reforestation with flood control infrastructure to reduce disaster-related health risks.

Case Study Sources

[330] Peña- Arancibia, J., Bruijnzeel, L.A, Mulligan, M, van Dijk, A.I.J.M (2019). Forests as "Sponges" and "Pumps": Assessing the Impact of Deforestation on Dry-Season Flows across the Tropics. Journal of Hydrology 574:946-963.

Browder, G., Ozment, S., Rehberger Bescos, I., Gartner, Lange, G.M., (2019). Integrating Green and Gray: Creating Next Generation Infrastructure. World Resources Institute.
Buckingham, K., Hanson, C. The Restoration Diagnost. Case Example: Costa Rica. Washington D.C: World Resources Institute
Porras, I.T., Barton, D.N., Miranda, M., Chacón- Cascente. Learning from 20 years of Payments for Ecosystem Services in Costa Rica. [Online]. Available at: https://www.iied.org/16514iied

---

CASE STUDY 2

Ecosystems Protecting Infrastructure and Communities (EPIC) Nepal
Nepal

Overview

Over 80% of Nepal is composed of steep mountainous terrain which experiences high precipitation rates, especially during the monsoon season.[331] The intense rainfall the country receives leads to many incidences of flash floods, landslides and severe soil erosion, disrupting livelihoods and infrastructure, especially in rural areas. The region of Panchase, where the Ecosystems Protecting Infrastructure and Communities (EPIC) project was implemented, is no anomaly and the high rainfall combined with the commonly occurring landslides threaten local agriculture, infrastructure, biodiversity and human health. The project aimed to reduce landslide instability along rural roadways using ecosystem-based engineering techniques i..e. low cost bioengineering techniques, in addition to building the capacity of communities advocating for ecosystem-based disaster risk reduction (Eco-DRR) at global, national, and local levels by influencing policy processes to integrate Eco-DRR approaches into development planning.

Successes

The EPIC project in Nepal established three demonstration sites where low cost bioengineering techniques were used to stabilize landslide-prone areas along earthen rural roads. All together nine local grass species were planted in order to stabilize slopes and reduce soil erosion. Among them, broom grass (*Thysanolaena maxima*) proved to be especially effective due to having the deepest roots and high survival rate, whereas scented grass (*Chrysopogon gryllus*) had the strongest roots.

[331] Food and Agriculture Organization of the United Nations. (1999). State of the World's Forests 1999. https://www.fao.org/4/x6900e/x6900e0m.htm

The project also established nurseries in two District Soil Conservation Offices for bioengineering species which were distributed to communities who were also able to generate income as the different products of broom grass such as broom, leaf, stem could be sold, sometimes for up to 20,000 NPR/km (~USD 148) of broom harvested. These communities were involved throughout every stage of the project, from vulnerability assessments in bioengineering techniques, to focused group meetings (~90) and community discussions. Sixty-six community members were trained in bioengineering techniques in order to develop the skills needed to manage and sustain the intervention long-term (the Gharelu community extended the project on their own). Communities actively participated in monitoring the survival rates of bioengineering grass species, an engagement which fostered citizen science, and 5 workshops were organized at the national and regional levels with more than 300 participants. In all, it was estimated that around 450 community members benefited directly from the project. Workshops were also organized for journalists to raise awareness of Eco-DRR; EPIC Nepal's results were disseminated via newspapers, televisions, and presentations from local to international level; and the project worked with the Nepalese government to integrate ecosystem-based approaches into national and regional policies, with Eco-DRR being included in the National Strategic Framework for Nature Conservation (2015-2030).

Utilizing Green Infrastructure in Transport Systems to Enhance Disaster Resilience and Community Health

Climate change and climate-sensitive disasters significantly and increasingly impact health.[332] Climate change in the Himalayan range is intensifying the already high rates of natural erosion, sediment transport and deposition, and landslides. More frequent extreme weather events such as glacial lake outburst floods, floods, droughts and landslides are predicted to occur and from 1992 to 2021, many of these climatic hazards in Nepal have increased in frequency.[333] DRR and Climate Change Adaptation (CCA) strategies can greatly reduce the health burden from such disasters and health practitioners play a crucial role in responding in these emergencies.[334] By incorporating NbS, the EPIC-Nepal project bridges the silos of human health, biodiversity conservation, DRR and CCA. The project's evidence-based approach (the use of rhizotron studies to monitor how plant roots interact with the soil, drone imagery, and LiDAR scans) ensured that bioengineering techniques were adjusted to the specific conditions of each site so that the best outcomes for both ecosystems and communities could be achieved, thereby ameliorating one health.

Future Opportunities for Nature-Health Linkages

[332] Watts, N.; Amann, M.; Ayeb-Karlsson, S.; Belesova, K.; Bouley, T.; Boykoff, M.; Byass, P.; Cai, W.; Campbell-Lendrum, D.; Chambers, J.; et al. (2017). The Lancet Countdown on Health and Climate Change: From 25 Years of Inaction to a Global Transformation for Public Health. Lancet 391:581-630.

[333] Chapagain, D., Bharati, L., Borgemeister, C. (2022). Declining Vulnerability but Rising Impacts: The Trends of Climatic Disasters in Nepal. Regional Environmental Change 22(55).

[334] Banwell, N, Rutherford, S., Mackey, B., Chu, C. (2018). Towards Improved Linkage of Disaster Risk Reduction and Climate Change Adaptation in Health: A Review. *International Journal of Disaster Risk Science.* 15(4), 793.

Climate change and transport systems can degrade ecosystems leading to such disasters of evermore increasing magnitude,[335] yet, well-managed ecosystems can act as Eco-DRR.[336] The fields of DRR, CCA, environmental management, and human health can work together to facilitate learning and exchange information, as well as address mismatched finance structures.[337] Inter-sectoral cooperation can be built upon and Eco-DRR can be a viable method for buffering the environmental and human health blows caused by disasters. EPIC-Nepal and future projects can demonstrate how nature can play a vital role in reducing disaster risks, greening transport systems, safeguarding health and promoting resilience in the face of climate change.

Future projects in a similar vein could:

- Conduct assessments to identify areas where transport systems directly threaten public health, such as roads prone to landslides, high-traffic areas with pollution.
- Integrate eco- DRR into road design and plant species that are economically viable (like broom grass or scented grass) and investigate whether medicine or edible plants are good for bioengineering.
- Collaborate with local health authorities to ensure that key transport routes to hospitals and clinics are stabilized using bioengineering methods.

Case Study Sources

Devkota, S., Shakya, N.M., Sudmeier- Rieux, K. (2019). Framework for Assessment of Eco-Safe Rural Roads in Panchase GeographicRegion in Central- Western Nepal Hills. Environments, 6(6), 59.

Green-Gray Community of Practice. (2020). Practical Guide to Implementing Green-Gray Infrastructure. [Online]. Available at: https://www.conservation.org/docs/default-source/publication-pdfs/ci-green-gray-practical-guide-v08.pdf

Monty, F., Murti, R., Miththapala, S., Buyck, C. (eds). (2017). Ecosystems Protecting Infrastructure and Communities: Lessons Learned and Guidelines for Implementation. Gland, Switzerland: IUCN.

[335] UNDRR. (2019) Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: United Nations Office for Disaster Risk Reduction (UNDRR).

[336] Teich, M., Accastello, C., Perzl, F., Berger, F. (eds.) (2022). Protective Forest as Ecosystem-based Solution for Disaster Risk Reduction (Eco-DRR). IntechOpen. doi: 10.5772/intechopen.95014

[337] Aitsi-Selmi, A.; Murray, V.; Wannous, C. (2017). Health Supporting Disaster Risk Reduction including Climate Change Adaptation. In The Routledge Handbook of Disaster Risk Reduction Including Climate Change Adaptation; Kelman, I., Mercer, J., Gaillard, J., Eds.; Routledge: Abingdon, UK; New York, NY, USA.

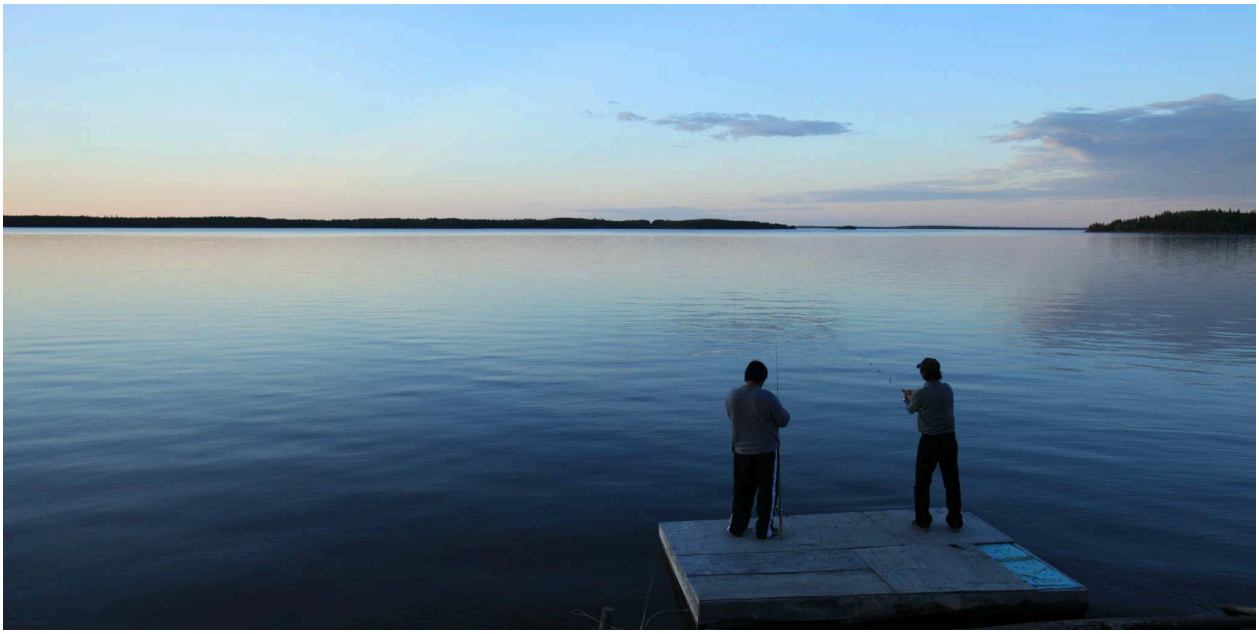


Photo Credit: Otake Hidehiro

Recommendation VII: Place Equity at the Centre of the Design, Governance, and Implementation of Nature-based Solutions for Health.

Health equity is a core aspect of social justice, representing the absence of avoidable, unfair, or fixable disparities between groups of people based on their social, economic, demographic, or geographic conditions.[338] Health inequities can occur at various levels: between countries, within countries, or among communities, and as a general rule, those with lower socioeconomic status exhibit a higher risk of poor health.[339] The most concerning aspect of health inequity is unmet health needs, where individuals either cannot access necessary care (forgone care) or are unaware of their need for it (unexpressed demand).[340] These unmet needs stem from barriers on both the supply and demand sides of healthcare and thus addressing health inequities is crucial for improving public health and achieving universal health coverage. Women and girls for instance, are often reported to encounter more significant barriers than men and boys when it comes to accessing health information and services due to limitations on their mobility, exclusion from decision-making, lower literacy rates, and discriminatory attitudes from both communities and healthcare providers.[341] In addition, Indigenous and under-resourced communities frequently face health challenges, originating from historical and systemic factors that have contributed to

[338] Pan American Health Organization. Health Equity. https://www.paho.org/en/topics/health-equity Accessed 29th September, 2024.

[339] World Health Organization (2023). To Meet the Unmet: Preparing for Health Equity Challenges in WHO South-East Asia Region. New Delhi.

[340] World Health Organization (2023). To Meet the Unmet: Preparing for Health Equity Challenges in WHO South-East Asia Region. New Delhi. .

[341] World Health Organization. Gender and Health. https://www.who.int/health-topics/gender#tab=tab_1 Accessed 29th September, 2024.

disparities in access to healthcare, clean water and healthy food.[342] These challenges are deeply interconnected and impact the overall well-being of these communities and as a result, a resolution on The Health of Indigenous Peoples was agreed upon during the 76th World Health Assembly (WHA76) in 2023 which underscores the equal right of Indigenous Peoples to enjoy the highest attainable standard of physical and mental health in accordance with the United Nations Declaration on the Rights of Indigenous Peoples.

Addressing health inequities not only involves improving access to healthcare services, but also recognizing the role that traditional medicine plays, particularly in Indigenous and rural communities, in providing accessible and culturally appropriate healthcare. Traditional medicine in various societies can be the primary source of healthcare and in others can play a key complementary role in addition to the mainstream health system .[343] For instance, approximately 80% of Africa's population and 40% of China's use traditional medicine in their healthcare,[344] with the former relying on traditional medicine as their primary source of health provision as the ratio of traditional healers to population lies at 1:500; while that of medical doctors lies at 1:40,000.[345]

Globally, the demand for herbal medicines is increasing, driven by factors such as cost- effectiveness and perceptions of greater safety.[346]However, medicinal and aromatic plants are coming under increased threat due to overharvesting, combined with habitat and climate changes, which jeopardizes both species and the livelihoods of collectors.[347] For example, in India around 90% of medicinal plants are harvested from the wild[348] and in South Africa an estimated 99% of species sold in traditional medicine come from wild sources,[349] which puts great pressure on natural resources. It is estimated that 15,000, or 21%, of medicinal plant species are endangered[350][351]and that we lose at least one potential major medicine every two years.[352] Deforestation in the

[342] UN Department of Economic and Social Affairs Indigenous Peoples. https://www.un.org/development/desa/indigenouspeoples/mandated-areas1/health.html Accessed 29th September, 2024.
[343] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review.
[344] World Health Organization (2002). WHO Traditional Medicine Strategy 2002- 2005. Geneva.
[345] World Health Organization (2013). WHO Traditional Medicine Strategy 2014-2023. Hong Kong.
[346] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review.
[347] World Health Organization and the Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review.
[348] Mishara, M, Kotwal, P.C., Prasad, C. (2009). Harvesting of Medicinal Plants in the Forest of Central India and Its Impact on Quality of Raw Materials: A Case of Nagpur District, India. Ecoprint 16:35-42.
[349] Williams, V.L. (1996). The Witwaterrand Muti Trade. Veld and Flora 82:12-14.
[350] Schippmann, U, Leaman, D., Cunningham, A. (2006). A Comparison of Cultivation and Wild Collection of Medicinal and Aromatic Plants under Sustainability Aspects. In Bogers, R.J., Cracker, L.E., Lange, D (ed). Medicinal and Aromatic Plants. Agricultural, Commercial, Ecological, Legal, Pharmacological and Social Aspects.pp.75-95, Springer, Dordrecht.
[351] Chen, S.L, Yu, H., Luo, H.M, Wu, Q., Li C.F, Steinmetz, A. (2016). Conservation and Sustainable Use of Medicinal Plants: Problems, Progress, and Prospects. Chinese Medicine 11(37).
[352] Groombridge, B. Jenkins, M.D. (2002). World Atlas of Biodiversity: Earth's Living Resources in the 21st Century. UNEP World Conservation Monitoring Centre. University of California Press, Berkeley, USA.

Brazilian Amazon has resulted in the decline of various medicinal plant species and is predicted to continue at an ever-increasing rate, eroding the primary healthcare options for many Brazilian rural and urban poor. [353]

Climate change can also decrease medicinal plants' availability and productivity, as well as their phytochemical content, which potentially affects their pharmaceutical properties.[354]Changes in climate can shrink the environmental ranges of species;[355][356] while warmer temperatures can increase populations of damaging insects and pathogens which risk decimating certain species.[357][358]This adds to threats on human health for populations whose access to conventional treatments is already unaffordable and/or inaccessible.

These increased environmental stresses can lead to economic losses as well, for when stewardship of medicinal plants is effective, it can also have a positive influence on the economic well-being of communities.[359]To ensure the sustainability of medicinal plants, the WHO Global Center for Traditional Medicine has emphasized the integration of traditional medicine into global healthcare systems through evidence-based learning, data analysis, sustainability, innovative technology and equity. Acknowledging, bio-cultural heritage - the wisdom and customs of Indigenous Peoples in their utilization of biological resources, such as the cultivation of diverse crops to the deliberate shaping of their surrounding landscapes- is vital in building healthier communities.[360]

Equity is thus crucial to ensure that healthcare, be it conventional or traditional, reaches all, especially in a world of growing biodiversity loss and climate change. As NbS become increasingly used to tackle global issues, it is vital to ensure that social equity and justice is not overlooked. NbS projects should be build on inclusive, effective governance[361]and incorporate diverse perspectives and knowledge of nature.[362] Crucially, equity is

---

[353] Shanley, P., Luz, L. (2003). The Impacts of Forest Degradation on Medicinal Plant Use and Implications for Health Care in Eastern Amazonia. BioScience 53(6): 573-584.

[354] Applequist, W.L., Brinckmann, J.A., Cunningham, A.B., Hart, R.E., Heinrich, M., Katerere, D.R., van Andel, T. (2020). Scientists' Warning on Climate Change and Medicinal Plants. Planta Medica 86(1):10-18.

[355] Shafer, S.L., Bartlein, P.J., Thompson, R.S. (2001). Potential Changes in the Distributions of Western North American Tree and Shrub Taxa under Future Climate Scenarios. Ecosystems 4:200-215.

[356] Guo, Y., Wei, H., Lu, C., Gao, B., Gu. W (2016). Predictions of Potential Geographical Distribution and Quality of *Schisandra sphenanthera* under Climate Change. PeerJ 4:e2254.

[357] William, D.W., Liebhold, A.M (2002). Climate Change and the Outbreak Ranges of Two North American Bark Beetles. Agricultural and Forest Entomology 4:87-99.

[358] Bosso, L., di Febbraro, M., Cristinzio, G., Zoina, A., Russo, D. (2016). Shedding Light on the Effects of Climate Change on the Potential Distribution of *Xylella fastidiosa* in the Mediterranean Basin. Biological Invasions 18:1759-1768.

[359] Hamilton, A.C. (2004). Medicinal Plants, Conservation and Livelihoods. Biodiversity & Conservation, 13(8):1477-1517.

[360] Swiderska, K. (2017). What is Biocultural Heritage?
https://www.researchgate.net/publication/319483204_What_is_biocultural_heritage

[361] Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., Bonn, A. (2016). Nature-based Solutions to Climate Change Mitigation and Adaptation in Urban Areas: Perspectives on Indicators, Knowledge Gaps, Barriers, and Opportunities for Action. Ecology and Society, 21(2).

[362] Woroniecki, S., Wendo, H., Brink, E., Islar, M, Krause, T., Vargas, A.M., Mahmoud, Y. (2020). Nature Unsettled: How Knowledge and Power Shape "Nature-based" Approaches to Societal Challenges.

deeply interwoven with community engagement and cultural relevance, and ensuring active community participation, in addition to considering cultural norms and values is fundamental.

CASE STUDY 1

Indigenous Peoples Assistance Facility (IPAF)

Argentina, Bangladesh, Bolivia, Cambodia, Cameroon, Chile, Colombia, Congo, DRC, El Salvador, Ghana, Guatemala, Guyana, India, Indonesia, Kenya, Mexico, Morocco, Nepal, Paraguay, Pakistan, Peru, Philippines, Tanzania, Thailand, Uganda, Vanuatu

Overview

Hosted by The International Fund for Agricultural Development (IFAD) , the Indigenous Peoples Assistance Facility (IPAF) aims to strengthen Indigenous Peoples' communities and their organizations in Africa; Asia and the Pacific; and Latin American and the Caribbean by financing projects which foster their self-driven development in the framework of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). The IPAF is directed both operationally and strategically by the IPAF Board which is composed mostly of Indigenous members. Since the COVID-19 pandemic hit in full force, there have been numerous reports attesting to the disproportionately negative health impact on Indigenous Peoples globally which intensified underlying structural inequalities, increased hardships for these communities in accessing food and water, and disrupted their traditional economies. Despite these issues, the 2018 IPAF cycle projects were instrumental in helping communities address the pandemic and reduce its adverse impacts, partly thanks to their basis on community governance and self-identified priorities, in short: equity.

Successes

Community solidarity, awareness raising, advocacy actions, and the promotion of Indigenous governance and Indigenous foods systems, which are anchored in sustainable livelihood practices, lie at the heart of the IPAF projects. Three regional Indigenous Peoples Organizations (Foro Internacional de Mujeres Indígenas for LAC, Samburu Women Trust for Africa, and Tebtebba for Asia and the Pacific) successfully coordinated and managed the IPAF in their respective regions through a wide range of activities. For instance, in the Guatemala sub-project the livelihoods of Q'eqchís and Pocomchís Mayas in the department of Verapaz were improved as the project enabled the target population to develop community and development protocols and to set up demonstration plots, nurseries and community gardens by recovering over 58 varieties of local and traditional seeds as well as medicinal herbs. This impacted the community in terms of food availability and nutrition security during the

outbreak of the COVID-19 pandemic. The three regional organizations supported grassroots organizations to finalize the design of projects with the organization of inception meetings, and ensured the monitoring and evaluation of the Facility by improving baselines and logframes, monitoring project results and undertaking annual reporting. The added value of their support is that M&E practices and formats used were conceived and carried out based on principles and criteria which were relevant for Indigenous Peoples and based upon their vision of development. The organizations also provided supervision and implementation support to subgrantees through midterm review missions, which were key to building the capacities of grassroots organization and addressing any implementation issues and associated risks.

Photo Credit: Sandra Sebastián

Strengthening Indigenous Health and Ecosystem Integrity through Community-Led Initiatives

The program empowers Indigenous Peoples to manage natural resources and protect biodiversity which are essential components of ensuring health all round. By incorporating traditional ecological practices, focusing on sustainable development, environmental conservation, and the recovery of traditional seeds, medicinal herbs and ancestral knowledge, the IPAF has helped maintain ecosystem integrity, contributing to both environmental sustainability and community health and well-being. Crucially, via the revival and transmission of traditional knowledge of practices related to medicinal herbs and sustainable agriculture, the project has strengthened health and Indigenous food systems. For instance, in Cameroon, the Baka way of harvesting and cooking Sapa was linked to the project's success, and in Guyana, Wapichan put together videos on their cultural heritage and traditional knowledge which was to be presented to the government. In addition, IPAF has promoted the active

participation of women and youth in decision-making processes and project activities, and as these groups are susceptible to various barriers to healthcare, their inclusion addresses the intersecting inequalities related to gender and age within Indigenous Peoples' communities.

Further Opportunities for Nature-Health Linkages

Future projects in a similar vein could:

- Focus on integrating traditional ecological knowledge with modern health and environmental strategies, expanding the use of medicinal plants, sustainable agricultural practices, and biodiversity conservation to support Indigenous food systems and improve community health.
- Embed gender and age-sensitive monitoring and evaluation systems from the start as collecting disaggregated data regularly and creating targeted initiatives for women and youth would empower these groups and aid in ensuring equity across the board.
- Ensure free, prior and informed consent is crucial from a rights perspective, but also to guarantee project sustainability and greater community participation.

