PAS SCRIPTA VARIA 157 • PASS STUDIA SELECTA 13

THE PONTIFICAL ACADEMY OF SCIENCES

THE PONTIFICAL ACADEMY OF SOCIAL SCIENCES

Edited by

Joachim von Braun
Helen Alford

Indigenous Peoples' Knowledge and the Sciences: Combining Knowledge and Science on Vulnerabilities and Solutions for Resilience

Proceedings of a Joint Workshop
Casina Pio IV, Vatican City, 14-15 March 2024

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Combining Knowledge and Science on Vulnerabilities and Solutions for Resilience

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Pontificiae Academiae Scientiarvm Scripta Varia 157
Pontificiae Academiae Scientiarvm Socialivm Studia Selecta 13

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ISBN: 978-88-266-1014-6

I give thanks for this visit, ... an opportunity to recognize the fundamental role Indigenous Peoples hold in the protection of the environment, and to highlight their wisdom in finding global solutions to the immense challenges that climate change poses to humanity every day. ... We should listen to Indigenous Peoples more and learn from their way of life, so as to understand properly that we cannot continue to greedily devour natural resources... The contribution of Indigenous Peoples is fundamental in the fight against climate change. And this has been scientifically proven... Therefore, I ask governments to recognize the Indigenous Peoples of the whole world, with their cultures, languages, traditions and spirituality, and to respect their dignity and their rights, in the knowledge that the richness of our great human family consists precisely in its diversity.

Address of His Holiness Pope Francis
To participants in the Indigenous People's Forum
Consistory Hall, Friday, 10 February 2023


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Introduction: Indigenous Peoples' Knowledge and the Sciences – Combining Knowledge and Science

Joachim von Braun
President of The Pontifical Academy of Sciences

Helen Alford
President of The Pontifical Academy of Social Sciences

Recognizing and respecting Indigenous Peoples' knowledge

Indigenous Peoples worldwide have a dual relationship with climate change. On the one hand, Indigenous Peoples represent a clear case of climate injustice, as they have contributed the least and are suffering the most from climate-related extreme events and ecosystem degradation. These changes have profound consequences on their livelihoods and wellbeing and their voices are often not heard at local or national levels. These peoples have very low historic and present-day greenhouse gas emissions, while they are usually less supported by public policies and programs than other segments of societies.

On the other hand, Indigenous Peoples can play an important role to meet the challenges of climate change and biodiversity loss, and offer opportunities for health-related knowledge. They have rich and often neglected traditional knowledge systems, especially on ecology, management and restoration of natural ecosystems and response to climate change. There is an opportunity for an ideological bridge between their knowledge systems and science to develop new and innovative solutions for mitigation and resilience to climate change, as well as conservation of biodiversity.

Indigenous Peoples often are at the bottom of the poverty pyramid and suffer from racism and other forms of discrimination. There is a need to increase the respect for the rights of Indigenous Peoples, especially in the face of the advance of deforestation and illegal logging and mining, among other economic activities worldwide.

Finding opportunities among indigenous knowledge and the science

Indigenous Peoples inhabit diverse ecosystems around the globe, most of which less degraded than those occupied by other populations. Indigenous Peoples are often caretakers of key natural ecosystems and have an important role in bending the nature degradation curve, with positive impacts for mitigation, adaptation and biodiversity challenges. Indigenous peoples can play a fundamental role in protecting natural ecosystems against degradation and in restoring ecosystems for multiple outcomes, including climate, biodiversity and water resources.

Nature-based solutions (NBS) are increasingly considered as having lower costs and delivering more co-benefits than other alternatives. Nature-based solutions now play an important role in the agenda of UNFCCC, but the concept has not yet been adequately incorporated in the CBD process. Combining indigenous knowledge and NBS can lead to innovative solutions that address social and environmental challenges, including climate change impact and biodiversity loss, while respecting cultural values and promoting social equity. This Joint PAS and PASS Workshop explored NBS and many effective medical and food systems innovations, and related indigenous knowledge.