Case Study Sources

International Fund for Agricultural Development. Indigenous Peoples Assistance Facility. [Online]. Available at: https://www.ifad.org/en/ipaf [Accessed 3rd October, 2024].

International Fund for Agricultural Development. (2023). The Indigenous Peoples Assistance Facility (IPAF): Assessment of the Performance of the Fifth IPAF Cycle. IFAD.

CASE STUDY 2

Pimachiowin Aki Assembly of Partners Inc.

Canada

Overview

The Pimachiowin Aki World Heritage mixed site in Canada spans over 29,040km^2 and is the most complete and largest example of the North American boreal shield, forming part of the ancestral home of the Anishinaabeg, Indigenous People who rely on fishing, hunting, and gathering. The four Anishinaabe First Nations in Pimachiowin Aki are Bloodvein, Little Grand Rapids, Pauingassi and Poplar River, and Pimachiowin Aki stands as a model of meaningful community engagement, which emphasizes traditional land use practices and incorporates Indigenous perspectives into conservation efforts. It is a remarkable example of the cultural tradition of Ji-ganawendamang Gidakiiminaan (keeping the land) which involves honouring the Creator's gifts, respecting all forms of life, and fostering harmonious relationships with others. Adhering to the principles of

Ji-ganawendamang Gidakiiminaan, the Anishinaabeg's physical and mental well-being is enhanced by regularly being on the land, consuming a healthy diet, and strengthening kinship and community ties by fostering cooperation and sharing resources. The Anishinaabe First Nations protect and monitor biodiversity, adapting to a changing climate. Pimachiowin Aki supports ecological and cultural preservation, and generates health benefits, as the Anishinaabe way of life promotes physical fitness and a diet based on locally-sourced, fresh and healthy foods.

Successes

Pimachiowin Aki is so unique that it inspired UNESCO to change the way it evaluates mixed World Heritage sites (less than 1% of all World Heritage Sites are in this category) and deepened UNESCO's understanding of nature-culture connections in the World Heritage Convention which has instilled sense of a pride, ownership and local responsibility among the communities. All Pimachiowin Aki activities follow approaches that benefit Anishinaabeg and all living and non-living beings, as such, it has a highly-participatory, non-hierarchical and inclusive management system that ensures that Anishinaabeg are key players in decisions about land use planning, resource allocation, and protection of land-based livelihoods.

Pimachiowin Aki's Lands Guardians program consists of Anishinaabe men and women who work with Elders and other community members, wildlife biologists, satellite image analysts, and land and resource managers to document customary laws and governance practices. Community-based Lands Guardians are active on the land, observing, recording and reporting any changes in the attributes of the site and the overall state of conservation and community well-being. Habitat mapping and migratory bird monitoring enhance and extend the reach of Guardians' activities and the partnership monitors ecosystem health indicators including: condition of habitat for species at risk; presence of species; wildlife occurrences; and changes in climate. Range maps, place names research and mapping, and development of seasonal land use calendars contribute structure and standardization to Lands Guardian's monitoring activities. Lands Guardians periodically report on ecological, socio-economic and cultural impacts of their work. Results are stored in an information management system maintained by the Pimachiowin Aki Assembly of Partners. Pimachiowin Aki has created meaningful and culturally-relevant employment and training opportunities through the Lands Guardians program, and established an endowment fund to generate income to support the site. Investment in local economic development potential, consistent with the organization's charitable purpose, may be realized as the market value of the fund grows. Pimachiowin Aki has also initiated work on biocultural asset mapping and product design to inform thinking about new enterprises, foster innovation, and create social capital for a diversified regional economy. Through adherence to Ji-ganawendamang Gidakiiminan, sustainable management and use of Pimachiowin Aki's ecosystems and their services is assured.

Promoting Well-being through Cultural and Environmental Stewardship

The traditional Anishinaabe way of life involves an understanding that humans are not separate from the land, but are part of it; the boreal shield ecosystem provides crucial services including carbon sequestration, clean

water, and food security, while ensuring biodiversity and ecosystem health. Anishinaabeg have a diet rich in locally-sourced, fresh and healthy foods, which contribute to physical health and reduced rates of diet-related health issues. In addition, the connection to nature has a positive mental impact, and cultural practices contribute to a sense of identity and spiritual health. By promoting land-based enterprises, Pimachiowin Aki supports economic well-being within these communities, reducing financial stress, and enhancing mental wellness. Finally, by protecting biodiversity and Indigenous ways of living, Pimachiowin Aki contributes to both ecological sustainability and the well-being of Anishinaabe people, serving as a model for how nature and culture can support human health.

Further Opportunities for Nature-Health Linkages

Future projects in a similar vein could:

- Integrate community health programs with land stewardship efforts, such as partnering with healthcare providers.
- Introduce monitoring systems which track not only biodiversity and environmental conditions, but also the health and wellness of the people involved, showing a direct and quantifiable link between nature conservation and well-being
- Provide education on the mental health benefits of nature, perhaps via workshops that emphasize the cultural and physical well-being derived from traditional land use.

Case Study Sources

Pimachiowin Aki. [Online]. Available at: pimaki.ca [Accessed 3rd October, 2024].

Photo Credit: Chris Beauchamp

Recommendation VIII: Empower Indigenous and Under-Resourced Communities to Safeguard Health and Well-Being.

The global Indigenous population of 300 million people consists of approximately 5000 distinct cultures which inhabit various climates: from the Arctic Circle to the tropical rainforests.[363]Indigenous Peoples account for 95% of the planet's cultural diversity, yet comprise only 4% of the global population.[364]Due to various barriers such as geography, language, discrimination and finance, Indigenous People grapple with limited access to quality healthcare services which can lead to delayed diagnosis and inadequate treatment.[365] For example, research shows that Indigenous populations in Australia and Nepal are likely to live 20 years less than non-Indigenous populations; 17 years less in Canada; and 13 years less in Guatemala.[366] Chronic disease, such as cardiovascular disease in Australia has a mortality rate among Indigenous populations 1.5 times higher than that of non-Indigenous Peoples,[367] and in regards to tuberculosis- though there do exist initiatives to combat this disease- many initiatives frequently fail to reach Indigenous Peoples' communities due to a myriad of challenges, amongst

[363] Sobrevila, C (2008). The Role of Indigenous Peoples in Biodiversity Conservation: The Natural but Often Forgotten Partners. The International Bank for Reconstruction and Development, The World Bank. Washington D.C.

[364] Sobrevila, C (2008). The Role of Indigenous Peoples in Biodiversity Conservation: The Natural but Often Forgotten Partners. The International Bank for Reconstruction and Development, The World Bank. Washington D.C.

[365] Davy, C., Hartfield, S., McArthur, A., Munn, Z., Brown, A. (2016). Access to Primary Health Care Services for Indigenous Peoples: A Framework Synthesis, International Journal for Equity in Health 15(163).

[366] UN Department of Economic and Social Affairs Indigenous Peoples. https://www.un.org/development/desa/indigenouspeoples/mandated-areas1/health.html Accessed 29th September, 2024.

[367] Australian Institute of Health and Welfare (2016). Cardiovascular Disease, Diabetes and Chronic Kidney Disease- Australian Facts: Aboriginal and Torres Strait Isalnder People. Canberra.

them poverty; substandard living conditions; and limited healthcare access and essential medication.[368] Indigenous Peoples' communities often experience high rates of depression, substance abuse, and suicide, which can be linked to colonization, dispossession, genocide, and other forms of historical inter-generational trauma.[369] In Australia, for example, the suicide rate is 2 to 3 times higher among Aboriginal people,[370] in Brazil approximately 3 times higher,[371] and in Canada up to 5 to 6 times higher amongst Indigenous youth.[372] Malnutrition is also a pressing concern in cases of extreme poverty, stemming from environmental degradation and ecosystem contamination within certain traditional territories,[373] and in some countries, Indigenous Peoples are confronted with "food deserts" where access to fresh fruits, vegetables, and other healthy options are limited, if not non-existent, although alcohol and other addictive and harmful substances may well be easier to access.[374]

At the same time, Indigenous Peoples possess valuable knowledge and wisdom about principles crucial to One Health. Indigenous territories make up approximately 22% of the Earth's land surface; hold 80% of the world's biodiversity;[375] and make up 11% of legally owned forest land worldwide.[376]In Australia, Brazil and Canada, vertebrate biodiversity in Indigenous territories is comparable or even greater than that found in officially protected areas.[377] Studies have demonstrated that traditional ways of interacting with biodiversity are based in progressive principles of sustainability and that Indigenous Peoples' knowledge is a crucial and underutilized fount in conservation. Indigenous conservation practices often encompass reciprocal relationships between people and land, placing them at the core of their cultural and stewardship traditions. These practices are grounded in Indigenous knowledge systems, and ecological and scientific insights are passed down from generation to generation via ceremonies, laws, language, practices, and stories.[378]Many Indigenous Peoples have

[368] UN Department of Economic and Social Affairs Indigenous Peoples. https://www.un.org/development/desa/indigenouspeoples/mandated-areas1/health.html Accessed 29th September, 2024.
[369] UN Department of Economic and Social Affairs Indigenous Peoples. https://www.un.org/development/desa/indigenouspeoples/mandated-areas1/health.html Accessed 29th September, 2024. .
[370] Elliot- Farrelly, T. (2004). Australian Aboriginal Suicide: the Need for an Aboriginal Suicidology? Australian e-Journal for the Advancement of Mental Health 3(4).
[371] Ministério da Saúde (2020). Mortalidade por Suicídio na População Indígena no Brasil, 2015 a 2018. Boletim Epidemiológico Vol 51.
[372] Giroux, R., Homer, K., Kassam, S., Pokrupa, T., Robinson, J., Sauve, A., Sumner, A. (2018). Mental Health and Suicide in Indigenous Communities in Canada. Canadian Federation of Medical Students.
[373]UN Department of Economic and Social Affairs Indigenous Peoples. https://www.un.org/development/desa/indigenouspeoples/mandated-areas1/health.html Accessed 29th September, 2024. .
[374] Liddell, J.L., Kington, S.G., McKinley, C.E. (2022). "You Got to Drive 30 Miles to Get an Apple": Indigenous Food Sovereignty, Food Desserts, and Changing Subsistence Practices in the Gulf Coast. SN Social Sciences 2(232).
[375] World Resource Institute in collaboration with the United Nations Development Programme, United Nations Environment Programme, and World Bank (2005). Securing Property and Resource Rights through Tenure Reform. In World Resources Report 2005: The Wealth of the Poor- Managing Ecosystems to Fight Poverty. Washington D.C.: WRI.
[376] White, A., Molnar, A., Kahre, A. (2004). Who Owns, Who Conserves and Why it Matters. Forest Trends, Washington D.C.
[377] Schuster, R.,German R.R, Bennet, J.R., Reo, N.J., Arcese, P. (2019). Vertebrate Biodiversity on Indigenous-Managed Lands in Australia, Brazil and Canada Equals That in Protected Areas. Environmental Science and Policy 101:1-6.
[378] World Wildlife Fund (2023). Food Systems Transformation: Ensuring Regenerative and Resilient Production and Consumption. World Wildlife Fund.

worldviews (cosmovisions), beliefs and knowledge about the strong relationship between people and the environment which have been shared in terms used by Maori (whakapapa)[379], Dene (nene),[380] Cree (askiy),[381] Mi'kmaq (netukulimk)[382], Quechua (ayllu) and other Indigenous Peoples.[383]

Indigenous Peoples are the stewards of almost one fifth of the total carbon stored in tropical and subtropical forests (218 gigatonnes) and their territories account for 40% of protected areas worldwide[384] which are not only important as habitats for biodiversity but are also vital due to their carbon-sink capacity, making them crucial to mitigating the effects of climate change.[385] Traditionally living "low carbon" lives, and thereby contributing very little to global warming, Indigenous Peoples nonetheless are susceptible to climate change: the ecosystems that certain groups live in are vulnerable to climate change, such as polar regions, mountain regions, deserts, etc.; depend upon resources for basic needs and livelihoods, such as food, fuel, medicine, shelter; and are among the most economically vulnerable.[386] However, as mentioned above, Indigenous knowledge is critical in biodiversity conservation and climate stability, and Indigenous Peoples play vital roles in climate change mitigation and NbS which they must co- design and implement to avoid negative impacts such as displacement, livelihood restrictions, and ensuing cultural effects.[387]

CASE STUDY I

[379] Lyver, P.O.B., Timoti, P., Gormley, A.M., Jones, C.J., Richardson, S.J., Tahi, B.L., Greenhalgh (2017). Key Maori Values Strengthen The Mapping of Forest Ecosystem Services. Ecosystem Services 27:92-102.

[380] Parlee, B. et al, (2008). Understanding and Communicating About Ecological Change: Denesoline Indicators of Ecosystem Health. in Fikret Berkes et al, (eds.) Breaking Ice: Integrated Ocean Management in the Canadian North, Calgary, University of Calgary Press, 2008, 165.

[381] M'Lot, M., (2002). Kâ Isinâkwâk Askîy: Using Cree Knowledge to Perceive and Describe The Landscape of The Wapusk National Park Area, Masters of Natural Resource Management, Natural Resources Institute, University of Manitoba, 2002 [unpublished].

[382] Prosper, K., et al., (2011). Returning to Netukulimk: Mi'kmaq Cultural and Spiritual Connections with Resource Stewardship and Self-Governance 2:4 Int. Indig. Policy J. 7.

[383] Argumendo, A., Yun Loong Wong, B. (2010. The Ayllu System of the Potato Park (Peru)" in Caroline Bélair et al, Sustainable use of Biological Diversity in Socio-Ecological Production Landscapes: Background to the 'Satoyama Initiative for the benefit of Biodiversity and Human Well-being. Secretariat of the Convention on Biological Diversity CBD Technical Series. (52) 84

[384] Rights and Resources Initiative. (2019). Indigenous and community response to IPCC report. A statement on the Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change and Land from Indigenous Peoples and local communities* from 42 countries spanning 76% of the world's tropical forests [online]

[385] Walker W, Baccini A, Schwartzman S, Ríos S, Oliveira-Miranda MA, Augusto C, et al. 2014. Forest carbon in Amazonia: the unrecognized contribution of indigenous territories and protected natural areas. Carbon Management, 5(5–6): 479–485.

[386] Ramos-Castillo, A., Castellanos, E.J., Galloway McLean, K., (2017). Indigenous Peoples, Local Communities and Climate Change Mitigation. Climate Change 140:1-4.

[387] Vanclay F. 2017. Principles to gain a social licence to operate for green initiatives and biodiversity projects. Current Opinion in Environmental Sustainability, 29: 48–56.

Health Systems Reimagined According to the NbS of Rainforest Communities
Indonesia

Overview

Health in Harmony was founded on the understanding that the health of humans, ecosystems, and the planet cannot be addressed in separate silos. The organization's mission is to reverse the climate and nature crises by protecting and expanding tropical rainforests. It does this through its Radical Listening methodology: a commitment to directly fund and resource the systems solutions for rainforest protection designed and led by the Indigenous Peoples, Afro Descendent Peoples and Local Peoples of Earth's tropical rainforests.

Indonesia has experienced some of the world's highest rates of deforestation for several decades. By 2012, annual primary forest loss in Indonesia was estimated to be higher than in Brazil (0.84 Mha and 0.46 Mha, respectively), and in late 2015, nearly 100,000 active fire detections in Indonesia - particularly prominent on peat lands - generated emissions each day exceeding the average daily emissions from all U.S. economic activity. Between 2000 and 2010, Indonesian Borneo experienced an annual loss of 3234 km² of forest. Borneo's Gunung Palung National Park, a significant carbon storehouse, was under threat of degradation, and many households had no choice but to turn to illegal logging to afford the out-of-pocket costs of healthcare. In 2008, Health in Harmony and its Indonesian partner, Alam Sehat Lestari, initiated their trust- and reciprocity-based Radical Listening approach, engaging with communities to understand what they required from the world community - as a thank you - to be stronger guardians of their massive rainforest. Communities concluded that a holistic, systems solution anchored in access to affordable quality healthcare; just transition and training in alternative livelihoods; and conservation would allow them to halt logging and extractive practices.

Successes

The first ten years of program data from the Health In Harmony - Alam Sehat Lestari proof of concept site in Borneo was analysed by research scientists and their analysis culminated in the publication of the ten-year impact in the Proceedings of the National Academy of Sciences, USA. From 2008 to 2018, Health in Harmony's and Alam Sehat Lestari's direct funding of USD$5.2m into the community designed solutions resulted in impressive outcomes across the Planetary Health/ One Health landscape, including: a 90% reduction in the number of households reliant on logging for their livelihoods; 70% less forest loss in the program area compared to the control group; and the averted loss of USD$65m worth of above ground carbon into Earth's atmosphere. From a human health perspective, the intervention contributed to a 67% reduction in infant mortality for the clinic's catchment population of ~80k people, and to significant declines in the prevalence of malaria, tuberculosis, and noncommunicable diseases, such as diabetes. Health in Harmony trusted the rainforest people's expertise, and that trust resulted in the design of a new kind of health system, one that links their own well-being outcomes to the integrity and well-being of their rainforest ecosystem. Health in Harmony has replicated its Radical Listening model alongside rainforest communities in Brazil and Madagascar, and is working with partners today to scale this approach across Earth's tropics.

Empowering Rainforest Communities for Health and Conservation

The Health in Harmony-Alam Sehat Lestari project in Gunung Palung excellently exemplifies the Planetary Health/ One Health approach. By utilizing the "Radical Listening" methodology, the program centers and is explicitly guided by the expertise of tropical rainforest communities in identifying their health and conservation needs. The initiative addresses human thriving through improved access to affordable healthcare and sustainable livelihoods, significantly reducing reliance on harmful practices like illegal logging, which threaten the rainforest ecosystem, biodiversity, and community well-being. Notably, it has achieved measurable health benefits, such as reduced infant mortality and lower disease prevalence, demonstrating the direct link between ecosystem integrity and human health. Together with rainforest communities and a global coalition of leading partners, Health in Harmony aims to have a significant impact on protecting half of the world's tropical rainforests – a bold scale plan to keep CO^2 out of the atmosphere that is deeply rooted in social justice, research, impact data, and innovation.

Further opportunities for nature-health linkages

Global institutions can adopt the Radical Listening methodology to center and be guided by communities' ecosystem-based, climate- and biodiversity-critical expertise, allowing local citizens to identify the linkages between their health, livelihoods, and conservation needs.

Future projects in a similar vein could:

- Foster intersectoral, systems collaboration among healthcare, conservation, livelihood, and other organizations to overcome the currently inherently siloed institutions
- Recognize that investments in just transition to sustainable livelihoods reduce reliance on harmful practices and are an essential component of human, ecosystem, and planetary health.
- Understand that the people who know best how to design true health care systems (i.e., systems that improve *both* human health *and* ecosystem health) are the local Indigenous and non-Indigenous Peoples inhabiting the ecosystem.

Case Study Sources

Alam Sehat Lestari. [Online]. Available at: https://www.alamsehatlestari.org Accessed 28th September, 2024.

Health In Harmony. [Online]. Available at: www.healthinharmony.org Accessed 28th September, 2024.

Leo, S., Izza, Q., Finley, N.L., Sumardi, I., Andiani, J. (2024). Wildlife Species Recorded by Camera Traps in Reforested Lowland Rainforest and Peat Swamp Forest of Gunung Palung National Park, Indonesia. Tropical Natural History, 24(1):8 -19.

Jones, I.J., MacDonald, A.J., Hopkins, S.R., Sokolow, S.H. (2020). Improving Rural Health Care Reduces Illegal Logging and Conserves Carbon in a Tropical Forest. PNAS 117(45):28515- 28524.

CASE STUDY 2

Ărramăt Project

Bolivia, Brazil, Canada, Fiji, Finland India, Mali, Mexico, Mongolia, New Zealand, Norway, Peru, Thailand, Uganda, United States, Zimbabwe

Overview

The word "Ărramăt" (written in Tifinagh as ⵄⵔⵔⴰⵎⴰⵜ) is a concept in Tamasheq, the Indigenous language spoken by the Tuareg people whose ancestral land encompasses the current territories of Algeria, Burkina-Faso, Libya, Mali and Niger, that describes a state of well-being shared by the environment, animals, and humans. These words teach us that if the lands (water, fish, animals, plants) are not healthy, then the people are neither. The main objective of the Ărramăt Project is to build Indigenous organizations' capacity to document, share and use their knowledge about the interconnectedness of biodiversity conservation and human health and well-being. Answering the call of Indigenous leaders, the project creates opportunities for Indigenous partners to access funding, design, and implement locally relevant projects that reinforce and expand their capacities and provide significant and sustainable impacts and opportunities moving forward. The project supports Indigenous-led place based research projects that evidence health and well-being outcomes of biodiversity conservation, thereby supporting them in driving institutional change at local, regional, and global scales to improve health and well-being and curb the decline of biodiversity.

Successes

The main triumph of the Ărramăt project is to have elevated Indigenous Peoples and their knowledge on the holistic approaches to health and well-being of all (biodiversity-people-environment) in academic research projects. The initiative has conducted workshops to gather input for Indigenous Peoples, fostering relationships and understanding their needs and priorities, as well as establishing formal agreements with Indigenous governments and organizations to ensure mutual respect and shared objectives. They have developed and delivered training sessions on sustainable land management, biodiversity conservation, and Indigenous ecological knowledge; provided access to tools and resources that enable communities to implement their own projects effectively; and created a streamlined process for Indigenous partners to apply for and receive funding for locally relevant projects (so far 66 Indigenous place based projects). As well as funding and supporting initiatives aimed at restoring native vegetation and improving habitat quality for local wildlife, Ărramăt has implemented community-led water monitoring programs to assess and improved the health of local water bodies; encouraged the establishment of community gardens that promote traditional agricultural practices and food sovereignty; and developed guidelines for the sustainable use of local resources, such as plants and fish to ensure long-term availability.

Photo Credit: Carrie Oloriz

Strengthening Indigenous-Led Initiatives for Biodiversity and Well-being

One Health is embedded in the Interdepence-Indigenous concepts (*whakapapa, nene, askiy, netukilimk, ayllu, Ărramăt*) which all illustrate the intrinsic link between environmental health and human wellbeing. The project clearly empowers Indigenous Peoples to implement traditional land management practices, enhancing ecosystem and social resilience. Via the funding of Indigenous-led place based projects, the initiative promotes the conservation of critical habitats and species, and via the support of initiatives focused on restoring degraded waters, the project directly contributes to the health of ecosystems. The project incorporates Indigenous knowledge regarding the sustainable harvesting of plants, fish, and wildlife; and supports local food systems, combating food insecurity and promoting health through traditional and nutritious food. Habitats are enhanced, which fosters biodiversity and healthier ecosystems, which provide essential services like clean water and carbon sequestration, which in turn helps communities to adapt to climate change impacts. Lastly, revitalizing Indigenous ecological knowledge and practices strengthens the connection between communities and their environments, solidifying cultural identity and community cohesion, supporting spiritual, mental and physical health, and training and resources empower Indigenous Peoples to effectively tackle the loss of biodiversity and related environmental and health challenges.

Further Opportunities for Nature-Health Linkages

The Ărramăt project presents numerous opportunities for furthering nature-health linkages by empowering Indigenous Peoples to harness their ecological knowledge in addressing contemporary biodiversity, environmental and health challenges.

Future projects in a similar vein could:

- Create inclusive frameworks that facilitate dialogue and collaboration among diverse stakeholders from various disciplines and knowledge systems with regular workshops and co-learning sessions helping to build trust and foster relationships, which allow participants to share their expertise and insights in a supportive environment
- Incorporate Indigenous-led evaluation and feedback mechanisms that can ensure projects remain aligned with community needs and values, reinforcing the commitment to co-create knowledge and solutions that elevateIndigenous sovereignty and expertise.

Case Study Sources

Ărramăt [Online]. Available at: https://arramatproject.org [Accessed 3rd October, 2024].

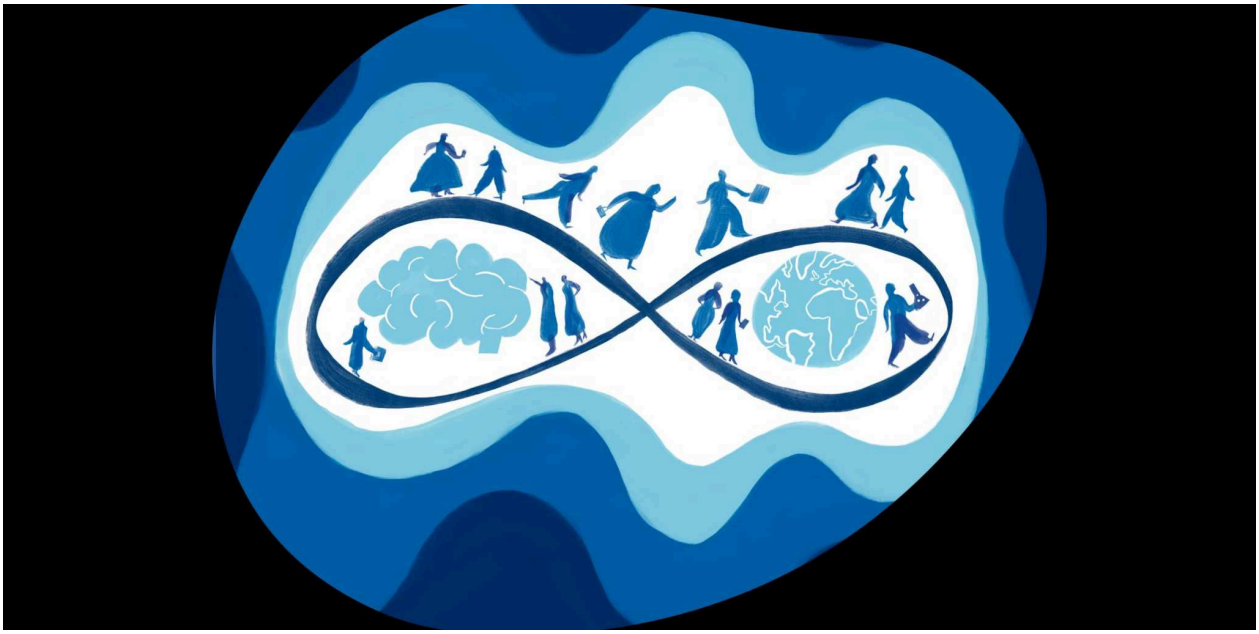


Image Credit: Rebekah Ryvolaa

Recommendation IX: Support/ Enable Youth Leadership and Innovation in Nature and Health Decision-Making.

The inclusion and empowerment of youth in discussions regarding environmental and health challenges is a vital step towards building a more equitable, sustainable future. The youth population -people between the ages of 15 and 29- amounts to 1.8 billion, 90% of whom live in developing countries, and one in three people in many African and South Asian countries is a young person.[388] Climate change has longer-lasting consequences on young people due to their age and in many places around the world, such as SIDS, its effects are already being severely felt. By 2050, a child born in 2000 is expected to experience CO^2 levels between 463 and 623 per million by volume, compared to around 400 in 2016.[389] They will also likely share a planet with 8.4 million to 11.3 billion others with temperatures 0.8°C to 2.6°C warmer and sea level 5 to 32 cm higher compared to 1990.[390] The decisions and policies made today will shape outcomes for the rest of the century and beyond, with today's youth having significant impacts in that future.

---

[388] Commonwealth Secretariat (2016). Global Youth Development Index and Report 2016. Commonwealth Secretariat, London.

[389] Intergovernmental Panel on Climate Change (IPCC) (2013). Technical Summary. Pages 33-115 in T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley, editors. Climate change 2013: the physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK..

[390] Intergovernmental Panel on Climate Change (IPCC) (2013). Technical Summary. Pages 33-115 in T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley, editors. Climate change 2013: the physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK..

The world's largest mobilization on climate change, with an estimated participation of 6 million, is Fridays for Future, spearheaded by Greta Thunberg, which demonstrates the power of young voices in pushing for change. Several other youth-led movements have been influential in advocating for policies which promote sustainability, such as the Sunrise Movement and Zero Hour in the United States, which have successfully mobilized thousands of young activists to call for ambitious policies. Mobile phones and social media are making it easier for young people to connect, organize and mobilize affordably and across nations.[391]Research from Sudan shows the role of social media in Sudanese youth activism, which has brought more young women into the activist fray as it secures a safer space,[392] as well as in other countries such as Nigeria,[393]and transnational movements, like Fridays for Future.[394] Social media is a tool which can help facilitate youth mobilization in many contexts around the globe and is only likely to grow in future years.

The myriad of woes that climate change brings, as has been discussed throughout the report, also includes what is termed "climate change anxiety", or "eco-anxiety", defined as *"distress relating to the climate and ecological crises"*,[395] which is particularly prevalent amongst young people. A 2021 study surveyed 10,000 children and young people up until the ages of 25 in ten countries around the world and the findings showed that 59% of respondents were very or extremely worried about climate change; 84% at least moderately so; 50% felt a combination of negative emotions; over 45% said it negatively affected their daily lives; with 75% saying the future is frightening; and 83% responding that humans have failed the planet.[396] Feelings of climate anxiety and distress have been linked to the perception that government responses are insufficient, often accompanied by a sense of betrayal.[397]Bringing youth to the decision-making table on issues that influence them to a large extent, where their future hangs in the balance, is vital to addressing climate issues and ensuring meaningful, long-term solutions.

In November 2021 at CoP26 in Glasgow, Scotland The Global Youth Biodiversity Network, YOUNGO, and Youth4Nature came together to form the NbS Youth Coalition. They launched their Global Youth Position

[391] Mason, P. (2013). Why It's Still Kicking off Everywhere: The New Global Revolutions. London: Verso.
[392] Kadoda, G., Hale, S., (2015). Contemporary Youth Movements and the Role of Social Media in Sudan. Canadian Journal of African Studies 49(1).
[393] Olanrewaju, M.M., Sanusi, B.O., Ajala, A.O., Oluwasanmi, O.P. (2024). Social Media and Youth Mobilisation during the End Sars Protest. IMSU Journal of Communication Studies 8(1).
[394] Belotti, F., Donato, S., Bussoletti, A., Comunello, F. (2022). Youth Activism for Climate *on* and *beyond* Social Media: Insights from FridaysForFuture- Rome. The International Journal of Press/Politics.
[395] Hickman, C., Marks, E., Pihkala, P., Clayton, S., Lewandowski, R.E., Mayall, E.E., Wray, B., Mellor, C., van Susteren, L. (2021). Climate Anxiety in Children and Young People and Their Beliefs about Government Responses to Climate Change: A Global Survey. The Lancet Planetary Health 5(2): E863-E873.
[396] Hickman, C., Marks, E., Pihkala, P., Clayton, S., Lewandowski, R.E., Mayall, E.E., Wray, B., Mellor, C., van Susteren, L. (2021). Climate Anxiety in Children and Young People and Their Beliefs about Government Responses to Climate Change: A Global Survey. The Lancet Planetary Health 5(2): E863-E873.
[397] Hickman, C., Marks, E., Pihkala, P., Clayton, S., Lewandowski, R.E., Mayall, E.E., Wray, B., Mellor, C., van Susteren, L. (2021). Climate Anxiety in Children and Young People and Their Beliefs about Government Responses to Climate Change: A Global Survey. The Lancet Planetary Health 5(2): E863-E873.

Statement on Nature- Based Solutions which aimed to fill a glaring gap in the NbS field: the absence of a cohesive voice representing youth perspectives. The statement emphasizes the growing prominence of NbS in addressing climate change, ecosystem degradation, inequality, and injustice; and acknowledges the potential of NbS while highlighting concerns about its potential misuse and exclusion of Indigenous Peoples and local communities. The statement represents the collective perspective of more than 1000 young people from 118 countries and calls for the re-evaluation of NbS in global environmental governance, and underscores that NbS should be rooted in inclusivity, equity, and justice, focusing on the rights of Indigenous Peoples, local communities, women and youth. It advocates for place-based actions, local standards, and safeguards to address risks, such as biodiversity loss and green-washing. Furthermore, it insists that NbS should not serve as a substitute for emissions reduction efforts and reinforces the need for fair financing and meaningful support for youth-led initiatives.[398] This is a prime example of youth from different groups feeling empowered to make their voice heard in the climate arena to bring about change that affects their entire future, and other young people should also feel emboldened to follow suit and have a say in the nature and health decision-making rings.

CASE STUDY 1

Connecting Climate Minds

Global

Overview

Increasing evidence shows how climate change, environmental degradation and biodiversity loss are a risk multiplier for poor mental health by increasing the risk of new mental health challenges, exacerbating existing ones, and increasing the vulnerability of people living with mental health challenges to morbidity and mortality.[399] The projected economic cost of the additional mental health burden from climate-related hazards, air pollution, and lack of green space is estimated at US$47 billion by 2030, rising to US$537 billion by 2050.[400] However, this vicious cycle can be shifted to a virtuous cycle. NbS are an opportunity multiplier for creating the conditions that foster good mental health such as more connected and equal societies, clean air, and access to

[398] Global Youth Biodiversity Network, YOUNGO, Youth4Nature (2021). https://static1.squarespace.com/static/60d345a74ed9f630745b8646/t/61868053f73d0949acb7dd1e/1636204632840/Nature-Based+Solutions-Position+2021-Nov+C.pdf Accessed 29th September, 2024.

[399] Lawrance, E.L., Thompson, R., Newberry Le Vay, J., Page, L. Jennings, N. (2022). The Impact of Climate Change on Mental Health and Emotional Wellbeing: A Narrative Review of Current Evidence, and Its Implications. International Review of Psychiatry, 34(5), 443-498 .

[400] Kumar, P., Brander, L., Kumar, M.,Cuijpers, P. (2023). Planetary Health and Mental Health Nexus: Benefits of Environmental Management. Annals of Global Health 89(1).

green and blue spaces. In turn, good mental health and psychological resilience are key enablers of sustained climate action and the integration of NbS across sectors.[1,401]

Young people, among the most vulnerable to climate change and environmental degradation, offer essential perspectives on their needs and actions that can drive engagement in environmental efforts. This was highlighted in the Wellcome-funded Connecting Climate Minds (CCM) global initiative, launched to build a connected, collaborative, and multidisciplinary research field on climate change and mental health. The initiative aimed to develop a research and action agenda that is inclusive and aligned with the needs of people with lived experience of mental health challenges in the context of climate change. Its goal was to stimulate and strengthen research that fills priority evidence gaps and informs policy changes at both local and global levels, including within the UNFCCC and CBD Global Biodiversity Framework. More than 960 experts from 90 countries participated in 21 dialogues, surveys, expert consultations, and a global event, alongside youth, Indigenous Nations and Peoples, small farmers, and fisher peoples.[402]

Successes

A series of virtual and in-person youth dialogues on climate change and youth mental health were led by SustyVibes, Force of Nature and the Climate Mental Health Network in collaboration with the Climate Cares Centre at Imperial College London. The physical dialogues were held in Port Harcourt, Nigeria, and Bangalore, India, to promote inclusivity and highlight diverse, localized perspectives. These locations were selected due to the high engagement of young people in both countries, their vulnerability to climate hazards, and the presence of established networks that facilitated participant recruitment. In total, 57 individuals took part in the global virtual dialogue, while 20 attended the in-person dialogue in India, and 18 participated in the in-person dialogue in Nigeria. In addition, youth ambassadors were appointed to co-produce and contribute to the development of the seven regional and global agendas for the Connecting Climate Minds initiative for the year.[403]

Empowering Youth Voices in Climate and Mental Health Solutions

A youth research and action agenda was developed to address the urgent need to streamline, accelerate, and unify knowledge generation and sharing at the intersection of youth, nature, climate change, and mental health.[5] The outcomes of the Connecting Climate Minds dialogues and the agenda culminated in the creation of a Youth Declaration, where young people collectively called on world leaders and relevant stakeholders to commit to a future in which youth are actively involved in shaping solutions for a sustainable and equitable world. The

---

[401] Coventry PA, Brown JE, Pervin J, Brabyn S, Pateman R, Breedvelt J, Gilbody S, Stancliffe R, McEachan R, White PL. (2022). Nature-based Outdoor Activities for Mental and Physical Health: Systematic Review and Meta-Analysis. SSM-Population Health. 16:100934.

[402] Lawrance, E., Newberry Le Vay, J., El Omrani, O., Howitt, P., Jennings, N., Meinsma, N., Watson, D. (2024). Global Agenda for Research and Action in Climate Change and Mental Health. (Imperial College London,)

[403] Wright, S., Lekwa,H., Uchendu, J., Chigozie, S., Olude, A., Ogbodum, M. Youth Research and Action Agenda: Vulnerability and Resilience in the Generation Inheriting the Climate Crisis. (Connecting Climate Minds, 2024); https://nbswmzwquzluimyqnfsf.supabase.co/storage/v1/object/public/documents/Full%20TRAA%20youth%2018-03.pdf?t=2024-03-19T11%3A08%3A20.042Z

declaration emphasized the integration of NbS into mental health care, promoting education on nature's benefits, supporting research and innovation, and ensuring policy alignment. This envisioned future relies on collaborative efforts, with the voices and actions of young people, communities, and nations driving a global movement towards thriving youth, healthy environments, and resilient ecosystems.[404]

Further opportunities for nature-health linkages

Future projects in a similar vein could:

- Facilitate structured dialogues of forums that allow youth to voice their experiences and perspectives.
- Build multi-disciplinary teams that include youth alongside professionals in relevant fields. Foster collaboration across sectors like health, climate, and policy-making to create holistic solutions that address both environmental and mental health challenges.

Case Study Sources

Connecting Climate Minds. [Online]. https://nbswmzwquzluimyqnfsf.supabase.co/storage/v1/object/public/documents/Full%20TRAA%20youth%2018-03.pdf?t=2024-03-19T11%3A08%3A20.042Z [Accessed 5th October, 2024].

CASE STUDY 2

Active in Nature

Australia

Overview

The Active in Nature project was developed in response to the recognition that many young people in Victoria face barriers- such as social isolation, physical limitations, and cultural differences- that prevent them from fully accessing and enjoying nature. Many of these young people are disadvantaged or from underrepresented communities, including multicultural groups, First Nations people, and those with disabilities. The project was co-designed with young participants and community organizations, and aims to remove these barriers by providing structured opportunities for outdoor activities in Victoria's parks. The project is part of the broader Healthy Parks Healthy People initiative, which emphasizes the significant health and well-being benefits that arise from time spent in nature and it is funded by VicHealth.

Successes

[404] Connecting Climate Minds Youth Declaration.(2024). https://nbswmzwquzluimyqnfsf.supabase.co/storage/v1/object/public/documents/Connecting_Climate_Minds__Youth_Declaration.pdf

The project consists of 30 outdoor recreational events held across four parks in Victoria: Yarra Bend Park, You Yangs Regional Park, Lysterfield Park, and the Grampians National Park. It has successfully engaged over 100 young people who were less active due to various barriers and offers them a range of activities, such as water-based adventures kayaking and canoeing, land-based activities like bush-walking, mountain biking, and abseiling, cultural and educational activities to foster respect and understanding of the natural environment, including Indigenous cultural learning and safety practices in nature. Active in Nature has resulted in improved physical and mental well-being among participants, with high levels of reported confidence in nature (84% of respondents) and happiness (86%). The program effectively increased physical activity levels and social connections, with 83% intending to get more active and 72% feeling more connected to other peoples, demonstrating the benefits of nature-based activities. The impact extends beyond individual participants and has strengthened community connections and raised awareness of the value of nature for health.

Photo Credit: Outdoors Victoria

Youth Engagement in Nature-based Health Initiatives

The project directly links biodiversity and health, firstly, by promoting physical and mental health via outdoor activities, participants benefit from exercise and stress relief, contributing to overall health and well-being. Secondly, by spending time in natural settings, participants are able to develop a deeper appreciation for biodiversity and ecosystem preservation which leads to greater environmental understanding of the importance of protecting natural spaces. The co-designing of the program with young people was of great importance to ensure relevance and inclusiveness. By involving young people not just in the project, but as program designers, the project has empowered youth to take ownership of their health through nature-based recreation. It fosters

leadership by encouraging participants to engage with environmental conservation, cultural practices and the importance of protecting natural spaces. This hands-on involvement builds their capacity to make informed decisions about health and environmental issues.

Further Opportunities for Nature-Health Linkages

Future projects can build upon Active in Nature in the following ways:

- Extend outreach to engage harder-to-reach groups. Specific programmes can target these groups by removing financial, geographic or language barriers, offering transportation or translated materials, for instance, that can bring nature-based activities directly to communities.
- Assign roles like project coordinators, event planners, or team leaders within the project to youth, possibly with the aid of a mentorship program where experienced mentors from conservation, health, or community development can provide guidance as they navigate their roles.
- Sustaining participant involvement can deepen the health and environmental benefits. Programs that encourage long-term participation - through clubs, memberships, or continued educational support- could build lasting relationships with nature and health.
- Expand partnerships with public transport systems, local businesses, or government bodies to tackle the logistical issues around accessing nature spaces, like transport costs and accessibility for people with disabilities.

* *Evaluation summary of the Active in Nature pilot program and subsequent programs in 2024-2026 will be available on websites listed below.*

Case Study Sources

Active in Nature. [Online]. Available at: https://www.outdoorsvictoria.org.au/projects/active-in-nature-ov/ [Accessed 28th September, 2024].
Parks Victoria (2024). Helping Young People Get Active in Nature. [Online]. Available at: https://www.parks.vic.gov.au/news/2024/04/02/23/24/helping-young-people-get-active-in-nature [Accessed 28th September, 2024].
VicHealth. [Online]. Available at: https://www.vichealth.vic.gov.au/ [Accessed 28th September, 2024].

Photo Credit: World Organisation for Animal Health

Recommendation X: Finance Inclusive Nature-based Solutions that Prioritize Health Outcomes.

The global economy is becoming increasingly at risk from worldwide loss of biodiversity. The New Nature Economy report highlights that more than half of the world's GDP relies on natural ecosystems, and investing in nature could unlock US$10 trillion in economic value and create 395 million jobs.[405] The Dutch Central Bank's recent report, "Indebted by Nature", quantifies the financial sector's dependence on ecosystems: of the €1400 billion in assets reviewed, €510 billion - 38% of the total- were tied to industries heavily reliant on nature.[406]The economic worth of pollinators, for example, has been estimated at least US$14 trillion and the carbon capture and storage of tropical forests at the very least at US$9.5 trillion.[407]As such, environmental degradation also affects health and well-being via generating severe economic losses.

Although nature-based solutions are well-accepted as offering a promising approach to addressing biodiversity loss, the climate crisis and human health issues, they receive only a small share of climate and biodiversity finance. The spending on biodiversity conservation is estimated at US$124-$143 billion/yr, however the needed spending

[405] World Economic Forum (2020). New Nature Economy Report II: The Future of Nature and Business. In Collaboration with AlphaBeta. Geneva.
[406] DNB (2020). Indebted to Nature- Exploring Biodiversity Risks for the Dutch Financial Sector. De Nederlandsche Bank, Planbureau voor de Leefomgeving.
[407] Deutz, A., Heal, G.M., Niu, R., Swanson, E., Townshend, T., Zhu, L., Delmar, A., Meghji, A., Sethi, S.A., Tobin- de la Puente, J. (2020). Financing Nature: Closing the Global Biodiversity Financing Gap. The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability.

lies between US$598 billion and US$824 billion,[408] indicating that there is a substantial global financing gap of over US$700 billion.[409] Public financing alone is insufficient to close this gap, necessitating the involvement of private investors and the capacity building of NbS projects to attract private capital. However, currently, most NbS projects are financed by mainly domestic public and philanthropic funds, with only 14% coming from the private sector.[410]

NbS could contribute up to 37% of the most cost-effective methods to close the 32 gigaton emissions gap needed to meet the Paris Climate Agreement targets[411][412] due to their ability to mitigate damage and reduce future costs.[413] 66% of governments have incorporated ecosystem restoration or protection into their NDCs, however, only 17% of NDCs that include current or planned NbS for adaptation set measurable, clear targets.[414] In addition, while over 70% of NDCs reference actions in the forestry sector, only 20% include quantifiable targets, and only 8% in terms of tonnes of CO2 equivalent.[415] Furthermore, just 17 countries have set goals to address both adaptation and mitigation; and only 27% of high income countries explicitly include NbS, demonstrating significant potential for countries to enhance NbS in NDCs.[416]

NbS public investment in 2019 channelled approximately US$53 billion in biodiversity and landscape protection, rehabilitation, and restoration; US$23 billion in agriculture, forestry, and fishing; US$17 billion within water and water resources, conservation and land management, pollution control amongst others; US$11 billion for pollution abatement, wastewater management, and improved enforcement; US$8 billion environmental policies.[417] The United States, China, Japan, Germany and Australia were the top spenders on NbS spending US$36 billion, US$31 billion, US$9 billion, US$5 billion, and US$5 billion respectively.

---

[408] Deutz, A., Heal, G.M., Niu, R., Swanson, E., Townshend, T., Zhu, L., Delmar, A., Meghji, A., Sethi, S.A., Tobin- de la Puente, J. Financing Nature: Closing the Global Biodiversity Financing Gap. The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability. (2020)

[409] Finance Earth. A Market Review of Nature-Based Solutions: An Emerging Institutional Asset Class (2021) (commissioned by the Green Purposes Company).

[410] United Nations Environment Programme (2021). State of Finance for Nature 2021. Nairobi.

[411] United Nations Environment Programme. (2019). Nature-based Solutions for Climate Manifesto. https://wedocs.unep.org/bitstream/handle/20.500.11822/29705/190825NBSManifesto.pdf?sequence=1

[412] United Nations Environment Programme (2021). State of Finance for Nature 2021. Nairobi.