The role of Indigenous Peoples in the climate agenda is being increasingly recognized in the UNFCCC processes. The Climate COP 26 final statement on Indigenous Peoples recognized the critical role of indigenous knowledge, innovations, and practices in protecting and conserving biodiversity and ecosystems. The statement emphasized the importance of promoting the full and effective participation of Indigenous Peoples in decision-making processes, especially those that affect their lands, territories, and resources. Additionally, the Indigenous Peoples' Climate Finance Facility was launched to provide financial resources and technical support to Indigenous Peoples' initiatives and projects. More recently, the global indigenous communities under the leadership of the International Indigenous Peoples Forum on Climate Change (IIPFCC) had a strong presence in COP 27 in Egypt, and in COP 28 in Dubai.

The role of Indigenous Peoples in the biodiversity agenda is being increasingly recognized in the CBD process. Recently, in COP 15 in Montreal and COP 16 in Cali, Indigenous Peoples were given special recognition. The final text, known as the Kunming-Montreal agreement, officially recognizes Indigenous Peoples' work, knowledge, innovations and practices as the most effective tool for biodiversity protection.

Toward building unusual knowledge and science platforms

Indigenous knowledge communities and advanced science communities are lacking platforms to exchange views and work jointly to develop innovative nature-based solutions for climate change impact and resilience. Overcoming that may contribute to advancements in sustainability, justice and equity. Indigenous knowledge communities, PAS and PASS Academicians and others are called upon here, to explore opportunities for cooperation.

The conference on which this volume is based provided an opportunity to build bridges between the views and knowledge systems of Indigenous Peoples and science, to explore new opportunities for solutions to the global challenges of resilience to climate change and biodiversity loss. The conference created opportunities for dialogue among Indigenous Peoples and science community on how ethnoecological knowledge can play an important role in developing local solutions that can have global consequences for climate and biodiversity agendas.

The concluding statement of the Academies with the workshop participants, and the important messages from Pope Francis to the participants, highlight opportunities for further consultations and for cooperation and "braiding" indigenous knowledge and science.

Acknowledgements

We are grateful to all the participants for sharing their insights, knowledge, and science-based papers, and for their willingness to engage in meaningful dialogue across established boundaries of thought. We thank Academicians Mohamed Hassan (PAS) and Virgilio Viana (PASS), as well as Nigel Crawhall, for their invaluable support in developing the program.

We are deeply appreciative of the generous support provided by the Sloan Foundation and the Rockefeller Foundation. Their contributions, along with the resources of the Pontifical Academies, made it possible for many speakers from Indigenous Peoples to participate.

Address of His Holiness Pope Francis to the Participants in the Workshop on "Indigenous Peoples' Knowledge and the Sciences: Combining Knowledge and Science on Vulnerabilities and Solutions for Resilience"

14 March 2024 | Clementine Hall

Dear friends!

I offer you a warm welcome on the occasion of this Workshop on *Indigenous Peoples' Knowledge and the Sciences*, which aims to join these two forms of knowledge for the sake of a more comprehensive, rich and humane approach to a number of urgent critical issues, including climate change, the loss of biodiversity, and threats to food and health security.

I thank the Chancellor, Cardinal Turkson, and the Presidents of the Pontifical Academies of Sciences and of Social Sciences for having sponsored this initiative: it makes a significant contribution to acknowledging the great value of the wisdom of native peoples and to advancing an integral and sustainable human development.

I would note that three years ago the Food and Agriculture Organization of the United Nations (FAO) held study days on indigenous food systems. This gave rise to a platform that has brought together indigenous and non-indigenous scientists, students and experts in order to pursue a dialogue aimed at ensuring the protection of indigenous peoples' food systems. In line with that experience, I appreciate your own initiative, which contributes to this effort.

I would say before all else that your Workshop represents an opportunity to *grow in reciprocal listening*: listening to indigenous peoples, in order to learn from their wisdom and from their lifestyles, and at the same time listening to scientists, in order to benefit from their research.

This study seminar also sends a message *to government leaders and to international organizations*, encouraging them to acknowledge and respect the rich diversity within the great human family. The fabric of humanity is woven with a variety of cultures, traditions, spiritualities and languages that must be protected, since their loss would represent an impoverishment of knowledge, identity and memory for all of us. For this reason, projects of scientific research, and accordingly investments, ought to be directed decisively to the promotion of *human fraternity*, justice and peace, so that resources can be coordinated and allocated to respond to the urgent challenges facing the earth, our common home, and the family of peoples.