[413] De Mel, M., Weerathunge, C. (2011). Valuation of Ecosystem Services of the Maha Oya. Environmental Foundation, Sri Lanka.

[414] Seddon, N., Sengupta, S., García- Espinosa, M., Hauler, I., Herr, D, Rizvi, A.R. (2019). Nature-based Solutions in Nationally Determined Contributions: Synthesis and Recommendations for Enhancing Climate Ambition and Action by 2020. Gland, Switzerland and Oxford, UK: IUCN and University of Oxford.

[415] Seddon, N., Sengupta, S., García- Espinosa, M., Hauler, I., Herr, D, Rizvi, A.R. (2019). Nature-based Solutions in Nationally Determined Contributions: Synthesis and Recommendations for Enhancing Climate Ambition and Action by 2020. Gland, Switzerland and Oxford, UK: IUCN and University of Oxford.

[416] Seddon, N., Sengupta, S., García- Espinosa, M., Hauler, I., Herr, D, Rizvi, A.R. (2019). Nature-based Solutions in Nationally Determined Contributions: Synthesis and Recommendations for Enhancing Climate Ambition and Action by 2020. Gland, Switzerland and Oxford, UK: IUCN and University of Oxford.

[417] United Nations Environment Programme (2021). State of Finance for Nature 2021. Nairobi.

Private investment (representing 14% and equal to US$18 billion annually) lay in the following categories: sustainable supply chain (US$7 billion/yr); biodiversity offsets (~US$5 billion/yr); private equity impact investments (US$3 billion/yr); conservation NGOs (US$2 billion/yr); philanthropy (US$308 million/yr); voluntary carbon markets (US$221 million/yr); private finance (US$542 million/yr); and PES (US$51 million/yr).

The significant dependence on public finance for NbS stems from several key factors. Firstly, NbS is still a relatively new concept. Although the term "ecosystem services" was introduced in the 1980s,[418] and the IUCN put forward their definition of NbS in 2009,[419] awareness of NbS outside of the environmental sector and academic circles remains scarce, and investors and stakeholders generally have low awareness and understanding of the concept.[420] Secondly, many NbS approaches are still in their infancy, localized, or have only been implemented on a small scale.[421] Thirdly, NbS typically require long-term investments and come with high risks as these projects often demand substantial upfront capital with returns expected in the medium to long-term.[422] Additionally, quantifying and disseminating results is complex,[423]and the return on investment is not yet clearly evident.[424]

However, the private sector can play a far greater role in NbS, despite its hesitancy. Blended finance is a mechanism whereby capital from public or philanthropic sources is used to attract private sector investment which tackles the two major challenges of perceived and actual high levels of risk, as well as the comparatively low return relative to similar investments.[425] Additionally, governments need to put in place an amenable regulatory environment for private investment in NbS, implement market structures and come up with smart initiatives

[418] Ehrlich, P.R, Ehrlich, A.H. (1981). Extinction: The Causes and Consequences of the Disappearance of Species. Random House.

[419] International Union for the Conservation of Nature (2009). No Time to Loses- Make Full Use of Nature-based Solutions in the Post-2012 Climate Change Reimes. Position Paper for the 15th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (CoP15), 1-5. https://iucn.org/sites/default/files/import/downloads/iucn_position_paper_unfccc_cop_15_1.pdf

[420] López- Portillo Purata, V., Gómez, S., Rodríguez, S.E. (2022). 5 Barriers That Hinder Green Financing [Project Update]. World Resources Institute.

[421] Van Raalte, D., Ranger, N. (2023). Financing Nature-Based Solutions for Adaptation at Scale: Learning from Specialised Investment managers and Nature Funds. Global Center on Adaptation and Environmental Change Institute, University of Oxford.

[422] European Investment Bank (2023). Investing in Nature- Based Solutions: State of Play and Way forward for Public and Private Financial Measures in Europe. European Investment Bank.

[423] European Investment Bank (2023). Investing in Nature- Based Solutions: State of Play and Way forward for Public and Private Financial Measures in Europe. European Investment Bank.

[424] Van Raalte, D., Ranger, N. (2023). Financing Nature-Based Solutions for Adaptation at Scale: Learning from Specialised Investment managers and Nature Funds. Global Center on Adaptation and Environmental Change Institute, University of Oxford.

[425] Convergence, (2022). State of Blended Finance 2022: Climate Edition. Convergence.

which can catalyse financial flows.[426]Banking institutions within the private sector are pivotal in promoting NbS investment due to their practices and standards, which can make NbS more attractive and economically viable. A variety of financial institutions are available for public and private financial institutions to direct capital and capital supply tools, such as bonds, equity, grants, and loans; risk mitigation instruments that manage risk, like insurance, guarantees, and off-take agreements; as well as fiscal and revenue instruments, such as subsidies.[427]

The health sector can also assist in a variety of ways as financing NbS often has important public health outcomes. By investing in NbS that prioritize health outcomes, the health care community can leverage the mutual benefits of human and ecosystem health.

CASE STUDY 1

The Meloy Fund for Sustainable Community Fisheries
Indonesia, The Philippines

Overview

Current ocean funding comes overwhelmingly from public and philanthropic sources, which though vital, is insufficient. An estimated US$174.52 billion is needed for the health of the world's oceans,[428] and private finance has the potential to unlock substantial capital by aiming for positive financial returns and environmental benefits. This dual focus attracts investors who prioritize financial performance, creating an open market which has the potential to grow considerably. Despite this, private investors are typically risk-averse and the risks associated with ocean investments limit their involvement. As such, innovative models are necessary to encourage greater private sector participation.

Blended finance is a financial strategy aimed at mitigating project risk and attracticing market-rate capital by combining various funding sources from the public, private and philanthropic sectors. Many NbS projects are pioneering innovative approaches to enhance water security and manage disaster risks.[429] The Meloy Fund for Sustainable Community Fisheries is an impact investment fund managed by Meloy Fund GP, a subsidiary of

---

[426] Deutz, A., Heal, G.M., Niu, R., Swanson, E., Townshend, T., Zhu, L., Delmar, A., Meghji, A., Sethi, S.A., Tobin- de la Puente, J. Financing Nature: Closing the Global Biodiversity Financing Gap. The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability. (2020)

[427] United Nations Environment Programme (2021). State of Finance for Nature 2021. Nairobi.

[428] Johansen, D.F., Vestvik, R.A. (2020). The Cost of Saving Our Ocean- Estimating the Funding Gap of Sustainable Development Goal 14. Marine Policy 112:103783.

[429] Marsters, L., Morales, G., Ozment, S., Silva, M., Watson, G., Netto, M., Frisari, G.L. (2021). Nature-based Solutions in Latin America and the Caribbean: Financing Mechanisms for Regional Replication. Washington D.C. Inter-American Development Bank and the World Resources Institute.

Rare. It promotes sustainable fisheries in Indonesia and the Philippines through debt and equity investments in fishing-related businesses[430] and is funded by a mix of public and private sources, such as the Global Environment Facility (GEF), JPMorgan Chase & Co., FMO, USAID and others, with a final fund size of US$22 million. The fund's goal is to enhance the management of community-based coastal fisheries, bolster sustainable practices, and improve operational efficiencies, benefiting local small-scale fisheries and conserving marine habitats. Blended finance has a burgeoning role in catalysing investments where commercial return may be limited, but where social, environmental, and economic gains can be substantial, aligning diverse investor interests. Beyond businesses and supply chains, the fund seeks to invest in broader sector-building activities: creating new market platforms, introducing innovative financing solutions to reduce fishers' indebtedness, supporting certification and labelling programs, and encouraging climate-smart adaptations.

Photo Credit: Jason Houston for Rare

Successes

Since the inception of the Meloy Fund for Sustainable Community Fisheries over 1,515,326 hectares of seascape are now under improved management and practices- a real win for promoting biodiversity conservation and ecosystem health. More than 10,720 fishers have experienced safer working conditions and more secure incomes, ensuring that fishing practices are both sustainable and economically viable. The fund also successfully supports small and medium-sized enterprises in expanding their operations sustainably, increasing supply chain efficiency and opening new markets for sustainable sourced seafood. By encouraging more transparent supply chains, the

[430] Food and Agriculture Organization of the United Nations (2020). FAO's Blue Growth Initiative: Blue Finance Guided Notes: Blended Finance. FAO. Rome.

fund has helped combat potential illegal, unreported and unregulated fishing which poses significant threats to marine biodiversity and local economies.

Investing in Nature to Enhance Health and Resilience

By improving the health of marine ecosystems, the project aims to safeguard vital habitats such as coral reefs and mangroves which are essential for the survival of many marine species. At the same time, the project enhances human health by supporting food security and nutrition, and providing more stable livelihoods for small-scale fishers. Sustainable fisheries ensure a consistent supply of fish which is a critical source of protein for millions of people. Fish is a highly nutritious food source, and is a key source of animal protein and essential nutrients like omega-3 fatty acids, vitamins and micronutrients, particularly in low-income and Small Island Developing States (SIDS); securing fish availability can improve nutrition and combat malnutrition.[431] The project also improves the social conditions of fishing communities, as it addresses issues like fisher indebtedness, safety, and fair labour practices, which are key to enhancing overall well-being, and several UN Sustainable Development Goals are targeted: SDG 2 (Zero hunger), SDG 3 (Good Health and Well-Being), and SDG 14 (Life Below Water).

Future Opportunities for Nature-Health Linkages

Future projects working in a similar vein could

- Conduct health assessments to identify how marine ecosystem health impacts local populations, particularly in terms of nutrition, livelihoods, and well-being.
- Strengthen data-collection and monitoring systems that evaluate both ecological and health outcomes in order to provide a clearer understanding of sustainable fisheries that contribute to community health and resilience.
- By capturing such data, projects can demonstrate the tangible benefits of investing in ecosystems, making a compelling case to health stakeholders.

Case Study Sources

Blended Finance Taskforce. Meloy Fund for Sustainable Community Fisheries. Available at: https://www.blendedfinance.earth/blended-finance-funds/2020/11/16/meloy-fund-for-sustainable-community-fisheries [Accessed 28th September, 2024].

Rare. The Meloy Fund: Earning Returns for People, Nature, and Impact Investors. [Online]. Available at: https://rare.org/meloy-fund/ [Accessed 28th September, 2024].

The Meloy Fund for Sustainable Fisheries. [Online]. Available at: https://www.meloyfund.com/about [Accessed 28th September, 2024].

[431] Balami, S., Sharma, A., Karn, R. (2019). Significance of Nutritional Value of Fish for Human Health. Malaysian Journal of Halal Research Journal. 2(2).

CASE STUDY 2

Insuring the Mesoamerican Coral Reef
Mexico

Overview

Covering a mere 0.2% of the seafloor, coral reefs support at least 25% of marine species, making them one of the most productive ecosystems on Earth.[432] They provide ecosystem services such as biodiversity, food security and livelihoods, human health and well-being, medicines, shoreline protection, and tourism.[433] However, coral reefs are one of the most vulnerable ecosystems in the world due to anthropogenic pressures such as climate change, ocean acidification, land-originating pollution from agricultural run-off, marine pollution, and overfishing and destructive fishing practices.[434]Due to their ecosystem services and alarming degradation rate, NbS efforts, albeit fewer than needed, are being adopted. Amongst these is the insurance of their Mesoamerican Coral Reef.

Stretching nearly 1000 km along the Caribbean coasts of Mexico, Belize, Guatemala and Honduras, the Mesoamerican Barrier Reef is crucial for biodiversity, coastal protection, and the local economy, particularly through tourism and fishing. It is the first insurance policy specifically designed for a natural asset and is an innovative parametric insurance model which triggers payouts based upon predefined weather conditions, such as wind speeds exceeding 100 knots, allowing for rapid funding for damage assessment and restoration after storms. The fund disburses funds to facilitate the repair and restoration of the reef in the case of a significant storm. This is important not only to protect a spectacular ecosystem, but also to protect the estimated 840 million people at risk from coastal flooding. Healthy coral reefs can diminish up to 97% of wave energy,[435] weakening storm surges and lowering the probability of daily erosion. This particular insurance mechanism is designed for the swift disbursal of funds, allowing trained community members to address reef damage in the aftermath of severe storms.

Successes

The Coastal Zone Management Trust in Quintana Roo, Mexico, is the first-ever insurance policy on nature, designed to generate private capital for coral reefs, and beach protection and restoration. Following Hurricane

[432] Souter, D., Planes, S., Wicquart, J., Logan, M., Obura, D., Staub, F., (eds.) (2001). Status of Coral Reefs of the World: 2020 Report. Global Coral Reef Monitoring Network (GCRMN) and International Coral Reef Initiative (ICRI).
[433] Souter, D., Planes, S., Wicquart, J., Logan, M., Obura, D., Staub, F., (eds.) (2001). Status of Coral Reefs of the World: 2020 Report. Global Coral Reef Monitoring Network (GCRMN) and International Coral Reef Initiative (ICRI).
[434] Souter, D., Planes, S., Wicquart, J., Logan, M., Obura, D., Staub, F., (eds.) (2001). Status of Coral Reefs of the World: 2020 Report. Global Coral Reef Monitoring Network (GCRMN) and International Coral Reef Initiative (ICRI).
[435] Ferrario, F., Beck, M.W., Storlazzi, C.D., Michei, F., Shepard, C.C., Airoldi, L., (2014). The Effectiveness of Coral Reefs for Coastal Hazard Risk Reduction and Adaptation. Nature Communications 5:3794.

Delta in October 2020, the policy paid out over US$800,000 to the Coastal Zone Management Trust, which facilitated immediate stabilization and restoration activities, including re-attaching coral fragments and repairing damaged colonies. It has also bolstered local communities by training "reef brigades" composed of volunteers who respond quickly to reef damage, fostering stewardship and connection to the reef. By maintaining the reef's health, the project supports the local economy, particularly through tourism, ensuring communities can return to normalcy more swiftly after natural disasters and safeguarding livelihoods reliant on the reef. The success of this model has attracted global interest, and Swiss Re and the Nature Conservancy have explored the feasibility of replicating the model in other regions, such as Hawaii and Australia, as well as mangrove forests in various countries.

Financing Nature's Solutions for Healthier Communities

The restoration efforts funded by the insurance payouts contribute to the overall health and resilience of the reef ecosystem, which is vital for marine biodiversity and the conservation of various species dependent on the coral reefs, including people. Insuring natural assets helps improve disaster resilience, which is a component of public health. Protecting coral reefs can reduce the impacts of severe storms and coastal flooding, thereby safeguarding the health and well-being of coastal communities. Coral reefs also play a significant role in mitigating the impacts of climate change as they absorb carbon and act as natural buffers against storms, and as such mitigating its effects are important to human health.

Future Opportunities for Nature-Health Linkages

The project demonstrates a collaborative approach involving the insurance industry, private sector, local governments, and NGOs, serving as a blueprint for future conservation finance initiatives. It has raised awareness about the intrinsic value of healthy ecosystems, potentially leading to increased community support for conservation efforts.

Future projects working in a similar vein could:

- Collaborate with a wide array of stakeholders to piece together a multi-faceted approach which in essence, incorporates One Health.
- Health professionals should be interested in such schemes as the protection and restoration of coral reefs directly contributes to improved health outcomes by safeguarding the natural resources that communities depend on for food, clean water, and recreational opportunities.

Case Study Sources

Swiss Re (2022). Designing a New Type of Insurance to Protect the Coral Reefs, Economies and the Planet. [Online]. Available at: https://www.swissre.com/our-business/public-sector-solutions/thought-leadership/new-type-of-insurance-to-protect-coral-reefs-economies.html [Accessed 29th September, 2024].

The Nature Conservancy. [Online]. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC-CoastalManagementTrust_Infographic_04.pdf [Accessed 29th September, 2024].
World Economic Forum (2021). Mexico's Mesoamerican Barrier Reef Is Now Being Protected with insurance- Here's How. [Online]. Available at: https://www.weforum.org/agenda/2021/09/mesoamerican-coral-reef-mexico-using-insurance-to-protect-ecosystem/ [Accessed 29th September, 2024].

Photo Credit: Mike Wilkinson

Bridging the Gap Between Promise and Policy: Unmet Research Needs in Nature-Based Solutions for Health

The potential for Nature-based Solutions (NbS) to address interconnected global health challenges is immense. However, realizing its full potential requires deeper, more systematic research into the complex interplay between ecosystems and human well-being. Despite promising evidence of positive associations between nature and health, several knowledge gaps remain, particularly in quantifying short and long-term health impacts and understanding the synergies and trade-offs between different NbS interventions.

Current research often lacks the longitudinal data and standardized evaluation methods needed to fully capture the benefits of NbS across diverse populations and settings. Moreover, much of the existing research does not adequately address the complexities of implementing NbS at scale, including how best to integrate traditional knowledge and ensure equitable benefit-sharing among vulnerable communities. To maximize the effectiveness and sustainability of NbS for improved health outcomes, further research is needed to:

- **Integrate Health into NbS Design Methodologies**: Develop and refine design methodologies that explicitly incorporate health as a core objective from the outset. This requires integrating health data, indicators, and assessments into the planning and implementation phases of NbS projects.
- **Quantify Long-Term Health Impacts of NbS:** Longitudinal studies are needed to fully quantify the long-term impacts of NbS on a wide range of physical, mental, and social health outcomes across diverse populations and contexts.

- **Develop Standardized Assessment Methodologies for NbS:** Develop and implement standardized methods for evaluating the multiple co-benefits and trade-offs of NbS interventions, considering their ecological, social, and economic impacts across different sectors. These methods should incorporate One Health principles.
- **Address Health Inequities and Ensuring Equitable Benefit-Sharing:** Investigate and address social and cultural barriers to accessing NbS benefits, particularly among vulnerable populations (Indigenous Peoples, women, marginalized communities). Develop culturally sensitive benefit-sharing mechanisms to ensure equitable resource distribution.
- **Understand Biological Mechanisms Linking NbS and Health:** Illuminate the specific biological and ecological pathways through which NbS influence human and ecosystem health. This includes research on the impacts of NbS on the human microbiome and other relevant biological processes.
- **Develop and Validate Health Indicators for NbS:** Identify, validate, and standardize health indicators that accurately measure the impacts of NbS interventions across diverse settings.
- **Incorporate Traditional Ecological Knowledge (TEK):** Integrate TEK into NbS design to improve effectiveness, cultural appropriateness, and equity.
- **Improve Data Integration and Analysis for NbS and One Health:** Develop standardized methods for integrating and analyzing data from various sectors (health, environment, agriculture, etc.) to better understand the complex relationships between NbS interventions, ecosystem health, and human well-being. This involves identifying appropriate data sources, developing robust data-collection protocols, and creating analytical tools that can effectively capture and interpret the multiple co-benefits and trade-offs associated with NbS, particularly from a One Health perspective.

Beyond these research gaps, the successful implementation and long-term sustainability of NbS for health depend on robust policy frameworks. These frameworks must address land tenure, resource management, and equitable benefit-sharing while mitigating negative consequences. Effective policies should incorporate comprehensive monitoring and evaluation (M&E) plans using standardized methodologies and indicators to track both ecological and health outcomes. Strong legal frameworks and effective enforcement mechanisms are also crucial to protect both biodiversity and human rights, support meaningful community participation, regulate potentially harmful activities, and incentivize NbS adoption. Where possible and appropriate, these policies should also incentivize the integration of traditional ecological knowledge and ensure meaningful community participation throughout all phases of NbS, from planning to monitoring. Community engagement is vital for culturally appropriate design, implementation, and monitoring, maximizing health co-benefits and fostering project ownership. Failure to establish these supportive policies, robust M&E, and effective enforcement will severely limit the potential of NbS to address global health challenges.

Photo Credit: Souleymane Ag Anara

Conclusion

As the world faces escalating environmental and health crises, the urgency to act has never been greater. This report arrives at a critical juncture as the world grapples with a convergence of health and planetary crises. The destabilization of ecosystems through biodiversity loss, climate change, pollution, conflict, and socio-economic pressures threatens both environmental and human health, exacerbating inequities on a global scale.

Nature-based Solutions offer a powerful pathway for addressing these interconnected crises. To maximize their potential, NbS must be designed to integrate not only climate mitigation and adaptation but also the protection, restoration, and sustainable management of ecosystems that are essential for the health of both people and the planet. Policymakers must recognize that NbS are indispensable strategies for building resilience and securing the health and well-being of future generations.

By leveraging the capacity of natural systems, NbS provide critical co-benefits that extend beyond environmental conservation to improve human health—whether through cleaner air and access to freshwater, more sustainable food systems, reduced risk of zoonotic diseases, or spaces that enhance physical and mental health.

This report presents a set of core recommendations and real-world examples to serve as practical models for scaling up NbS in ways that benefit people and nature. These examples demonstrate how NbS, when integrated into public health strategies and policies, can offer transformative change. Importantly, these efforts must prioritize vulnerable communities, ensuring that equity and human rights are embedded within NbS and health efforts. Indigenous Peoples, women, youth and marginalized communities should be empowered as active

agents, stakeholders and rights holders, not just beneficiaries, in shaping NbS efforts that are aligned with their needs and knowledge systems.

Health professionals, policymakers, and related sectors all play a pivotal role in mainstreaming health into NbS efforts. Policymakers, scientists, professionals, and community members in health and health-related sectors must all play an important role in mainstreaming health into NbS efforts. Importantly, these efforts also require targeted resource allocation, long-term planning, and a whole-of-government approach to ensure cross-sectoral collaboration. Only through embedding health as a key co-benefit of NbS efforts can decision-makers effectively address the root causes of health risks and build resilient, sustainable health systems.

At the same time, developing effective M&E frameworks will be essential to demonstrating the impact and effectiveness of NbS initiatives. These frameworks should incorporate both quantitative and qualitative data to capture the range of benefits, including improved human health, enhanced ecosystem resilience, and strengthened community well-being. Key performance indicators (KPIs) should be established that are relevant to both environmental and social outcomes and clearly linked to specific NbS interventions. Regular data collection, analysis, and reporting, coupled with community engagement and participation, are essential for ensuring that M&E processes are participatory, transparent, and accountable. By actively monitoring and evaluating the outcomes of NbS interventions, decision-makers can refine their strategies, improve future interventions, and strengthen the evidence base for informed policy decisions.

Moreover, while NbS offer transformative potential, careful planning and implementation are essential to mitigating potential risks and trade-offs and ensuring sustainability and equity. An integrated approach that balances ecological, social, and economic considerations, such as One Health, can further consolidate this potential.

The window for action is narrowing, but the opportunity to address these planetary crises remains. NbS, coupled with holistic approaches like One Health, provide a cornerstone for safeguarding human, animal, plant, and ecosystem health. Policymakers must work collaboratively with other stakeholders to scale up investments in NbS, share knowledge, and ensure that vulnerable communities are protected and empowered.

The time to act is now, to ensure that future generations inherit a world where healthy ecosystems and healthy people thrive together. This report serves as a springboard for that action, laying the groundwork for a future where healthy ecosystems and healthy people thrive together.