We have come to understand that, in order to realize this goal, a conversion is required, an *alternative vision* to the one that is presently driving our world to increased conflict. Meetings like your own are important in this regard: indeed, open dialogue between indigenous knowledge and the sciences, between communities of ancestral wisdom and those of the sciences, can help to confront in a new, more integral and more effective way such crucial issues as water, climate change, hunger and biodiversity. These issues, as we know very well, are all interconnected.

Thanks be to God, there is no lack of positive signs in this regard, such as the United Nations' inclusion of indigenous knowledge as a core component of the International Decade of Sciences for Sustainable Development. This is a sign that should be encouraged and supported by joining forces. In the dialogue between indigenous knowledge and science, we need to keep clearly in mind that this entire patrimony of knowledge should be employed as a means of overcoming conflicts in a nonviolent manner and combating poverty and the new forms of slavery. God, the Creator and Father of all peoples and of everything that exists, calls us today to live out and bear witness to our human call to universal fraternity, freedom, justice, dialogue, reciprocal encounter, love and peace, and to avoid fueling hatred, resentment, division, violence and war.

God has made us stewards, not masters of the planet: all of us are called to an ecological conversion (cf. *Laudato Si'*, 216-221), a commitment to saving our common home and to fostering intergenerational solidarity in order to preserve the life of future generations, rather than wasting resources and aggravating inequality, exploitation and destruction.

Dear representatives of indigenous communities and dear men and women of science, I thank you for your efforts and I encourage you to draw from the patrimony of the wisdom of your forebears and from the fruits of your scientific research the vital energy needed to continue to cooperate in the service of truth, freedom, dialogue, justice and peace. The Church is with you, an ally of the indigenous peoples and their wisdom, and an ally of science in striving to make our world one of ever greater fraternity and social friendship.

I accompany you with my prayers and, in respect for the convictions of each, I invoke upon you God's blessing. I ask you, in your own way, also to pray for me. Thank you.

Final Statement of the Workshop on Indigenous Peoples' Knowledge and the Sciences: Combining Traditional Knowledge and Sciences for Resilience to Address Climate Change, Biodiversity Loss, Food Security, Health[1]

Also available in Spanish at https://www.pas.va/en/events/2024/indigenous_peoples/final_statement/final_statement_es.html

Sixty-three participants from thirty-three countries, including many Indigenous Peoples' socio-cultural regions of the world, converged in a momentous dialogue on the intersection of traditional knowledge systems and science, addressing critical challenges faced by our planet and humanity. This significant event was jointly organized by the Pontifical Academy of Sciences (PAS) and the Pontifical Academy of Social Sciences (PASS). It brought together Indigenous leaders, scholars, knowledge holders, and a diverse array of scientists, alongside representatives from United Nations agencies. The following Statement provides a summary of key insights and recommendations.

Conference Purpose

The Pontifical Academy of Sciences (PAS) and the Pontifical Academy of Social Sciences (PASS) champion an interdisciplinary approach to scientific knowledge, fostering international collaboration. Their mission is to promote the study and progress of both the social and natural sciences,

[1] This Statement is based on presentations and discussions during the workshop. A draft set of conclusions was presented by the Presidents of PAS & PASS at the end of the workshop and discussed with and augmented by workshop participants. The Presidents of PAS & PASS have made efforts to integrate comments made. In view of the many and diverse suggestions received, this may not reflect the opinions of all. The full information, concerns, and action proposals are in the more than 40 presentations given at the workshop. While the workshop participants are listed below the Statement issued by the Presidents and the Chancellor of PAS & PASS, this does not imply their individual endorsement of it or the endorsement of their organizations.

with a focus on the promotion of justice, development, solidarity, peace, and conflict resolution. PAS and PASS serve as bridges between faith and reason, encouraging dialogue that transcends scientific, spiritual, cultural, philosophical and religious boundaries. This conference called upon Indigenous Peoples and Scientists in the social and natural sciences to hold an open dialogue, based on mutual respect, and shared concerns for human and planetary health.

The urgency of our gathering stems from the alarming decline in planetary health, manifested by climate change and biodiversity loss. It also served as a platform for meaningful dialogue on the pivotal role of knowledge in crafting locally relevant solutions with the potential for global impact. By integrating the insights and knowledge systems of Indigenous Peoples[2][1] and science communities we explored new opportunities for solutions to the global challenges of resilience to climate change, biodiversity loss, and food systems problems.