References

Active in Nature. [Online]. Available at: https://www.outdoorsvictoria.org.au/projects/active-in-nature-ov/ [Accessed 28th September, 2024].

Afelt, A., Frutos, R., Devaux, C. (2018). Bats, Coronaviruses, and Deforestation: toward The Emergence of Novel Infectious Diseases?. Frontiers in Microbiology, 9, 702.

AFROHUN Secretariat (2023). Africa One Health University Network, 2022-23 One Health Workforce- Next Generation AFROHUN Secretariat Kampala, Uganda

Ahmed, S., de la Parra, J., Elouafi, I., German, B., Jarvis, A., Lal, V., Lartey, A. Longvah, T., Malpica, C., Vázquez- Manjarrez, N., Prenni, J., Aguilar-Salinas, C.A., Srichamnong, W., Rajasekharan, M., Shafizadeh, T., Bloomfields Siegel, J., Steiner, R., Tohme, J., Watkins, S. (2022). Foodnomics: A Data- Driven Approach to Revolutionize Nutrition and Sustainable Diets. Front. Nutri. 9:874312.

Ahmed, S., Chien., C.M., de la Parra, J., German, J.B., Jarvis, A., Lal, V., Lartey, A., McDade, M., Morgan, K., Prenni, J., Rajasekharan, M., Shafizadeh, T., Vázquez- Manjarrez, N., Watkins, S. (2023). What Is in A Tomato? Mapping The Building Blocks of Food. Front. Young Minds 11:1038318.

Aitsi-Selmi, A.; Murray, V.; Wannous, C. (2017). Health Supporting Disaster Risk Reduction Including Climate Change Adaptation. In The Routledge Handbook of Disaster Risk Reduction Including Climate Change Adaptation; Kelman, I., Mercer, J., Gaillard, J., Eds.; Routledge: Abingdon, UK; New York, NY, USA.

Alam Sehat Lestari. [Online]. Available at: https://www.alamsehatlestari.org Accessed 28th September, 2024.

Anenberg, S.C., Horowitz, L.W., Tong, D.Q., West, J.J. (2010). An Estimate of the Global Burden of Anthropogenic Ozone and Fine Particulate Matter on Premature Human Mortality Using Atmospheric Modelling. Environmental Health Perspectives. 188(9), 1189-1195.

Applequist, W.L., Brinckmann, J.A., Cunningham, A.B., Hart, R.E., Heinrich, M., Katerere, D.R., van Andel, T. (2020). Scientists' Warning on Climate Change and Medicinal Plants. Planta Medica 86(1):10-18.

Arce-Mojica, T., Nehren, U., Sudmeier-Rieux, K., Miranda, P.J., Anhuf, D., (2019). International Journal of Disaster Risk 41:101293.

Argumendo, A., Yun Loong Wong, B. (2010. The Ayllu System of the Potato Park (Peru)" in Caroline Bélair et al, Sustainable use of Biological Diversity in Socio-Ecological Production Landscapes: Background to the 'Satoyama Initiative for the benefit of Biodiversity and Human Well-being. Secretariat of the Convention on Biological Diversity CBD Technical Series. (52) 84

Ărramăt [Online]. Available at: https://arramatproject.org [Accessed 3rd October, 2024].

Association Médical Canadienne, Canadia Medical Association. Environmentally Sustainable Health Systems in Canada. [Online] Available at: https://policybase.cma.ca/link/policy14489 [Accessed 13th October, 2024].

Australian Institute of Health and Welfare (2016). Cardiovascular Disease, Diabetes and Chronic Kidney Disease- Australian Facts: Aboriginal and Torres Strait Isalnder People. Canberra.

Balami, S., Sharma, A., Karn, R. (2019). Significance of Nutritional Value of Fish for Human Health. Malaysian Journal of Halal Research Journal. 2(2).

Banerjee, S., Van der Hejiden, M.G.A (2023). Soil Microbes and One Health. Nature: 21.

Banwell, N, Rutherford, S., Mackey, B., Chu, C. (2018). Towards Improved Linkage of Disaster Risk Reduction and Climate Change Adaptation in Health: A Review. International Journal of Disaster Risk Science. 15(4), 793.

Barton, J., Pretty, J.N (2010). What is the Best Dose of Nature and Green Exercise for Improving Mental Health? A Multi-Study Analysis. Environmental Science and Technology 44(10):3947-55.

BBC News (2023). Paying for Healthcare with Tree Seeds. [Online], Available at: https://www.bbc.com/news/av/world-africa-66022969

Belotti, F., Donato, S., Bussoletti, A., Comunello, F. (2022). Youth Activism for Climate *on* and *beyond* Social Media: Insights from FridaysForFuture- Rome. The International Journal of Press/Politics.

Bhattacharyya, R., Ghosh, B.N, Mishra, P.K., Mandal, B., Rao, C.S., Sarkar, D., Das, K., Anil, K.S., Lalitha, M., Hati, K.M et al. (2015). Soil Degradation in India: Challenges and Potential Solutions. Sustainability 4:3528-3570.

Bindoff, N.L, Willebrand, J., Artale, V., Cazenave, A., Gregory, J.M, Guleve, S., Hanawa, K., Le Quere, C.,Levitus, S, Nojiri, Y., Shum, C.K., Talley, L.D., Unnikrishnan, A.S, Josey, S.A., Tamisa, M, Tsimplis, M., Woodworth, P. (2007). Observations: Oceans Climate Change and Sea Level In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M. Averyt, K.B., Tignor, M, Miller, H.L (eds.) Climate Change 2007: the Physical Science Basis: Contribution of Working Group I. Cambridge, Cambridge University Press, 385-428.

Blended Finance Taskforce. Meloy Fund for Sustainable Community Fisheries. Available at: https://www.blendedfinance.earth/blended-finance-funds/2020/11/16/meloy-fund-for-sustainable-community-fisheries [Accessed 28th September, 2024].

Borelli, S., Conigliaro, M., Salbitano, F. (2021). The Social Impacts of NBS: Access to and ccessibility of Green Spaces as a Measure of Social Inclusiveness and Environmental Justice. In Nature-Based Solutions for More Sustainable Cities–A Framework Approach for Planning and Evaluation (pp. 211-224). Emerald Publishing Limited.

Bosso, L., di Febbraro, M., Cristinzio, G., Zoina, A., Russo, D. (2016). Shedding Light on the Effects of Climate Change on the Potential Distribution of *Xylella fastidiosa* in the Mediterranean Basin. Biological Invasions 18:1759-1768.

Bremer, L. L., Keeler, B., Pascua, P., Walker, R., Sterling, E. (2021). Nature-based Solutions, Sustainable Development, and Equity. In Nature-based Solutions and Water Security (pp. 81-105). Elsevier.

Browder, G.S., Ozment, S., Rehberger Bescos, I., Gartner, T., Lange, G.M (2019). Integrating Green and Gray: Creating Next Generation Infrastructure. Washington D.C. World Bank and World Resources Institute.

Buckingham, K., Hanson, C. (2015). The Restoration Diagnostic Case Example: Costa Rica Case Study. The Restoration Diagnostic. Washington D.C: World Resources Institute.

Catapano F, Malafronte R, Lepre F, Cozzolino P, Arnone R, Lorenzo E, Tartaglia G, Starace F, Magliano L, and Maj M (2001) Psychological consequences of the 1998 landslide in Sarno, Italy: A community study. Acta Psychiatrica Scandinavica 104(6): 438–442.

Ccami-Bernal, F., Soriano-Moreno, D.R, Fernandez- Guzman, D., Tuco, K.G., Castro-Díaz, S.D., Esparza- Varaz, A.L., Medina- Ramirez, S.A, Caira- Chuquineyra, B., Cortez- Soto, A.G., Yovera-Aldana, M,

Rojas- Rueda, D. (2023). Green Space Exposure and Type 2 Diabetes Meliitus Incidence: A Systematic Review. Health & Place 82: 103045.

Chapagain, D., Bharati, L., Borgemeister, C. (2022). Declining Vulnerability but Rising Impacts: The Trends of Climatic Disasters in Nepal. Regional Environmental Change 22(55).

Chen, S.L, Yu, H., Luo, H.M, Wu, Q., Li C.F, Steinmetz, A. (2016). Conservation and Sustainable Use of Medicinal Plants: Problems, Progress, and Prospects. Chinese Medicine 11(37).

Chivian, E., (ed.) (2003). Biodiversity: Its Importance to Human Health, Interim Executive Summary, A Project of the Center for Health and the Global Environment Harvard Medical School under the Auspices of the World Health Organization, the United Nations Development Programme, and the United Nations Environment Programme. Center for Health and Global Environment Harvard Medical School.

Chua, Kaw Bing, Beng Hui Chua, and Chew Wen Wang. (2002). Anthropogenic Deforestation, El Nino and The Emergence of Nipah Virus in Malaysia. Malaysian Journal of Pathology 24(1): 15-21.

Clark, M. A., Springmann, M., Hill, J., Tilman, D. (2020): Multiple Health and Environmental Impacts of Foods. Proceedings of the National Academy of Sciences, 117(51), 32741-32750.

Clayton, S., Manning, C. M., Krygsman, K., Speiser, M. (2017). Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. Washington, D.C.: American Psychological Association, and ecoAmerica.

Clean50. (2023). BC Parks Foundation Brings the great Outdoors to a Prescription Pad Near You. Clean50. [Online]. Available at: https://clean50.com/projects/bc-parks-foundation-brings-the-great-outdoors-to-a-prescription-pad-near-you/ [Accessed 13th October, 2024].

ClinicalTrials.gov. Health, Environment and Action in Louisville 9HEAL) Green Heart Louisville Project (Heal). [Online]. Available at: https://clinicaltrials.gov/study/NCT03670524?term=HEAL&locStr=Louisville,%20KY,%20USA&country=United%20States&state=Kentucky&city=Louisville&rank=1 [Accessed 28th September, 2024].

Commonwealth Secretariat (2016). Global Youth Development Index and Report 2016. Commonwealth Secretariat, London.

Connecting Climate Minds Youth Declaration. 2024. https://nbswmzwquzluimyqnfsf.supabase.co/storage/v1/object/public/documents/Connecting_Climate_Minds__Youth_Declaration.pdf

Connecting Climate Minds. [Online]. https://nbswmzwquzluimyqnfsf.supabase.co/storage/v1/object/public/documents/Full%20TRAA%20youth%2018-03.pdf?t=2024-03-19T11%3A08%3A20.042Z [Accessed 5th October, 2024].

Convention on Biological Diversity (CBD) (2023): Kunming-Montreal Global Biodiversity Framework. Available from: https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

Convergence, (2022). State of Blended Finance 2022: Climate Edition. Convergence.

Coventry, P.A., Brown, J.E., Pervin, J., Brabyn, S., Pateman, R., Breedvelt, J., Gilbody, S., Stancliffe, R., McEachan, R., White, P.L. (2021) Nature-based Outdoor Activities for Mental and Physical Health: Systematic Review and Meta-Analysis. SSM-Population Health. 16:100934.

Cox, D.T.C., Shanahan, D.F., Hudson, H.L., Fuller, R.A., Anderson, K., Hancock, S., Gaston, K.J (2017). Doses of Nearby Nature Simultaneously Associated with Multiple Health Benefits. International Journal of Environmental Research and Public Health. 14(2):172.

Dasandi, N., Cai, W., Friberg, P., Jankin, S., Kuylenstierna, J., Nilsson, M. (2022). The Inclusion of Health in Major Global Reports on Climate Change and Biodiversity. BMJ Global Health, 7(6), e008731.

Davy, C., Hartfield, S., McArthur, A., Munn, Z., Brown, A. (2016). Access to Primary Health Care Services for Indigenous Peoples: A Framework Synthesis, International Journal for Equity in Health 15(163).

De Mel, M., Weerathunge, C. (2011). Valuation of Ecosystem Services of the Maha Oya. Environmental Foundation, Sri Lanka.

Deutz, A., Heal, G.M., Niu, R., Swanson, E., Townshend, T., Zhu, L., Delmar, A., Meghji, A., Sethi, S.A., Tobin- de la Puente, J. Financing Nature: Closing the Global Biodiversity Financing Gap. The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability. (2020)

Devkota, S., Shakya, N.M, Sudmeier-Rieux (2019). Framework for Assessments of Eco-Safe Rural Roads in Panchase Geographic Region in Central- Western Nepal Hills. Environments 6(6),59.

DNB (2020). Indebted to Nature- Exploring Biodiversity Risks for the Dutch Financial Sector. De Nederlandsche Bank, Planbureau voor de Leefomgeving.

Doney, S.C, Ruckelshaus, M., Emmett Duffy, J., Barry, J.P, Chan, F., English, C.A., Galindo, H.M, Grebmeier, J.M, Hollowed, A.B., Knowlton, N., Polovina, J., Rabelais, N.N., Sydeman, W.J., Talley, L.D. (2011). Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science 4.

EAT-Lancet (2023): Food, Planet, Health: Healthy Diets from Sustainable Food Systems. EAT-Lancet Commission. https://eatforum.org/eat-lancet-commission/

EAT-Lancet Commission (2023): Summary Report: Healthy Diets From Sustainable Food Systems. EAT-Lancet Commission. Available at: https://eatforum.org/eat-lancet-commission/eat-lancet-commission-summary-report/

Ehrlich, P.R, Ehrlich, A.H. (1981). Extinction: The Causes and Consequences of the Disappearance of Species. Random House.

Ehrlich, P.R., Kennedy, D. (2005) Millennium Assessment of Human Behavior. Science, 309(5734): 562-563.

Elliot- Farrelly, T. (2004). Australian Aboriginal Suicide: the Need for an Aboriginal Suicidology? Australian e-Journal for the Advancement of Mental Health 3(4).

Epstein, J. H., Hume, E., Field, S.L., Pulliam,J.R.C., Daszak, P. (2006). Nipah Virus: Impact, Origins, and Causes of Emergence. Current Infectious Disease Reports. 8(1): 59-65.

Escobedo, F. J., Kroeger, T., Wagner, J.E. (2011). Urban Forests and Pollution Mitigation: Analysing Ecosystem Services and Disservices. Environmental Pollution, 159 (8-9), 2078-2087.

European Investment Bank (2023). Investing in Nature- Based Solutions: State of Play and Way forward for Public and Private Financial Measures in Europe. European Investment Bank.

Evans, B.R., Leighton, F.A. (2014). A History of One Health. Rev.sci.tech.Off.int.Epiz., 33(2):413-420

Famiglietti, J. (2019): A Map of the Future of Water. The Pew Charitable Trusts. Link.

Ferrario, F., Beck, M.W., Storlazzi, C.D., Michei, F., Shepard, C.C., Airoldi, L., (2014). The Effectiveness of Coral Reefs for Coastal Hazard Risk Reduction and Adaptation. Nature Communications 5:3794.

Fierer, N. (2017). Embracing the Unknown: Disentangling the Complexities of the Soil Microbiome. Nature Reviews Microbiology, 15(10), 579-590.

Finance Earth. (2021). A Market Review of Nature-Based Solutions: An Emerging Institutional Asset Class. Green Purpose Company, Finance Earth.

Fitzky, A.C., Sandén, Karl, T., Fares, S., Calfapietra, C., Grote, R., Saunier, A., Rewald, B., (2019). The Interplay between Ozone and Urban Vegetation -BVOC Emissions, Ozone Deposition, and Tree Ecophysiology. Frontiers for Global Change 2.

Food and Agriculture Organization of the United Nations (1999). State of the World's Forests 1999. https://www.fao.org/4/x6900e/x6900e0m.htm

Food and Agriculture Organization of the United Nations (2016). The Future of Food and Agriculture-Trends and Challenges. Rome

Food and Agriculture Organization of the United Nations (2017). Migration, Agriculture and Climate Change: Reducing Vulnerabilities and Enhancing Resilience. Rome.

Food and Agriculture Organization of the United Nations (2020). FAO's Blue Growth Initiative: Blue Finance Guided Notes: Blended Finance. FAO. Rome.

Food and Agriculture Organization of the United Nations (2020): The State of World Fisheries and Aquaculture 2020: Sustainability in Action. Rome: Food and Agriculture Organization.

Food and Agriculture Organization of the United Nations (2022). The State of the World's Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome

Food and Agriculture Organization of the United Nations, United Nations Environment Programme (2020). State of the World's Forests 2020. Rome.

Food and Agriculture Organization of the United Nations, United Nations Environment Programme (2021). Global Assessment of Soil Pollution: A Hidden Reality. Rome.

Food and Agriculture Organization of the United Nations, World Health Organization (2019). Sustainable Healthy Diets: Guiding Principles. Rome.

Food and Agriculture Organization of the United Nations, United Nations Environmental Programme, World Health Organisation, World Organisation for Animal Health (2022). One Health Joint Plan of Action (2022-2026). Working Together for the Health of Humans, Animals, Plants and the Environment. Rome.

Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development, United Nations International Children's Emergency Fund, World Food Programme, and World Health Organization (2021): The State of Food Security and Nutrition in the World 2021. Transforming Food Systems for Food Security, Improved Nutrition and Affordable Healthy Diets for All. Food and Agriculture Organization of the United Nations (FAO).

Forster, V. (2022) Canadian Physicians Can Now Prescribe Nature to Patients. Forbes. [Online]. Available at: https://www.forbes.com/sites/victoriaforster/2022/02/08/canadian-physicians-can-now-prescribe-nature-to-patients/?sh=373b9c726f20 [Accessed 13th October, 2024].

Fox, H.E, Christian, C., Nordby, J.C., Pergams, O.R.W., Peterson, G.D., Pyke, C.R. (2006). Perceived Barriers to Integrating Social Science and Conservation. Conservation Biology 20:1817-1820.

Francisco, L., Sullivan, A., Goley, J., Martinez, S., (2018). Living with Bats. https://www.ecohealthalliance.org/living-safely-with-bats Accessed 28th September, 2024.

Fuller, R., Landrigan, P. J., Balakrishnan, K., Bathan, G., Bose-O'Reilly, S., Brauer, M., Caravanas, J., Chiles, T., Cohen, A., Corra, L., Cropper, M., Ferraro, G., Hanna, J., Hanrahan, D., Hu, H., Hunter, D., Janata, G., Kupka, R., Lanphear, B., Lichtveld, M., Martin, K., Mustaph, A., Sanchez- Triana, E., Sandilya, K., Schaefli, L., Shaw, J., Seddon, J., Suk, W. Téllez- Roho, M.M., Tan C. (2022). Pollution and Health: A Progress Update. The Lancet Planetary Health, 6(6), e535-e547.

Furlong, C., Lamb, Bastable, A., (2017). Learning from Oxfam's Tiger Worm Toilets Projects. [Online]. Available at:

https://wedc-knowledge.lboro.ac.uk/resources/conference/40/Furlong-2835.pdf [Accessed 28th September, 2024].

Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Rojas-Rueda, D., Plasència, A., Nieuwenhuijsen, M. J. (2016). Residential Green Spaces and Mortality: A Systematic Review. Environment International, 86, 60-67.

Geck, M. S., Cristians, S., Berger-Gonzalez, M., Casu, L., Heinrich, M., Leonti, M. (2020). Traditional Herbal Medicine in Mesoamerica: Toward its Evidence Base for Improving Universal Health Coverage. Frontiers in Pharmacology, 11, 1160.

Geist, H.J., Lambin, E.F. (2002). Proximate Cause and Underlying Driving Forces of Tropical Forests Are Disappearing as the Result of Many Pressures, Both Local and Regional, Acting in Various Combinations in Different Geographical Locations. Bioscience 52:143-150.

Ghose, M.K., & Majee, S.R. (2001). Environmental Impact of Coal Mining on Water Regime and Its Management. Water, Air, and Soil Pollution.

Gibb, R., Redding, D.W., Chin, K.Q., Donnelly, C.A., Blackburn, T.M., Newbold, T., Jones, K.E. (2020). Zoonotic Host Diversity Increases in Human- Dominated Ecosystems. Frontiers in Veterinary Science, 7: 123.

Giordano, R., Pluchinotta, I., Pagano, A., Scrieciu, A., Nanu, F. (2020). Enhancing Nature-based Solutions Acceptance through Stakeholders' Engagement in Co-benefits Identification and Trade-offs Analysis. Science of the Total Environment, *713*, 136552.

Giroux, R., Homer, K., Kassam, S., Pokrupa, T., Robinson, J., Sauve, A., Sumner, A. (2018). Mental Health and Suicide in Indigenous Communities in Canada. Canadian Federation of Medical Students.

Global Burden of Disease 2017 Risk Factor Collaborators (2017). Global, Regional, and National Comparative Risk Assessment of 84 Behavioral, Environmental and Occupational, and Metabolic Risks or Clusters of Risks for 195 Countries and Territories, 1990-2017: A Systematic Analysis for the Global Burden of Disease Study. Lancet 392:1923-94.

Global Youth Biodiversity Network, YOUNGO, Youth4Nature (2021). https://static1.squarespace.com/static/60d345a74ed9f630745b8646/t/61868053f73d0949acb7dd1e/1636204632840/Nature-Based+Solutions-Position+2021-Nov+C.pdf Accessed 29th September, 2024.

Go Green Routes. Lahti Health Forest Information Brochure. [Online]. Available at: https://gogreenroutes.eu/publication?t=Lahti%20Health%20 Forest%20 Informational%20Brochure [Accessed 28th September, 2024].

Golden, C. D., Allison, E. H., Cheung, W. W., Dey, M. M., Halpern, B. S., McCauley, D. J., Smith, M., Vaitla, B., Myers, S.S. (2016). Nutrition: Fall in Fish Catch Threatens Human Health. Nature, 534(7607), 317-320

Gomiero, T. (2016). Soil Degradation, Land Scarcity, and Food Security: Reviewing a Complex Challenge. Sustainability, 8(3), 281. https://doi.org/10.3390/su8030281

Göransson G, Edebalk P, Hedfors J, Carlin M, Odén K, Branzén H, and Stark M (2016) In: Multi-hazard: Contaminated land vulnerable to natural hazards and effects of climate change, Swedish Geotechnical Institute, Sweden, NGM 2016 Reykjavik Proceedings of the 17th Nordic Geotechnical Meeting Challenges in Nordic Geotechnic 25th–28th of May IGS 1127 NGM 2016

Green- Gray Community of Practice. (2020). Practical Guide to Implementing Green-Gray Infrastructure. [Online]. Available at:

https://www.conservation.org/docs/default-source/publication-pdfs/ci-green-gray-practical-guide-v08.pdf

Green Lahti. [Online]. Available ate: https://greenlahti.fi/en [Accessed 28th September, 2024].

Greenheart Louisville. [Online]. Available at: https://greenheartlouisville.com/ [Accessed 28th September, 2024].

Groombridge, B. Jenkins, M.D. (2002). World Atlas of Biodiversity: Earth's Living Resources in the 21st Century. UNEP World Conservation Monitoring Centre. University of California Press, Berkeley, USA.

Guo, Y., Wei, H., Lu, C., Gao, B., Gu. W (2016). Predictions of Potential Geographical Distribution and Quality of Schisandra sphenanthera under Climate Change. PeerJ 4:e2254.

Gunawardena, K.R., Wells, M.J., Kershaw, T. (2017). Utilizing Green and Bluespace to Mitigate Urban Heat Island Intensity. Science of the Total Environment 584-585: 1040-1065.

Hamilton, A.C. (2004). Medicinal Plants, Conservation and Livelihoods. Biodiversity & Conservation, 13(8):1477-1517.

Hamilton, M. (2022). Supporting India's Farmers to Regenerate the Soil. The Rockefeller Foundation. [Online]. Available at:
https://www.rockefellerfoundation.org/insights/grantee-impact-story/supporting-indias-farmers-to-regenerate-the-soil/ [Accessed 28th September, 2024].

Hartig, T., Mitchell, R., de Vries, S., Frumkin, H. (2014). Nature and Health. Annual Review of Public Health, 35:207-228.

Health in Harmony. [Online]. Available at https://healthinharmony.org/mission/ Accessed 28th September, 2024.

Hickman, C., Marks, E., Pihkala, P., Clayton, S., Lewandowski, R.E., Mayall, E.E., Wray, B., Mellor, C., van Susteren, L. (2021). Climate Anxiety in Children and Young People and Their Beliefs about Government Responses to Climate Change: A Global Survey. The Lancet Planetary Health 5(2): E863-E873.

High Level Panel of Experts on Food Security and Nutrition (2019). Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems that Enhance Food Security and Nutrition. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome.

Highland, L., Geertsema (2019). Human Health Effects of Landslides (ed.) Nriagu, J.O, Encyclopedia of Environmental Health 2nd Edition,, Elsevier.

Hilson, G. (2002). The Environmental Impact of Small-Scale Gold Mining in Ghana: Identifying Problems and Possible Solutions. The Geographical Journal.

Hunter, D., Gee, E., & Borelli, T. (2020). Nourishing People, Nurturing the Environment: Biodiversity for Food Systems Transformation and Healthier Diets. In Biodiversity, Food and Nutrition (pp. 3-20). Routledge.

Hunter, R.F, Nieuwenhuijsen, M., Fabian, C., Murphy, N., O'Hara, K., Rappe, E., Fleming Sallis, J., Lambert, E.V., Sarmiento Duenas, O.L., Sugiyama, T., Kahlmeier, S (2023). Advancing Urban Green and Blue Space Contributions to Public Health. The Lancet Public Health 8(1): E735-E742.

Huntignton, H., Steven, C., Seybolt, C., Carlson, S., Tobiason, A., Daut, E., Bouvier, I. (2024). Applications of Implementation Science in Integrated Conservation and Health Programs: Improved Learning to Achieve Environmental and Health Objectives. PLoS, 3(5).

International Labour Organization https://ilostat.ilo.org/data/country-profiles/ Accessed 1st October, 2024.

Intergovernmental Panel on Climate Change (2002). Climate Change and Biodiversity. Gitay, H., Suárez, A., Dokken, D.J., Watson, R.T (eds.).

Intergovernmental Panel on Climate Change (2013). Technical Summary. Pages 33-115 in T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley, editors. Climate change 2013: the physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK..

Intergovernmental Panel on Climate Change (2018). Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24.

Intergovernmental Panel on Climate Change. (2019): Special Report on Climate Change and Land. Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Intergovernmental Panel on Climate Climate Change (2022). Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Intergovernmental Panel on Climate Change (2023). Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2016). Assessment Report on Pollinators, Pollination, and Food Production. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: IPBES Secretariat.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). Global Assessment Report on Biodiversity and Ecosystem Services. IPBES Secretariat.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services. IPBES Secretariat.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2020). Workshop Report on Biodiversity and Pandemics of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Sazak P, Amuasi J, das Neves C G, Hayman D, Kuiken T, Roche B, Zambrana-Torrelio C, Buss P, Dundarova H, Feferholtz Y, Földvári G, Igbinosa E, Junglen S, Liu Q, Suzan G, Uhart M, Wannous C, Woolaston K, Mosig Reidl P, O'Brien K, Pascual U, Stoett P, Li H, Ngo H T. IPBES Secretariat, Bonn, Germany.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2023). Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H. E., Pauchard, A., Stoett, P., Renard Truong, T., Bacher, S., Galil, B. S., Hulme, P. E., Ikeda, T., Sankaran, K. V., McGeoch, M. A., Meyerson, L. A., Nuñez, M. A., Ordonez, A., Rahlao, S. J., Schwindt, E., Seebens, H., Sheppard, A. W., and Vandvik, V. (eds.). IPBES Secretariat. Bonn: Germany.

Internal Displacement Monitoring Centre and Norwegian Refugee Council (2015). People Displaced by Disasters. Geneva.

International Fund for Agricultural Development. Indigenous Peoples Assistance Facility. [Online]. Available at: https://www.ifad.org/en/ipaf [Accessed 3rd October, 2024].

International Fund for Agricultural Development. (2023). The Indigenous Peoples Assistance Facility (IPAF): Assessment of the Performance of the Fifth IPAF Cycle. IFAD.

International Labour Organization. [Online]. Available at: https://ilostat.ilo.org/data/country-profiles/ [Accessed 1st October, 2024]

International Union for the Conservation of Nature, Promoting Human Health through the Global Biodiversity Framework: Linking Forests and Human Health in National Biodiversity Strategies and Action Plans, Information Brief. [Online]. Availanle at: https://iucn.org/resources/information-brief/promoting-human-health-through-global-biodiversity-framework-linking [Accessed 1st October, 2024].

International Union for the Conservation of Nature (2009). No Time to Loses- Make Full Use of Nature-based Solutions in the Post-2012 Climate Change Reimes. Position Paper for the 15th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (CoP15), 1-5. https://iucn.org/sites/default/files/import/downloads/iucn_position_paper_unfccc_cop_15_1.pdf

International Union for Conservation of Nature (2018). Inclusivity across 4 African Landscapes. IUCN [Online]. Available at: https://iucn.org/news/forests/201805/inclusivity-across-4-african-landscapes [Accessed 28th September, 2024].

International Union for the Conservation of Nature, EcoHealth Alliance (2022). Healthy People and Wildlife through Nature Protection: Guidelines for Prevention, Detection, Response, and Recovery from Disease Risks in and around Protected and Conserved aAreas. Gland, Switzerland: IUCN, and New York, USA: EcoHealth Alliance.

Iyer, H.S., James, P., Valeri, L., Pernar, C.H., Mucci, L.A., Holmes, M.D., Laden, F., Rebbeck, T.R. (2020). Environmental Epidemiology. 4(2): e091.

James B. Molloy, Donald T. Rodbell, David P. Gillikin, Kurt T. Hollocher (2020); Citizen Science Campaign Reveals Widespread Fallout of Contaminated Dust from Mining Activities in the Central Peruvian Andes. Geology ; 48 (7): 678–682. doi: https://doi.org/10.1130/G47096.1

James, J.J., Christiana, R.W, Battista, R.A (2019). A Historical and Critical Analysis of Park Prescriptions. Journal of Leisure Research. 50(4):311-329.

Jani, N., Bhatia, A., Pathak, H. (2014). Emission of Air Pollutants from Crop Residue Burning in India. Aerosol and Air Quality Research 14:422-430.

Jarvis, A., Gallo-Franco, J., Portilla, J., German, B., Debouck, D., Rajasekharan, M., Khoury, C., Herforth, A., et al.., (2024). Periodic Table of Food Initiative for Generating Biomolecular Knowledge of Edible Biodiversity. Nature Food. 5:189-193.

Jaureguiberry, P., Titeux, N., Wiemers, M., Bowler, D. E., Coscieme, L., Golden, A. S., Guerra, C.A., Jacob, Takahashi, Y., Settele, J., Díaz, Molnár, Z., Purvis, A. (2022). The Direct Drivers of Recent Global Anthropogenic Biodiversity Loss. Science Advances, 8(45), eabm9982

Jimenez, M.P, Oken, E., Gold, D.R., Luttmann-Gibson, H., Requia, W.J., Rifas- Shiman, S.L., Gingras, V., Hivert, MF., Rimm, E.B, James P. (2020). Early Life Exposure to Green Space and Insulin Resistance: An Assessment from Infancy to Early Adolescence. Environment International 142:105849.

Johansen, D.F., Vestvik, R.A. (2020). The Cost of Saving Our Ocean- Estimating the Funding Gap of Sustainable Development Goal 14. Marine Policy 112:103783.

Jones, I.J., MacDonald, A.J., Hopkins, S.R., Sokolow, S.H. (2020). Improving Rural Health Care Reduces Illegal Logging and Conserves Carbon in a Tropical Forest. PNAS 117(45):28515- 28524.

Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A., Balk, D., Gittleman, J.L., Daszak, P. (2008): Global Trends in Emerging Infectious Diseases. Nature, 451, 990–993.

Kabata- Pendias, A., Mukherjee, A.B. (2007). Trace Elements from Soil to Human. Geophysical Research Abstracts 9:11054.

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., Bonn, A. (2016). Nature-based Solutions to Climate Change Mitigation

and Adaptation in Urban Areas: Perspectives on Indicators, Knowledge Gaps, Barriers, and Opportunities for Action. Ecology and Society, 21(2).

Kabisch, N., van den Bosch, M., Lafortezza, R. (2017). The Health Benefits of Nature-based Solutions to Urbanisation Challenges for Children and the Elderly–A Systematic Review. Environmental research, 159, 362-373.

Kadoda, G., Hale, S., (2015). Contemporary Youth Movements and the Role of Social Media in Sudan. Canadian Journal of African Studies 49(1).

Kahane, R., Hodgkin, T., Jaenicke, H., Hoogendoorn, C., Hermann, M., Keatinge, J.D.H., d'Arros Hughes, J., Padulosi, S., Looney, N.E (2013). Agrobiodiversity for Food Security, Health and Income. Agronomy for Sustainable Development. 33(4):671-693.

Keeley, A. T. H., Beier, P., Creech, T., Jones, K., Jongman, R. H., Stonecipher, G. & Tabor, G. M. (2019). Thirty Years of Connectivity Conservation Planning: An Assessment of Factors Influencing Plan Implementation. Environmental Research Letters, 14(10), 103001.

Keim M. E. (2011). Preventing disasters: public health vulnerability reduction as a sustainable adaptation to climate change. Disaster medicine and public health preparedness, 5(2), 140–148. https://doi.org/10.1001/dmp.2011.30

Keith, R.J, Hart, J.L, Bhatnagar, A., (2024). Greenspaces and Cardiovascular Health. Circulation Research, 134(9), 1179-1196.

Kew Gardens (2023). State of the World's Plants and Fungi 2023. Royal Botanic Gardens, Kew.

Kondo, M.C, Oyekanmi, K.O., Gibson, A., South, E.C., Bocarro, J. Hipp, J.A (2020). Nature Prescriptions for Health: A Review of Evidence and Research Opportunities. International Journal of Environmental Research and Public Health 17(12):4213.

Kor, L., Homewood, K., Dawson, T. P., & Diazgranados, M. (2021). Sustainability of Wild Plant Use in The Andean Community of South America. Ambio, 50(9), 1681-1697.

Kremen, C., Merelender, A.M. (2018). Landscapes that Work for Biodiversity and People. Science, 362(6412).

Kumar, P., Brander, L., Kumar, M.,Cuijpers, P. (2023). Planetary Health and Mental Health Nexus: Benefits of Environmental Management. Annals of Global Health 89(1).

Kumar, K & Pokhrel, P.R. (2024). A Case for Intersectoral Health- Conservation Collaboration: Barriers and Opportunities. IUCN

Laffoley, D., Baxter, J.M (eds.) (2019). Ocean Deoxygenation: Everyone's Problem- Causes, Impacts, Consequences and Solution. Full Report. Gland.

Lal, R. (2004). Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science, 304(5677), 1623-1627.

Lara, R.J, Neogi, S.B., Islam, M.S, Mahmud, Z.H., Yamasaki, S., Nair, G.B. (2009). Influence of Catastrophic Climatic Events and Human Waste on Vibrio Distribution in the Karnaphuli Estuary, Bangladesh. EcoHealth 6(2): 279-286

Lawrance, E.L., Thompson, R., Newberry Le Vay, J., Page, L. Jennings, N. (2022). The Impact of Climate Change on Mental Health and Emotional Wellbeing: A Narrative Review of Current Evidence, and Its Implications. International Review of Psychiatry, 34(5), 443-498 .

Lawrance, E., Newberry Le Vay, J., El Omrani, O., Howitt, P., Jennings, N., Meinsma, N., Watson, D. (2024)/Global Agenda for Research and Action in Climate Change and Mental Health. (Imperial College London).

Lelieveld J, Evans JS, Fnais M, Giannadaki D, Pozzer A (2015): The Contribution of Outdoor Air Pollution Sources to Premature Mortality on a Global Scale. Nature, 525, 367–71.

Lemieux, C.J., Groulx, M.W., Buxton, R.T., Reining, C.E., Blye, C.J., Hassen, N., Harding, S.L., Halpenny, E.A., Lem, M., Jakubec, S.L., Wright, P., Maklettzoff, T., Kerry, M, Keenleyside, van der Leest, P.S, Bueddefeld, J., Lemelin, R., Carruthers den Hoed, D, Steinberg, B., Moon, R., Scott, J., Grant, J., Khan, Z., Carr, D., McLaughlin, L., Krehbiel, R. (2022). The "Healthy Parks-Healthy People" Movement in Canada: Progress, Challenges, and an Emerging Knowledge and Action Agenda. International Journal of Protected Areas and Conservation. 21(1).

Leo, S., Izza, Q., Finley, N.L., Sumardi, I., Andiani, J. (2024). Wildlife Species Recorded by Camera Traps in Reforested Lowland Rainforest and Peat Swamp Forest of Gunung Palung National Park, Indonesia. Tropical Natural History, 24(1):8 -19.

Liddell, J.L., Kington, S.G., McKinley, C.E. (2022). "You Got to Drive 30 Miles to Get an Apple": Indigenous Food Sovereignty, Food Desserts, and Changing Subsistence Practices in the Gulf Coast. SN Social Sciences 2(232).

Liu, W., & Agusdinata, D.B. (2020). Interdependencies of Lithium Mining and Community Livelihoods in the Salar de Atacama, Chile. Journal of Cleaner Production

Liu, X.X., Ma, X.L., Huang, W.Z., Luo, Y.N., He, C.J., Zhong, X.M., Dadvand, P., Browning, M.H.E.M., Li, L., Zou, X.G., Dong, G.H., Yang, B.Y. (2022). Green Space and Cardiovascular Disease: A Systematic Review with Meta-Analysis. Environment Pollution 15(301):118990.

López- Portillo Purata, V., Gómez, S., Rodríguez, S.E. (2022). 5 Barriers That Hinder Green Financing [Project Update]. World Resources Institute.

Lozano, R., Naghavi, M., Foreman, K., Lim, S., Shibuya, K., Aboyans, V., et al. (2010). Global and Regional Mortality from 235 Causes of Death for 20 Age Groups in 1990 and 2010. Lancet 380(9859): 2095-128.

Lyver, P.O.B., Timoti, P., Gormley, A.M., Jones, C.J., Richardson, S.J., Tahi, B.L., Greenhalgh (2017). Key Maori Values Strengthen The Mapping of Forest Ecosystem Services. Ecosystem Services 27:92-102.

M'Lot, M., (2002). Kâ Isinâkwâk Askîy: Using Cree Knowledge to Perceive and Describe The Landscape of The Wapusk National Park Area, Masters of Natural Resource Management, Natural Resources Institute, University of Manitoba, 2002 [unpublished].

Machalaba, C., and Society for the Conservation of Nature of Liberia (2022). Integrating Biodiversity and Health Messaging and Tackling Superstition with Communities in Liberia. https://panorama.solutions/en/solution/integrating-biodiversity-and-health-messaging-and-tackling-superstition-communities Accessed 28th September, 2024.

Machovina, B., Feeley, K.J, Ripple, W.J. (2015). Biodiversity Conservation: The Key is Reducing Meat Consumption. Science of the Total Environment 536:419-431.

Markotter, W.,. Mettenleiter, T.C., Adisasmito, W.B., Almuhairi, S., Barton Behravesh, C., Bilivogui, P., Bukachi, S.A., Casas, N., Cediel Becerra, N., Charron, D.F., Chaudhary, A., Ciacci Zanella, J.R., Cunningham, A.A., Dar, O., Debnath, N., Dungu, B., Farag, E., Gao, G.F., Hayman, D.T.S., Khaitsa, M., Koppmans, M.P.G., Machalaba, C., Mackenzie, J., Morand, S., Smolenskiy, V., Zhou, L. (2023). Prevention of Zoonotic Spillover: From Relying on Response to Reducing The Risk at Source." PLoS Pathogens 19, no. 10 (2023): e1011504.

Marselle, M. R., Lindley, S.J., Cook, P.A., Bonn, A., (2021). Biodiversity and Health in the Urban Environment, Current Environmental Health Reports, 8:146-156.

Marsters, L., Morales, G., Ozment, S., Silva, M., Watson, G., Netto, M., Frisari, G.L. (2021). Nature-based Solutions in Latin America and the Caribbean: Financing Mechanisms for Regional Replication. Washington D.C. Inter-American Development Bank and the World Resources Institute

Martin, L., White, M.P., Hunt, A., Richardson, M., Pahl, S., Burt, J. (2020). Nature Contact, Nature Connectedness and Associations with Health, Well-being, and Pro-Environmental Behaviours. Journal of Environmental Psychology 68:101389.

Martín, E. G., Giordano, R., Pagano, A., Van Der Keur, P., Costa, M. M. (2020). Using a System Thinking Approach to Assess The Contribution of Nature-based Solutions to Sustainable Development Goals. Science of the Total Environment, 738, 139693.

Martinez, S., Sullivan, A., Hagan, E., Goley, J., Epstein, J.H., Olival, K.J., Saylors, K., Euren, J., Bangura, J., Zikankuba, S., Mouiche, M., Camara, A.O Desmond, J., Islam, I., Hughes, T., Wacharplusadee, S., Duong, V., Nga, N. T.T., Bird, B., Goldstein, T., Wolking, D., Johnson, C.K., Mazet, J. AK., Olson, S.H., Fine, A.E Valitutto, M., Karesh, W.B., Daszak, P., Francisco, L., the PREDICT Consortium (2022). Living Safely with Bats: Lessons in Developing and Sharing a Global One Health Education Resources. Global Health: Science and Practice, 10 (6).

Mason, P. (2013). Why It's Still Kicking off Everywhere: The New Global Revolutions. London: Verso.

Mateo- Sagasta, J., Zadeh, S.M., Turral, H., Burke, J. (2017). Water Pollution from Agriculture: A Global Review. Executive Summary. Rome: FAO; Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE).

Mbow,C.,C.Rosenzweig,L.G.Barioni,T.G.Benton,M.Herrero,M.Krishnapillai,E.Liwenga,P.Pradhan,M. G.Rivera-Ferre, T. Sapkota, F.N. Tubiello, Y. Xu, 2019: Food Security. In: Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. Cambridge: University Press.

Megaw, T., Kohlitz, J., Gero, A., Chong, J. (2020). Understanding and Responding to Climate Change Impacts in Inclusive WASH Programs- A Conceptual Framework- Learning Paper. Institute for Sustainable Futures, University of Technology Sydney.

Meloy Fund for Sustainable Fisheries. [Online]. Available at: https://www.meloyfund.com/about

[Accessed 28th September, 2024].

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Mills, J.G, Weinstein, P., Gellie, N.J.C., Wetrich, L.S., Lowe, A.J., Breed, M.F., (2017). Urban Habitat Restoration Provides a Human Health Benefit through Microbiome Rewilding: the Microbiome Rewilding Hypothesis. Restoration Ecology 25:6:866-872

Ministério da Saúde (2020). Mortalidade por Suicídio na População Indígena no Brasil, 2015 a 2018. Boletim Epidemiológico Vol 51

Mishara, M, Kotwal, P.C., Prasad, C. (2009). Harvesting of Medicinal Plants in the Forest of Central India and Its Impact on Quality of Raw Materials: A Case of Nagpur District, India. Ecoprint 16:35-42.

Mitchell, R., Popham, F. (2008). Effect of Exposure to Natural Environment on Health Inequalities: An Observational Population Study. The Lancet, 372(9650): 1655-1660.

Molnár, Z., Berkes, F. (2018). Role of Traditional Ecological Knowledge in Linking Cultural and Natural Capital in Cultural Landscapes. Reconnecting Natural and Cultural Capital: Contributions from Science and Policy; Paracchini, ML, Zingari, PC, Blasi, C., Eds, 183-193.

Monty, F., Murti, R., Miththapala, S., Buyck, C. (eds). (2017). Ecosystems Protecting Infrastructure and Communities: Lessons Learned and Guidelines for Implementation. Gland, Switzerland: IUCN.

Moore, E. (2020). Three Landscape Conservation Projects Converge in the Kilombero Valley. IUCN. [Online]. Available at:

https://iucn.org/news/forests/202009/three-landscape-conservation-projects-converge-kilombero-valley

[Accessed 28th September, 2024].

Moore, M, Razafindrina, K., Méndez, V.E & Niles, M.T (2024). An Analysis of the Adoption of the "System of Rice Intensification" (SRI): Why a Homegrown Technique Has Yet to Take Seed among Rice Farmers in Madagascar. Cogent Food & Agriculture 10(1).

Murray, V., Aitsi-Selmi, A., Blanchard, K. (2015). The role of public health within the United Nations post-2015 framework for disaster risk reduction. International Journal of Disaster Risk Science. 6:28-37.

Murray, M. H., Buckley, J., Byers, K. A., Fake, K., Lehrer, E. W., Magle, S. B., Stone, C., Tuten, H., Schell, C. J. (2022). One Health for All: Advancing Human and Ecosystem Health in Cities by Integrating an Environmental Justice Lens. Annual Review of Ecology, Evolution, and Systematics, 53(1), 403-426.

Myers, S. S., Zanobetti, A., Kloog, I., Huybers, P., Leakey, A.D.B., Bloom, A.J., Carlisle, E., Dietterich, L.H., Fitzgerald, G., Hasegawa, T., Holbrook, N.M., Nelson, R.L., Ottman, M.J., Raboy, V., Sakai, H., Sartor, K.A., Schwartz, J., Seneweera, S., Tausz, M., Usui, Y. (2014). Increasing CO_2 Threatens Human Nutrition. Nature, 510(7503), 139-142.

Naandi. [Online]. Available at: https://naandi.org/[Accessed 28th September, 2024].

Nanadeinboemi, O. A., Uju, M. L., Christopher, C. N., Hakeem, O. O., David, D. S. (2024). Environmental and Health Influences of Crude Oil Spills in Niger Delta, Nigeria: Case Study Oporoma Community. Journal of Health and Environmental Research, 10(2), 29-40. https://doi.org/10.11648/j.jher.20241002.11

Natl. Res. Counc (2011). Climate Stabilization Targets: Emissions, Concentrations and Impacts over Decades to Millennia. Washington D.C: Natl. Res. Counc..