The intersection of Indigenous Peoples' knowledge and scientific communities' analytical insights remains an untapped resource. Insufficient opportunities for exchange and collaborative platforms hinder joint efforts to develop innovative solutions. However, growing these opportunities and platforms can lead to significant advancements in sustainability, justice and equity.

Pope Francis captured the essence of our mission in his address at the workshop's outset, "...your Workshop represents an opportunity to grow in reciprocal listening: listening to indigenous peoples, in order to learn

[2] The 2007 United Nations Declaration on the Rights of Indigenous Peoples refers to both indigenous knowledge and traditional knowledge. While Indigenous and local knowledge are older concepts than traditional knowledge, the latter has gained more visibility in the literature. We acknowledge that there are as many Indigenous knowledges as there are Indigenous nations in the world. 'Indigenous' is not used here as an adjective but to refer to the knowledge holders and their diversity. We recognize that Indigenous Peoples self-identify and associate with the UN Declaration on the Rights of Indigenous Peoples, while many communities are the holders of sophisticated orally-transmitted knowledge systems. Defined by IPBES, "Indigenous and local knowledge (ILK) refers to dynamic bodies of integrated, holistic, social and ecological knowledge, practices and beliefs pertaining to the relationship of living beings, including people, with one another and with their environments. A cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment." https://www.ipbes.net/glossary-tag/indigenous-and-local-knowledge Encouraged by workshop participants we use the terminology "Indigenous Peoples' knowledge" throughout this Statement.

from their wisdom and from their lifestyles, and at the same time listening to scientists, in order to benefit from their research. This workshop was considered a success by the participants, and it sends a message to government leaders and to international organizations, encouraging them to acknowledge and respect the rich diversity within the great human family."[3]

Below are the key insights and specific calls to shift perspectives and drive action.

1. Recognition and Dialogue

1.1. Recognizing and Valuing Indigenous Peoples' Knowledge

We call for a new and respectful acknowledgment of Indigenous Peoples' world views and the value of their knowledge and wisdom. This may include promoting empirical approaches and appreciation of empirical aspects of Indigenous Peoples' knowledge, aligning oral histories with scientific methodologies, while respecting contextual, metaphysical and cultural differences. As Pope Francis pointed out in his address to participants, "...I encourage you to draw from the patrimony of the wisdom of your forebears and from the fruits of your scientific research the vital energy needed to continue to cooperate in the service of truth, freedom, dialogue, justice and peace. The Church is with you, an ally of the Indigenous Peoples and their wisdom, and an ally of science in striving to make our world one of ever greater fraternity and social friendship."[4]

1.2. Recognizing Historical and Ongoing Rights Violations against Indigenous Peoples

The diverse experiences of expropriation and exposure to violence endured by Indigenous Peoples across all hemispheres in the past must never be forgotten, and the lasting impacts of colonialism be acknowledged. In the present day, Indigenous Peoples continue to face rights violations. These ongoing issues demand urgent attention and resolution. It is imperative to respect their rights, both locally and internationally, as delineated in various United Nations Declarations and Conventions.[5] Gatherings among

[3] https://www.vatican.va/content/francesco/en/speeches/2024/march/documents/20240314-pas.html

[4] https://www.vatican.va/content/francesco/en/speeches/2024/march/documents/20240314-pas.html

[5] United Nations Declaration on Indigenous Peoples' Rights, the Indigenous and Tribal Peoples Convention, 1989 (ILO 169), the General Recommendation No. 39 on

Indigenous Peoples and scientists must be encouraged to amplify the voice of Indigenous Peoples in the realms of science and innovation.

1.3. Reframing Philosophical and Epistemic Perspectives

We advocate for nuanced discussions that explore the complementarity of Indigenous Peoples' knowledge and science, and promote engagement with faith-based communities. We acknowledge that traditional lifestyles and knowledge systems are not relics of the past, but are dynamic, evolving and integral to shaping the future.[6]

1.4. Enhancing Dialogue among Indigenous Peoples and Scientists

We are steadfast in our commitment and urge other Academies, as well as national and international scientific organizations, to foster substantive, participatory, and respectful dialogues between Indigenous Peoples and scientific communities. The aim is to bridge existing divides and overcome misconceptions. As mentioned by Pope Francis addressing the workshop,[7] "...open dialogue between indigenous knowledge and the sciences, between communities of ancestral wisdom and those of the sciences, can help to confront in a new, more integral and more effective way such crucial issues as water, climate change, hunger and biodiversity."

the Rights of Indigenous Women and Girls of the Committee on the Elimination of Discrimination against Women (CEDAW, among others. Additionally, for the meaningful participation of Indigenous Peoples and in the enactment of their right to self-determination, the effective implementation of their Free, Prior and Informed Consent in all the matters that affect Indigenous Peoples. The use of these frameworks should help improving the meaningful participation of Indigenous Peoples in the International Decade of Indigenous Peoples' languages, the Water Action Decade, the COPs of biodiversity and Climate Action, the implementation of the Sustainable Development Goals as well as other processes currently put in place.

[6] Aristotle points out in his *Metaphysics* that there are different kinds of knowledge: one is experimental knowledge which is the basis of science, and another is scientific knowledge by causes. Being the son of a physician, the Philosopher knew that his father cured diseases on the basis of his experience, not always knowing what the cause of the disease was. According to Aristotle, there is no opposition between experimental and scientific knowledge. https://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.01.0052%3Abook%3D1%3Asection%3D981a

[7] https://www.vatican.va/content/francesco/en/speeches/2024/march/documents/20240314-pas.html

1.5. Fostering Local and Global Connections through the "Braiding" of Indigenous Peoples Knowledge and Sciences

The concept of "braiding" is a unique form of cooperation where the knowledge of Indigenous Peoples and scientific insights intertwine, each preserving its distinct identity. The process of "braiding" and building bridges among diverse Indigenous Peoples and scientific communities, both locally and globally, is crucial. It is particularly significant for collaborative efforts in areas such as on climate change adaptation, biodiversity conservation, ecosystems functionality, and sustainable food system practices. While much of this knowledge holds specific local significance, its applicability across various locations gives it a global resonance.

2. Collaborative Policy and Decision-Making Involving Indigenous Peoples and Scientific Communities

2.1. Establishing New Science Policy Approaches

Innovative approaches are essential to foster collaboration between Indigenous Peoples and scientific communities. These should be rooted in respect, steering clear of extractive practices, and hold the knowledge of Indigenous Peoples in high esteem. We are committed to amplifying Indigenous-led research activities, either independently or in conjunction with science-driven research efforts. A combination of insights from both natural and social sciences can prove instrumental in crafting robust cooperation frameworks between scientists and communities. The knowledge of Indigenous Peoples is complex and embedded in their cultural practices and epistemologies that are often overlooked or misunderstood by natural scientists.

2.2. Enhancing International Policies to uphold the Rights of Indigenous Peoples

We urge national and regional governments worldwide to formally recognize the significance of Indigenous Peoples' knowledge and its invaluable contributions to tackling global challenges. We advocate for the incorporation of relevant indigenous Peoples' knowledge into policy formulations and decision-making processes. Our call extends to bolstering the rights and participation of Indigenous Peoples in international policy arenas, particularly where science policies and innovations unfold. These include the UN International Decade of Indigenous Languages, the UN Water Action Decade, The International Decade of Sciences for Sustainable Development, the

UN Decade of Ocean Science for Sustainable Development, the UN High Seas Treaty (Biodiversity Beyond National Jurisdiction), the UN Framework Convention on Climate Change (UNFCCC), The UN Convention on Biological Diversity (UNCBD), the UN Convention to Combat Desertification (UNCCD). We also emphasize their inclusion in influential intergovernmental bodies like the Intergovernmental Panel on Climate Change (IPCC)and the Intergovernmental Platform on Biodiversity and Ecosystems Services (IPBES), as well as powerful consultation mechanisms such as G20.

At an international level, we underscore the need for intellectual property rights protection. It is imperative for innovation brokers to meticulously document knowledge attribution to safeguard indigenous contributions from erasure, while honoring the collective nature of their wisdom.

2.3. Strengthening National and Sub-National Policy and Rights

We encourage national and subnational governments not only to appropriately regulate but also rigorously enforce the secure land rights of Indigenous Peoples. The aim of crafting and implementing comprehensive policies in cooperation with Indigenous communities is to overcome poverty and vulnerability tailored to their circumstances.