Nature Conservancy. [Online]. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC-CoastalManagementTrust_Infographic_04.pdf [Accessed 29th September, 2024].

Nature Conservancy, (2018). The Green Heart Louisville Project. [Online]. Available: https://www.nature.org/en-us/about-us/where-we-work/united-states/kentucky/stories-in-kentucky/green-heart-project/ [Accessed 28th September, 2024).

New York State. New York City Watershed Program. [Online]. Available at: https://dos.ny.gov/new-york-city-watershed-program [Accessed 3rd October, 2024].

Nierenberg, D. (2024). The Global Effort to Map Biomolecules in Food to Health Outcomes. Forbes. [Online]. Available at:

The Global Effort To Map Biomolecules In Food To Health Outcomes. [Accessed 3rd October, 2024].

Oke, T.R. (1982). The Energetic Basis of the Urban Heat Islands. Quarterly Journal of the Royal Meteorological Society. Vol 108(455), 1-24.

Olanrewaju, M.M., Sanusi, B.O., Ajala, A.O., Oluwasanmi, O.P. (2024). Social Media and Youth Mobilisation during the End Sars Protest. IMSU Journal of Communication Studies 8(1).

Olivero, J., Fa, J.E., Real, R., Márquez, A.L., Farfán, M.A, Vargas, J.M., Gaveau, D., Salim, M.A., Park, D., Suter, J., King, S., Leendertz, S.A., Sheil, D., Nasi.R. (2017). Recent Loss of Closed Forests is Associated with Ebola Virus Disease Outbreaks. Scientific Reports, 7: 14291. https://doi.org/10.1038/s41598-017-14727-9

One Health High-Level Expert Panel, Adisasmito W B, Almuhairi S, Behravesh C B, Bilivogui P, Bukachi S A et al. (2022). One Health: A New Definition for a Sustainable and Healthy Future. PloS Pathof 18(6): e1010537.

One Health High-Level Expert Panel (OHHLEP) (2022): One Health: A New Definition for a Sustainable and Healthy Future. PLOS Pathogens, 18(6), e1010537. DOI.

Owen, J.R. (2013). Social License and Mining: A Critical Perspective. Resources Policy.

Pacheco, F.A.L., Fernandes, L.F.S., Valera, C.A., & Pissarra, T.C.T. (2018). Land Degradation: Multiple Environmental Consequences and Routes to Neutrality. Current Opinion in Environmental Science & Health, 5, 79-86.

Parlee, B. et al, (2008). Understanding and Communicating About Ecological Change: Denesoline Indicators of Ecosystem Health. in Fikret Berkes et al, (eds.) Breaking Ice: Integrated Ocean Management in the Canadian North, Calgary, University of Calgary Press, 2008, 165.

Pan American Health Organization. Health Equity. https://www.paho.org/en/topics/health-equity Accessed 29th September, 2024.

Pan American Health Organization. (2021). Agenda for the Americas on Health, Environment, and Climate Change 2021–2030.

Park, J., Moon, J., Kim, H., Kong, M., Oh, Y. (2020). Sedentary Lifestyle: Overview of Updated Evidence of Potential Health Risks. Korean Journal of Family Medicine 41:365-373.

Parker, S. Y., Parchment, K. F., & Gordon-Strachan, G. M. (2023). The Burden of Water Insecurity: A Review of The Challenges to Water Resource Management and Connected Health Risks Associated with Water Stress in Small Island Developing States. Journal of Water and Climate Change, 14(12), 4404-4423.

Parks Victoria (2024). Helping Young People Get Active in Nature. [Online]. Available at: https://www.parks.vic.gov.au/news/2024/04/02/23/24/helping-young-people-get-active-in-nature [Accessed 28th September, 2024].

PaRx: A Prescription for Nature [Online] Available at: https://www.parkprescriptions.ca/ [Accessed 28th September, 2024).

Patz, J. A., Olson, S. H., Uejio, C. K., & Gibbs, H. K. (2008). Disease Emergence from Global Climate and Land Use Change. Medical Clinics of North America, 92(6), 1473-1491.

Paul, M.J., Meyer, J.L (2001). Streams in the Urban Landscape. Annual Review of Ecology and Systematics, 32:333-65.

Paul, L.A., Hystad, P., Burnett, R.T., Kwong, J.C., Crouse, D.L., van Donkelaar, A., Tu, K., Lavigne, E., Copes, R., Martin, R.V., Cheng, H. (2020). Urban Green Space and The Risks of Dementia and Stroke. Environmental Research.

Peña- Arancibia, J., Bruijnzeel, L.A, Mulligan, M, van Dijk, A.I.J.M (2019). Forests as "Sponges" and "Pumps": Assessing the Impact of Deforestation on Dry-Season Flows across the Tropics. Journal of Hydrology 574:946-963.

Periodic Table of Food Initiative. Discover. [Online] Available at: https://foodperiodictable.org/discover/

What's in your food? A new research effort intends to find out [Accessed 3rd October, 2024].

Philips, R.M., Vujic, J., Boscoe, A., Handzel, T., Aninyasi, M., Cookson, S.T., Blanton, C., Blum, L.S., Ram, P.K. (2015). Soap Is Not Enough: Handwashing Practices and Knowledge in Refugee Camps, Maban County, South Sudan. Conflict and Health 9(39).

Pimachiowin Aki. [Online]. Available at: pimaki.ca [Accessed 3rd October, 2024].

Plowright, R.K., Ahmed, A.N., Coulson, T., Crowther, T.W., Ejotre, I., Faust, C.L., Frick, F.F., Hudson, P.J., Kingston, T., Nameer, P.O., O'mAra, M.T., Peel, A.J., Possingham, H., Razgour, O., Reeder, D.M., Ruiz-Aravena, M., Simmons, N.B., Srinivas, P. N., Tabor, G.M., Tanshi, I., Thompson, I.G., Vanak, A.T., Vora, N.M., Willison, C.E., Keeley, A.T.H. (2024). Ecological Countermeasures to Prevent Pathogen Spillover and Subsequent Pandemics. Nature Communications 15:2577.

Pokhrel, P.R., Kante, A., Poe, K., Kuman, C. (2024). Integrating Health into Landscape Conservation: Conservation, Biodiversity, and Health Are inextricably Linked. [Online]. Available at:

https://storymaps.arcgis.com/stories/29d47cd7021a4e8e8462f3912e1895fe [Accessed 28th September, 2024].

Porras, I.T., Barton, D.N., Miranda, M., Chacón- Cascente. Learning from 20 years of Payments for Ecosystem Services in Costa Rica. [Online]. Available at: https://www.iied.org/16514iied

Pörtner et al. (2021). IPBES-IPCC co-sponsored workshop: Biodiversity and Climate Change Workshop Report.

Prescri- Nature (2024). Prescri-Nature de Temps Passé en Nature. [Online]. Available at: https://www.prescri-nature.ca/ [Accessed 2nd October, 2024].

Prosper, K., et al., (2011). Returning to Netukulimk: Mi'kmaq Cultural and Spiritual Connections with Resource Stewardship and Self-Governance 2:4 Int. Indig. Policy J. 7.

Pyle, R.M. (2003). Nature Matrix: Reconnecting People and Nature. Oryx, 37(2): 206-214.

Ramagosa, F., Eagles, P.F.J., Lemiuex, C.J. (2015). From the Inside out to the Outside in: Exploring the Role of Parks and Protected Areas as Providers of Human Health and Well-being. Journal of Outdoor Recreation and Tourism. 10:70-77.

Ramos-Castillo, A., Castellanos, E.J., Galloway McLean, K., (2017). Indigenous Peoples, Local Communities and Climate Change Mitigation. Climate Change 140:1-4.

Rare. The Meloy Fund: Earning Returns for People, Nature, and Impact Investors. [Online]. Available at: https://rare.org/meloy-fund/ [Accessed 28th September, 2024].

Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., Geneletti, D., Calfapietra, C. (2017). A Framework for Assessing and Implementing The Co-Benefits of Nature-based Solutions in Urban Areas. Environmental Science & Policy, 77: 15-24.

Razzaghmanesh, M., Beecham, S., Salemi, T. (2016). The Role of Green Roofs in Mitigating Urban Heat Island Effects in the Metropolitan areas of Adelaide, South Australia. Urban Forestry & Urban Greening 15: 89-102.

Redvers, N., Aubrey, P., Celidwen, Y., Hill, K. (2023). Indigenous Peoples: Traditional Knowledges, Climate Change, and Health. PLOS Global Public Health, 3(10), e0002474.

Reimers, E., Cusimamani, E., Rodriguez, E., Zepeda del Valle, J., Polesny, Z., Pawera, L. (2018). An Ethnobotanical Study of Medicinal Plants Used in Zacatecas State, Mexico. Acta Societatis Botanicorum Poloniae, 87(2).

Renz, H, Holt PG, Inouye M, Logan AC, Prescott SL, Sly PD. An Exposome Perspective: Early-Life Events and Immune Development in a Changing World. J Allergy Clin Immunol. 2017;140:24–40.

Reyes-Riveros, R., Altamirano, A., De La Barrera, F., Rozas-Vásquez, D., Vieli, L., & Meli, P. (2021). Linking Public Urban Green Spaces and Human Well-being: A Systematic Review. Urban Forestry & Urban Greening, 61, 127105.

Rights and Resources Initiative. 2019. Indigenous and community response to IPCC report. A statement on the Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change and Land from Indigenous Peoples and local communities* from 42 countries spanning 76% of the world's tropical forests [online].

Rigolon, A., Owusu, R. O., Becerra, M., Cheng, Y. D., Christensen, J., Connolly, J. J., Corbin, C.N.E., Douglas, J.A., Fernandez, M., Jennings, V., Ito, J., Mullenbach, L.E., Nesbitt, L., Jelks, N. O., Walker, R., Viera, S., Romero, Espiricueta, A. (2024). Advancing Green Space Equity Via Policy Change: A Scoping Review and Research Agenda. Environmental Science & Policy, 157, 103765.

Robinson, J.M, Aronson, J., Daniels, C.B., Goodwin, N., Liddicoat, C., Orlando, L., Philips, D., Stanhope, J., Weinstein, P., Cross A.T., Breed, M.F. (2022). Ecosystem Restoration is Integral to Humanity's Recovery from COVID-19. The Lancet Planetary Health 6:9:E769-E773.

Robinson, J.M, Breed, M.F (2023). The Aerobiome-Health Axis: A Paradigm Shift in Bioaerosol Thinking. Trends in Microbiology 31:7.

Robinson, J.M, Breed, A.C., Camargo, A., Redvers, N., Breed, M.F. (2024). Biodiversity and Human Health: A Scoping Review and Examples of Underrepresented Linkages. Environmental Research 246:118115.

Rockefeller Foundation. https://www.rockefellerfoundation.org/insights/grantee-impact-story/periodic-table-of-food-lays-the-ground-for-a-healthcare-revolution/ Accessed 1st October, 2024.

Rockefeller Foundation (2024). The Periodic Table of Food Initiative (PTFI). [Online]. Available at: https://www.rockefellerfoundation.org/initiative/periodic-table-of-food/. [Accessed 21st October, 2024].

Rockström, J., Gupta, J., Qin, D., Lade, S.L., Abrams, J.F, Andersen, L.S., Armstrong McKay, D.I., Bai, X., Bala, G., Bunn, S.E., Ciobanu, D., DeClerck, F., Ebi, K., Gifford, L., Gordon, C., Hasan, S., Kanie, N., Lenton, T.M., Loriani, S., Liverman, D.M., Mohamed, A., Nakicenovic, N., Obura, D., Ospina, D., Prodani, K., Rammelt, C., Sakschewski, B., Scholtens, J., Stewart-Koster, B., Tharammal, T., van Vuuren, D., Verburg, P.H., Winkelmann, R., Zimm, C., Bennett, E.M., Bringezu, S., Broadgate, W., Green, P.A., Huang, L., Jacobsnon, L., Ndehedehe, C., Pedde S., Rocha, J., Scheffer M., Schulte-Uebbing, de Vries, W., Xiao, C., Xu, C., Xu, X., Zafra-Calvo, N., Zhang, X. (2023): Safe and Just Earth System Boundaries. Nature 619: 102- 111.

Rojas-Rueda, D., Nieuwenhuijsen, M. J., Gascon, M., Perez-Leon, D., Mudu, P. (2019). Green Spaces and Mortality: A Systematic Review and Meta-Analysis of Cohort Studies. The Lancet Planetary Health, 3(11), e469-e477

Rook, G.A.W, Bloomfield, S.F. (2021). Microbial Exposures the Establish Immunoregulation are Compatible with Targeted Hygiene. The Journal of Allergy and Clinical Immunology 148:1:33-39.

Roslund, M.I, Puhakka, R., Gronroos, M., Murmienen, N., Oikarinen, S., Gazali, A.M, Cinek, O., Kramná, L., Siter, N., Vari, H.K., Soininen, L., Parajuli, A., Rajaniemi, J., Kinnunen, T., Laitinen, O.H, Hyoty, H., Sinkkonen, A., ADELE Research Group, (2020). Biodiversity Intervention Enhances Immune Regulation and Health-Associated Commensal Microbiota among Daycare Children. Science Advances, 6(42).

Ross, I. A. (2007). Medicinal Plants of the World, Volume 3: Chemical Constituents, Traditional and Modern Medicinal Uses (Vol. 3). Springer Science & Business Media.

Ruokolainen L, Lehtimäki J, Karkman A, Haahtela T, von Hertzen L, Fyhrquist N. (2017). Holistic View on Health: Two Protective Layers of Biodiversity. Ann Zool Fenn. 24:39–49

Saenz R, Bissell RA, and Paniagua F (1995) Post-disaster malaria in Costa Rica. Prehospital and Disaster Medicine 10(3): 154–160

Samus, A., Freeman, C., Dickinson, K. J., & Van Heezik, Y. (2022). Relationships between Nature Connectedness, Biodiversity of Private Gardens, and Mental Well-being during the Covid-19 Lockdown. Urban Forestry & Urban Greening, 69, 127519.

Sanchez, C., Lee, T.S., Young, S., Bates, D., Benjamin, J., Malilay, J. (2009). Risk Factors for Mortality during the 2002 Landslides in Chuuk, Federated States of Micronesia. Disasters 33(4): 705-720.

Schippmann, U, Leaman, D., Cunningham, A. (2006). A Comparison of Cultivation and Wild Collection of Medicinal and Aromatic Plants under Sustainability Aspects. In Bogers, R.J., Cracker, L.E., Lange, D (ed). Medicinal and Aromatic Plants. Agricultural, Commercial, Ecological, Legal, Pharmacological and Social Aspects.pp.75-95, Springer, Dordrecht.

Schneiker, J., Weisser, W.W., Settele, J., Bustamante, J.V., Marquez, L., Villareal, S., Arida, G., Chien, H.V., Heong, K.L., Türke, M.. Is There Hope for Sustainable Management of Golden Apple Snails, A Major Invasive Pest in Irrigated Rice? NJAS-Wageningen Journal of Life Sciences 79 : 11-21.

Schuster, R.,German R.R, Bennet, J.R., Reo, N.J., Arcese, P. (2019). Vertebrate Biodiversity on Indigenous-Managed Lands in Australia, Brazil and Canada Equals That in Protected Areas. Environmental Science and Policy 101:1-6.

Searchinger, T., Waite, R., Hanson, C., Ranganathan, J., Dumas, P., Matthews, E., Klirs, C. (2019). Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050. Final Report.

Secretariat of the Convention on Biological Diversity (2011). Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization to the Convention on Biological Diversity. Montreal, Canada.

Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., Turner, B. (2020). Understanding the Value and Limits of Nature-based Solutions to Climate Change and Other Global Challenges. Philosophical Transactions of the Royal Society B, 375(1794), 20190120.

Seddon, N., Sengupta, S., García- Espinosa, M., Hauler, I., Herr, D, Rizvi, A.R. (2019). Nature-based Solutions in Nationally Determined Contributions: Synthesis and Recommendations for Enhancing Climate Ambition and Action by 2020. Gland, Switzerland and Oxford, UK: IUCN and University of Oxford.

Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., House, J. Srivastava, Turner, B. (2021). Getting the Message Right on Nature-based Solutions to Climate Change. Global Change Biology, 27(8), 1518-1546.

Seewoo, B.J., Goodes, L.M., Thomas, K.V., Rauert, C., Elagali, A., Ponsonby, A.L., Symeonides, C., Dunlop, S.A. (2024). How Do Plastics, Including Microplastics and Plastic-Associated Chemicals, Affect Human Health?. Nature Medicine.

Selman, M., Greenhalgh, S. (2009). Eutrophication: Sources and Drivers of Nutrient Pollution. WRI Policy Note. Washington D.C: World Resources Institute.

Sen, T., Samanta, S. K. (2015). Medicinal Plants, Human Health and Biodiversity: A Broad Review. Biotechnological Applications of Biodiversity, 59-110

Shafer, S.L., Bartlein, P.J., Thompson, R.S. (2001). Potential Changes in the Distributions of Western North American Tree and Shrub Taxa under Future Climate Scenarios. Ecosystems 4:200-215.

Shaffer, R.M., Sellers, S.P., Baker, M.G., Kalmen, R., Frostad, J., Suter, M.K., Annenberg, S.C., Balbus, J., Basu, N., Bellinger, D.C., Birnbaum, L., Brauer, M., Cohen, A., Ebi, K.L., Fuller, R., Grandjean, P., Hess, J.J., Kogevinas, M., Kumar, P., Landrigan, P.J., Lanphear, B., London, S.J., Rooney, A.A., Stanaway, J.D., Trasande, L., Walker, K., Hu, H. (2019). Improving and expanding estimates of the global burden of disease due to environmental health risk factors. Environmental Health Perspective 127(10):105001

Shah, H. A., Carrasco, L. R., Hamlet, A., Murray, K. A. (2022). Exploring Agricultural Land-Use and Childhood Malaria Associations in Sub-Saharan Africa. Scientific Reports, 12(1), 4124.

Shanahan, D.F, Bush, R., Gaston, K.J., Lin, B.B., Dean, J. Barber, E., Fuller, R.A. (2016). Health Benefits from Nature Experiences Depend on Dose. Scientific Reports, 6:28551.

Shanley, P., Luz, L. (2003). The Impacts of Forest Degradation on Medicinal Plant Use and Implications for Health Care in Eastern Amazonia. BioScience 53(6): 573-584.

Snoad, C., (2018). Tiger Worm Toilet Manual: Globally Relevant Learnings from Myanmar. Oxfam.

Oxfam Wash. Tiger Worm Toilets. [Online]. Available at: https://www.oxfamwash.org/en/sanitation/tiger-worm-toilets [Accessed 28th September, 2024].

Sobrevila, C. (2008). The Role of Indigenous Peoples in Biodiversity Conservation: The Natural but Often Forgotten Partners. The International Bank for Reconstruction and Development, The World Bank. Washington D.C.

Soman Pillai, V., Krishna, G., Valiya Veettil, M. (2020). Nipah Virus: Past Outbreaks and Future Containment. Viruses, 12(4), 465.

Souter, D., Planes, S., Wicquart, J., Logan, M., Obura, D., Staub, F., (eds.) (2001). Status of Coral Reefs of the World: 2020 Report. Global Coral Reef Monitoring Network (GCRMN) and International Coral Reef Initiative (ICRI).

Stefanakis, A.I., Tsihrintzis, V.A. (2014). Effects of Loading, Resting Period, Temperature, Porous Media, Vegetation and Aeration on Performance of Pilot-Scale Vertical Flow Constructed Wetlands. Chemical Engineering Journal. 181-1812: 416-430.

Stoett, P., Daszak, P., Romanelli, C., Machalaba, C., Behringer, R., Chalk, F., Corsnish, S., Dalby, S., Ferreira de Souza Dias, Iqbal, Z., Koch, T., Krampe, F., Lo, M., Martin, K., Matthews, K., Nickerson, J.W., Orbinski, J., Price-Smith, A., Prieur-Richard, A.H., Raja, A., Seck, D.M., Suazo, A., Swain, Ashok. (2016). Avoiding Catastrophes: Seeking Synergies among The Public Health, Environmental Protection, and Human Security Sectors. The Lancet Global Health, 4(10), e680-e681.

Stoett, P., Scrich, V. M., Elliff, C. I., Andrade, M. M., de M. Grilli, N, Turra, A, (2024). Global Plastic Pollution, Sustainable Development, and Plastic Justice. World Development, Elsevier, vol. 184: 106756.

Strai, T., Flaxman, S., Guthold, R., Semenova, E., Cowan, M., Riley, L., Bull, F.C, Stevens, G.A, Country Data Author Group. National, Regional and Global Trends in Insufficient Physical Activity Among Adults from 2000 to 2022: A Pooled Analysis of 507 Population-Based Surveys with 5-7 Million Participants. The Lancet Global Health 12(8): E1232- E1243.

Swiderska, K. (2017). What is Biocultural Heritage? https://www.researchgate.net/publication/319483204_What_is_biocultural_heritage

Swiss Re (2022). Designing a New Type of Insurance to Protect the Coral Reefs, Economies and the Planet. [Online]. Available at: https://www.swissre.com/our-business/public-sector-solutions/thought-leadership/new-type-of-insurance-to-protect-coral-reefs-economies.html [Accessed 29th September, 2024].

Teich, M., Accastello, C., Perzl, F., Berger, F. (eds.) (2022). Protective Florest as Ecosystem-based Solution for Disaster Risk Reduction (Eco-DRR). IntechOpen.

Tigchelaar, M., Leape, J., Micheli, F., Allison, E.H., Basurto, X., Bennett, A., Bush, S.R., Cao, L., Cheung, W.W.L, Crona, B., DeClerck, D., Fanzo J., Gelcich, S., Gephart, J.A, Golden, C.D., Halpern, B.S, Hicks, C.C., Jonell, M., Kishore, A., Koehn, J.Z., Littel, D.C., Naylor, R.L., Phillips, M.J., Selig, E.R., Short, R.E., Rashid Sumaila, U., Thilsted, S.H., Troell, M., Wabnitz, C.C.C.(2022). The Vital Roles of Blue Foods in the Global Food System. Global Food Security 33:100637.

Today (2024). Does Planting Trees Help Improve the Health of Communities? [Online]. Today.com. Available at:

https://www.today.com/video/does-planting-trees-help-improve-the-health-of-communities-218060357885. Accessed 28th September, 2024.

Tomlinson, T. R., Akerele, O. (Eds.). (2015). Medicinal Plants: Their Role in Health and Biodiversity. University of Pennsylvania Press.

Tóth, G., Montanarella, L., & Rusco, E. (2013). Threats to Soil Quality in Europe. Publications Office of the European Union.

Twohigh-Bennet, C., Jones, A. (2018). The Health Benefits of the Great Outdoors: A Systematic Review and Meta-Analysis of Greenspace Exposure and Health Outcomes. Environmental Research 166:628-637.

United Arab Emirates. (2023). UAE Climate and Health Declaration. Adopted at the Twenty-Eighth Conference of the Parties (COP28) to the United Nations Framework Convention on Climate Change (UNFCCC), Dubai, United Arab Emirates.

United Nations (2022). FAO Warns 90 Percent of Earth's Topsoil at Risk by 2050 https://news.un.org/en/story/2022/07/1123462 Accessed 26th September, 2024.

United Nations Convention to Combat Desertification (2022). Global Land Outlook: Second Edition. Land Restoration for Recovery and Resilience.

United Nations Declaration on the Rights of Indigenous Peoples (2007). https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html

United Nations Department of Economic and Social Affairs Indigenous Peoples. https://www.un.org/development/desa/indigenouspeoples/mandated-areas1/health.html Accessed 29th September, 2024.

United Nations Disaster Risk Reduction. (2019) Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: United Nations Office for Disaster Risk Reduction (UNDRR).

United Nations Environment Assembly (2002). UNEP/EA.5/Res.6, 2022 [Online]. Available at: https://www.unep.org/resources/resolutions-treaties-and-decisions/UN-Environment-Assembly-5-2

United Nations Environment Programme (2018). Single-Use Plastics: A Roadmap for Sustainability.

United Nations Environment Programmes (2019). Global Environmental Outlook- GEO-6: Health Planet, Health People. Nairobi.

United Nations Environment Programme. (2019). Nature-based Solutions for Climate Manifesto. https://wedocs.unep.org/bitstream/handle/20.500.11822/29705/190825NBSManifesto.pdf?sequence=1

United Nations Environment Programme (2021): Making Peace with Nature: A Scientific Blueprint to Tackle the Climate, Biodiversity, and Pollution Emergencies. Nairobi United Nations Environment Programme.

United Nations Environment Programme (2021). State of Finance for Nature 2021. Nairobi.

United Nations Environment Programme (2022). CoP15 Ends with Landmark Biodiversity Agreement. https://www.unep.org/news-and-stories/story/cop15-ends-landmark-biodiversity-agreement Accessed 29/09/24.

United Nations General Assembly (2022). Resolution Adopted by The General Assembly on 28 July 2022: The Human Right to a Clean, Healthy and Sustainable Environment. A/RES/76/300.

United Nations Human Settlements Programme (2022). World Cities Report 22. Nairobi.

United Nations Human Settlements Programme, World Health Organization (2020). Integrating Health in Urban and Territorial Planning: A Sourcebook. Geneva.

United Nations Special Rapporteur on Human Rights and the Environment. (2019). Issue of Human Rights Obligations Relating to The Enjoyment of A Safe, Clean, Healthy and Sustainable Environment (A/HRC/40/55)

United Nations Special Rapporteur on Human Rights and the Environment. (2022). The Right to a Clean, Healthy and Sustainable Environment: Non-Toxic Environment (A/ HRC/49/53)

United States Agency for International Development . Predict Liberia: One Health in Action (2016-2020). Available at: USAID, Predict Liberia: One Health in Action Accessed 28th September, 2024.

Van den Bosch, M., Sang, Å. O. (2017). Urban Natural Environments As Nature-based Solutions for Improved Public Health–A Systematic Review of Reviews. Environmental Research, 158: 373-384.

Van Raalte, D., Ranger, N. (2023). Financing Nature-Based Solutions for Adaptation at Scale: Learning from Specialized Investment managers and Nature Funds. Global Center on Adaptation and Environmental Change Institute, University of Oxford.

Vanclay F. 2017. Principles to Gain a Social License to Operate for Green Initiatives and Biodiversity Projects. Current Opinion in Environmental Sustainability, 29: 48–56.

Vancouver Sun (2022). Canadian Medical Association Endorses B.C. Parks Foundation Plan to Precribe Nature. [Online] Available at: https://vancouversun.com/news/local-news/cma-endorses-nature-prescription [Accessed 13th October, 2024].

VicHealth. [Online]. Available at: https://www.vichealth.vic.gov.au/ [Accessed 28th September, 2024].

Von Hertzen, L., Hanski, I., Haahtela, T. (2011). Natural Immunity. Biodiversity Loss and Inflammatory Diseases are Two Global Megatrends that Might be Related. EMBO Reports, 12 (11): 1089-1093.

Vora, N. M., Hannah, L., Walzer, C., Vale, M. M., Lieberman, S., Emerson, A....Epstein, J. H. (2023). Interventions to Reduce Risk for Pathogen Spillover and Early Disease Spread to Prevent Outbreaks, Epidemics, and Pandemics. Emerging Infectious Diseases, 29(3), 1-9.

Walker W, Baccini A, Schwartzman S, Ríos S, Oliveira-Miranda MA, Augusto C, et al. 2014. Forest carbon in Amazonia: the unrecognized contribution of indigenous territories and protected natural areas. Carbon Management, 5(5–6): 479–485.

Ward, M., Saura, S., Williams, B., Ramírez-Delgado, J. P., Arafeh-Dalmau, N., Allan, J. R., Venter, O., Dubois, G. & Watson, J. E. M. (2020). Just ten percent of the global terrestrial protected area network is structurally connected via intact land. Nature Communications, 11(1), 4563.

Watako, D., Mougabe, K., Heath, T. (2016). Tiger Worm Toilets: Lessons Learned from Constructing Household Vermicomposting Toilets in Liberia. Waterlines, 35(2): 136-147.

Watershed Agricultural Council. [Online]. Available at: https://www.nycwatershed.org/. [Accessed 3rd October, 2024].

Watts, N.; Amann, M.; Ayeb-Karlsson, S.; Belesova, K.; Bouley, T.; Boykoff, M.; Byass, P.; Cai, W.; Campbell-Lendrum, D.; Chambers, J.; et al. (2017). The Lancet Countdown on Health and Climate Change: From 25 Years of Inaction to a Global Transformation for Public Health. Lancet 391:581-630.

Whitburn, J., Linklater, W., Abrahamse, W. (2019). Meta-Analysis of Human Connection to Nature and Proenvironmnetal Behavior. Conservation Biology 34(1):180-193.

White, A., Molnar, A., Kahre, A. (2004). Who Owns, Who Conserves and Why it Matters. Forest Trends, Washington D.C.

Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., de Souza Dias, B. F., Ezeh, A., Frumkin, H., Gong, P., Head, P., Horton, R., Mace, G.M., Marten, R., Myers, S.S., Nishtar, S., Osofsky, S.A., Pattanayak, S.K., Ponsiri, M.J., Romanelli, C., Soucat, A., Vega, J., Yach, D. (2015). Safeguarding Human Health in the Anthropocene Epoch: Report of The Rockefeller Foundation–Lancet Commission on Planetary Health. The Lancet, 386(10007), 1973-2028.

Whitmee, S., Green, R., Belesova, K., Hassan, S., Cuevas, S., Murage, P., Picetti, R., Clerq-Roques, R., Murray, K., Falconer, J., Anton, B., Reynolds, T., Waddington, H.S., Hughes, R.C., Spadaro, J., Aguilar Jaber, A., Saheb, Y., Campbell-Lendrum, D., Cortés-Puch, M., Ebi, K., Huxley, R., Mazzucato, M., Oni, T., de Paula, N., Peng, G., Revi, A., Rockström, J., Srivastava, L., Whitmarsh, L., Zougmoré, R., Phumaphi, J., Clar, H., Haines, A. (2024). Pathways to a Healthy Net-Zero Future: Report of the Lancet Pathfinder Commission. The Lancet, 403(10421), 67-110.

Williams, V.L. (1996). The Witwaterrand Muti Trade. Veld and Flora 82:12-14.

William, D.W., Liebhold, A.M (2002). Climate Change and the Outbreak Ranges of Two North American Bark Beetles. Agricultural and Forest Entomology 4:87-99.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L.J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J.A, de Vries, W., Sibanda, L.M., Afshin, A., Chaudhary, A., Herrero, M., Agustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M. Lindahl, T., Singh, S., Cornell, S.E., Reddy, K.S., Narain, S., Nishtar, S., Murray, C.J.L. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet, 393(10170), 447-492.

Wolch, J. R., Byrne, J., Newell, J. P. (2014). Urban Green Space, Public Health, and Environmental Justice: The Challenge of Making Cities 'Just Green Enough'. Landscape and Urban Planning, 125, 234-244.

World Bank Group Data. India https://data.worldbank.org/country/india Accessed 1st October, 2024.

World Economic Forum (2020). New Nature Economy Report II: The Future of Nature and Business. In Collaboration with AlphaBeta. Geneva.

World Economic Forum (2021). Mexico's Mesoamerican Barrier Reef Is Now Being Protected with insurance- Here's How. [Online]. Available at: https://www.weforum.org/agenda/2021/09/mesoamerican-coral-reef-mexico-using-insurance-to-protect-ecosystem/ [Accessed 29th September, 2024].

World Health Assembly. (2024). Resolution WHA77.14: Climate change and health. Seventy-seventh World Health Assembly, Geneva, 2024. Available at https://apps.who.int/gb/ebwha/pdf_files/WHA77/A77_R14-en.pdf.

World Health Organization. Landslides. [Online]. Available at: https://www.who.int/health-topics/landslides/#tab=tab_1 [Accessed 29th September, 2024].

World Health Organization. Gender and Health.[Online]. Available at: https://www.who.int/health-topics/gender#tab=tab_1 [Accessed 29th September, 2024].

World Health Organization. Water: Factsheet. [Online] Available from https://www.afro.who.int/health-topics/water [Accessed 4th October, 2024].

World Health Organization (2002). WHO Traditional Medicine Strategy 2002- 2005. Geneva.

World Health Organization (2006). Air Quality Guidelines: Global Update 2005. Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide. Copenhagen.

World Health Organization (2006). Constitution of the World Health Organization. Basic Documents, 45th edition, Supplement, October 2006. Geneva: World Health Organization.

World Health Organization (2013). WHO Traditional Medicine Strategy 2014-2023. Hong Kong.

World Health Organization (2016): Preventing Disease through Healthy Environments: A Global Assessment of the Burden of Disease from Environmental Risks. World Health Organization.

World Health Organization (2018). Global Action Plan on Physical Activity 2018-2030: More Active People for A Healthier World. https://iris.who.int/bitstream/handle/10665/272721/WHO-NMH-PND-18.5-eng.pdf?sequence=1 Accessed 29th September, 2024.

World Health Organization (2018a). Burden of Disease from Ambient Air Pollution for 2016, versions 2. Geneva.

World Health Organization (2018b). Global Status Report on Road Safety 2018. Geneva.

World Health Organization (2019): Air Pollution fact sheet. Link.

World Health Organization (2019a). WHO Global Water, Sanitation and Hygiene Annual Report 2018. Geneva.

World Health Organization (2019b). Safe Water, Better Health 2091 Update. World Health Organization, Geneva

World Health Organization (2019c). Microplastics in Drinking Water. World Health Organization. Geneva: World Health Organization.

World Health Organization (2020). Guidance on Mainstreaming Biodiversity for Nutrition and Health. Geneva. Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome.

World Health Organization (2021). Green and Blue Spaces and Mental Health: New Evidence and Perspectives for Action. Copenhagen: WHO Regional Office for Europe.

World Health Organization (2021): WHO Global Air Quality Guidelines. Particulate Matter (PM2.5. and PM10), Ozone, Nitrogen Oxide, Sulfur Dioxide and Carbon Monoxide. Geneva: World Health Organization.

World Health Organization. (2021). Nature, Biodiversity and Health: An Overview of Interconnections. World Health Organization. Copenhagen: WHO Regional Office for Europe.

World Health Organization (2022). Global Status Report on Physical Activity 2022. Geneva.

World Health Organization (2022). Sanitation and Health: Key Facts. World Health Organization. Link.

World Health Organization. (2023). World Malaria Report 2023. Geneva: World Health Organization.

World Health Organization (2023). Household Air Pollution. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health Accessed 29th September, 2024.

World Health Organization (2023). Road Traffic Injuries. https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries Accessed 29th September, 2024.

World Health Organization (2023). To Meet the Unmet: Preparing for Health Equity Challenges in WHO South-East Asia Region. New Delhi.

World Health Organization (2024). Ambient (Outdoor) Air Pollution. [Online]. Available at: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health [Accessed 29th September, 2024].

World Health Organization (2024). Sanitation https://www.who.int/news-room/fact-sheets/detail/sanitation Accessed 29th September, 2024.

World Health Organization, International Union for Conservation of Nature (2023): Highlights Brief on WHO-IUCN Report on Designing Nature-Based Solutions for Human Health. World Health Organization (WHO) and International Union for Conservation of Nature (IUCN). Link.

World Health Organization, Secretariat of the Convention on Biological Diversity (2015). Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review.

World Health Organization, United Nations Children's Fund. (2021) Progress on Household Drinking Water, Sanitation and Hygiene 2000-2020: Five Years into the SDGs. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF).

World Resource Institute in collaboration with the United Nations Development Programme, United Nations Environment Programme, and World Bank (2005). Securing Property and Resource Rights through Tenure Reform. In World Resources Report 2005: The Wealth of the Poor- Managing Ecosystems to Fight Poverty. Washington D.C.: WRI.

World Wildlife Fund (2022). Living Planet Report 2022- Building a Nature-Positive Society. Almond, R.E.A., Grooten, M., Juffe Bignoli, D. & Petersen, T. (Eds). WWF, Gland, Switzerland.

World Wildlife Fund (2023). Food Systems Transformation: Ensuring Regenerative and Resilient Production and Consumption. World Wildlife Fund.

Woroniecki, S., Wendo, H., Brink, E., Islar, M, Krause, T., Vargas, A.M., Mahmoud, Y. (2020). Nature Unsettled: How Knowledge and Power Shape "Nature-based" Approaches to Societal Challenges.

Wright, P.A., Matthews, C. (2015). Building a Culture of Conservation: Research Findings and Research Priorities on Connecting People to Nature in Parks. PARKS. 21(2):11-24.

Wright, S., Lekwa,H., Uchendu, J., Chigozie, S., Olude, A., Ogbodum, M. Youth Research and Action Agenda: Vulnerability and Resilience in the Generation Inheriting the Climate Crisis. (Connecting Climate Minds, 2024); https://nbswmzwquzluimyqnfsf.supabase.co/storage/v1/object/public/documents/Full%20TRAA%20youth%2018-03.pdf?t=2024-03-19T11%3A08%3A20.042Z

Zaccari, C., De Vivo, R., Pawera, L., Termote, C., Hunter, D., Borelli, T., Kettle, C.J., Maas, B., Novotny, I., Cherico Wanger, T., Dullo, M.E., Fadda, C., Gee, E. (2023). Lessons Learned from the Second International

Agrobiodiversity Congress: Adopting Agricultural Biodiversity As A Catalyst for Transformative Global Food Systems. Current Opinion in Environmental Science & Health, 31, 100411.

Appendix 1

This appendix outlines the IUCN Global Standard for NbS, detailing its key criteria and practical applications to ensure effective and sustainable implementation of NbS projects.

The IUCN Global Standard for Nature-based Solutions: Ensuring Effective and Sustainable Implementation

NbS offer a powerful tool to address critical societal challenges, such as climate change, biodiversity loss, and food security. However, the increasing demand for NbS has sometimes led to their misuse or misapplication. Even well-intentioned projects may cause unintended harm if not designed with care, potentially damaging ecosystems and undermining long-term sustainability.

For instance, a tree-planting initiative that uses only a single non-native species may disrupt soil biodiversity, making it harder to maintain a healthy, diverse forest in the future. Similarly, restoring a mangrove forest to reduce the risk of storm damage could be doomed from the start if upstream and downstream processes are not considered. Poor planning can also lead to social and economic consequences, such as over-extraction of water, placing undue pressure on local communities. Moreover, poorly designed or mislabelled NbS efforts can weaken confidence in the approach, diminishing donor support and misdirecting valuable resources.

To address these challenges, funders, investors, and decision-makers need a reliable framework to ensure the effectiveness, scalability, and sustainability of NbS projects. Recognizing this need, IUCN developed the first-ever Global Standard for Nature-based Solutions in 2020. This standard was created through an extensive public consultation involving stakeholders from over 100 countries, ensuring it reflects global perspectives and needs.

The IUCN Global Standard for NbS[436] is a self-assessment tool comprising eight criteria and associated indicators, which cover the core aspects of sustainable development: biodiversity, social and economic factors, and resilient project management. These criteria provide users with a clear pathway to design, evaluate, and scale NbS initiatives while addressing potential risks.

The standard is accompanied by detailed guidance that helps users apply it in three key ways:

1. **Designing new NbS projects** to ensure they achieve sustainability goals from the beginning.
2. **Scaling up pilot projects** by identifying gaps and areas for improvement.
3. **Verifying past projects and future proposals** against established best practices.

[436] Can be found at https://iucn.org/our-work/topic/iucn-global-standard-nature-based-solutions

The assessment generates a percentage match against good practices, using a traffic light system to identify areas that require additional work. This process ensures alignment with the IUCN Global Standard for NbS, thereby enhancing both accountability and performance.

The standard is designed for a diverse array of stakeholders, including governments, companies, NGOs, and funders. It fosters a shared language and approach, facilitating partnerships and promoting the ambitious scale and sustainability needed to tackle global challenges. By adopting the standard, donors and investors can minimize risk, boost confidence, and ensure their resources are directed toward effective, high-impact NbS projects.

Ultimately, the IUCN Global Standard for NbS provides essential guidance for developing solutions that harmonize with nature while delivering lasting social and economic benefits. By establishing clear parameters and fostering a common framework, the standard helps prevent unintended negative outcomes and promotes the widespread adoption of NbS, ensuring they fulfill their promise for people and the planet.

Appendix II

This appendix demonstrates how the IUCN Global Standard for NbS can be applied.

The Living Lab at Sesvete NbS for post-industrial urban regeneration, Zagreb (Croatia).

Zagreb, Croatia's capital, is rich in natural features, located along the Sava River and below Medvednica Mountain. The Living Lab in Sesvete, part of the EU's Horizon 2020 proGIreg – Productive Green Infrastructure for Post-industrial Urban Regeneration project, focuses on regenerating post-industrial areas using NbS. Sesvete, an industrial district with 70,000 residents, hosts multiple NbS projects aimed at restoring green spaces and fostering community engagement.

Key initiatives include developing community urban gardens on 10,250 m^2, to promote mental and physical health through exposure to nature and healthy sources of food, introducing aquaponics systems on 100 m^2 for local food production for healthier diets, and implementing 700 m^2 green roofs and walls on 4 historic buildings, and creation of 850 m green corridors to enhance biodiversity, reduce pollution, and increase urban resilience. The project will revitalize the former Sljeme meat-processing factory, transforming it into a business innovation centre with extensive green infrastructure.

Criterion	Your Criterion Score	Maximum Criterion Score	Normalized criterion	FINAL OUTPUT Your Criterion %
1. Societal challenges	9	9	1.00	100%
2. Design at scale	7	9	0.78	78%

3. Biodiversity net-gain	10	12	0.83	83%
4. Economic feasibility	10	12	0.83	83%
5. Inclusive governance	13	15	0.87	87%
6. Balance trade-offs	4	9	0.44	44%
7. Adaptive management	8	9	0.89	89%
8. Sustainability and mainstreaming	7	9	0.78	78%
Total Percentage match				80%
Is this in adherence with the IUCN Global Standard for NbS?			In adherence	

Legend

Key		Output
	Strong	Intervention adheres to the IUCN Global Standard for NbS.
	Adequate	
	Partial	
	Insufficient	Intervention does not adhere to the IUCN Global Standard for NbS.

This summarizes the insights from the NbS self-assessment overview report of "the Living Lab at Sesvete NbS for post-industrial urban regeneration project". For more details, please refer to the IUCN report titled "Planning and Delivering NbS in Mediterranean Cities" which evaluated 18 projects against the IUCN Global Standard for NbS.

Links between the Living Lab at Sesvete and WHO-IUCN Recommendations

The proGIreg project is primarily focused on enhancing human health and well-being through NbS actions. It illustrates how NbS can simultaneously benefit environmental preservation and improve public health. The project addresses all 10 recommendations from WHO-IUCN report in the following ways:

Recommendation I: Biodiversity, healthy ecosystems, and a stable climate are essential to achieving good health outcomes. The project *Societal challenges such as Climate change, Food security, Water security, Human health, and Economic and social development through NbS interventions.*

Recommendation II: Educate and empower health professionals to engage in NbS. *Users and educators from two mental health centres are designing butterfly gardens to promote pollinator biodiversity, establishing a network of health professionals who advocate for the mental health benefits from biodiversity.*

Recommendation III: Redesign food systems to be nature-positive, resilient and to sustain healthy communities. *The project transforms unused urban land into productive community gardens that enhance healthy*

and organic food production. Additionally, it uses aquaponics systems to foster local food production, especially in areas with poor soil quality.

Recommendation IV: Use nature-based solutions to support access to safe water, sanitation, hygiene, and waste management. *The Sesvete project serves as a living laboratory for innovative solutions to urban challenges, integrating waste management centres and water purifiers to model sustainable practices for Zagreb and Croatia.*

Recommendation V: Integrate urban ecosystems with public health planning. *The project's initiatives primarily focus on enhancing urban ecosystems through urban gardens and green infrastructures, improving community mental and physical health by increased access to nature and healthy food.*

Recommendation VI: Redesign energy and transport systems to integrate green-gray infrastructure to support health. *The project includes green roofs, vertical gardens, and green corridors that enhance building insulation, reduce stormwater runoff, capture CO2, filter pollutants, and promote sustainable transport, ultimately improving community health.*

Recommendation VII: Place equity at the centre of the design, governance, and implementation of nature-based solutions for health. *Monitoring and evaluating proGIreg's environmental and social benefits will inform local urban planning, ensuring that health and equity remain priorities in local policy development.*

Recommendation VIII: Empower Indigenous Peoples and under-resourced communities to safeguard human health and well-being. *The project co-design process actively engages local communities and stakeholders, fostering diversity and transparency. This approach empowers under-resourced groups, including women and marginalized individuals, to shape NbS that address their needs and prioritize their well-being. Additionally, the project includes a therapeutic garden specifically designed for people with disabilities.*

Recommendation IX: Support/enable youth leadership and innovation in nature and health decision-making. *The project is implemented in Sesvete, the district with the youngest population in Croatia. It engages youth as key beneficiaries by creating green jobs and establishing a city garden and nursery as educational centres for local schools, focusing on food security, human health, and NbS.*

Recommendation X: Finance inclusive nature-based solutions that prioritize health outcomes. *Local environmental compensation processes in Zagreb aim to build a strong evidence base for NbS, unlocking funds through adaptation funding, taxes, and public-private partnerships, to direct resources toward health-promoting initiatives.*

(Back cover)

Supported by:

Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection

based on a decision of
the German Bundestag

IKI INTERNATIONAL CLIMATE INITIATIVE

FEBA
Friends of Ecosystem-based Adaptation