2.4. Combatting Educational Segregation

Our focus extends to amplifying Indigenous Peoples' youth opportunities. This includes respecting and integrating Indigenous Peoples' knowledge and science into educational curricula, underscoring their synergistic relationship and fostering mutual understanding. Through inquiry-based learning approaches, a new generation of scholars and practitioners adept in both knowledge systems can become leaders in this field. Youth mentorship programs can be instrumental in transitioning to an understanding of both indigenous knowledge and scientific concepts, paving the way for innovative applications in various professional fields.

2.5. Promoting Inclusive Decision-Making

We are committed to ensuring that indigenous persons, both women and men, have an active role in the decision-making processes that affect their lands, waters, and lives, reflecting their rights, priorities and protocols. We recognize and protect providers of ethnoecological knowledge in territorial, national, regional, and international policies and legal frameworks to protect Indigenous Peoples' knowledge, making it easily accessible worldwide by building databases and digital libraries governed by explicit rules of ownership and use.

3. Critical Action Areas for Collaboration in Biodiversity, Food, Climate and Health

3.1. Supporting Indigenous Peoples' Knowledge for Biodiversity and a Healthy Planet

The preservation and enhancement of Indigenous Peoples' knowledge is pivotal in biodiversity conservation efforts. Central to this initiative is securing the land rights of Indigenous Peoples, while valuing their role in mitigating deforestation, sustainable use and conservation of wild species, combating land and soil degradation, and promoting ecosystem restoration. The participants took note of the Kunming-Montreal Global Biodiversity under UNCBD's auspices and the importance of the Joint Programme of Work focusing on the links between biodiversity and cultural diversity.

3.2. Addressing Food and Nutrition Challenges through the Collaboration of Indigenous and Scientific Communities

We are committed to holistic and sustainable approaches and support platforms and coalitions to enhance food and nutrition security, ensuring the protection of land, forest and water rights. We acknowledge the invaluable contributions of Indigenous Peoples' diets, including their integration into school meals, provision of plant germplasm, and inspiring a respectful relationship with nature.

3.3. Valuing and Making Use of Indigenous Peoples' Health and Pharmaceutical Knowledge

Indigenous Peoples' contributions to health offer big opportunities for all humankind. Partnerships with established science-based health systems must be explored further for mutual benefits. Fair and equitable sharing practices and sound joint assessments of use and impacts are to be implemented. The opportunities are not only in discovering new pharmaceutical products originating from Indigenous Peoples' knowledge, but also in adopting health insights derived from their lifestyles.

3.4. Operationalizing Indigenous Peoples' Knowledge for Climate and Macro-Environmental Action

Indigenous Peoples are disproportionally impacted by climate injustice, suffering the most from the climate change impacts on their environments, including health of oceans and waters, despite minimal contribution. The increasingly deep insights into the earth's atmosphere and beyond are relevant both for scientists and Indigenous Peoples. All efforts should be encouraged to include Indigenous Peoples in national platforms on climate adaptation and mitigation. Addressing air and light pollution is also a critical component of the broader planetary health agenda. We encourage an augmented co-production of knowledge that combines Indigenous Peoples' perspectives with scientific methodologies to bolster effective climate adaptation, mitigation, and transformation toward resilience. Nature-based solutions embedded in a bioeconomy can be mutually pursued in both urban and rural spaces, harnessing the synergy between scientific and Indigenous Peoples knowledge.

3.5. Promoting Ethical Partnerships and Research Funding, and Future Engagement by Global Academies

We encourage scientists to reassess fundamental assumptions, promote ethical collaborations and support knowledge preservation and research capacities of Indigenous Peoples. To realize this vision, science communities need to design structured and unbiased funding mechanisms, in consultations with funders, placing value on the knowledge of Indigenous Peoples and promoting its co-production with science. We foresee huge opportunities arising from the engagement between Indigenous Peoples' knowledge and scientists. Academies of sciences and arts around the world are ideally positioned to seize these opportunities. The Pontifical Academies of Sciences and of Social Sciences aim to continue the engagement beyond this initial workshop. It is crucial to support the sustainability of Indigenous institutions, including their recovery and recognition, as a foundation for sustaining and revitalizing Indigenous Peoples' knowledge systems.[8]

[8] The financial support by the Alfred P. Sloan Foundation and by the Rockefeller Foundation facilitating participation of a number of workshop participants is gratefully acknowledged.

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The United Nations System and Indigenous Peoples – Towards Knowledge Partnerships for Sustainable Development

Nigel Crawhall
Chief of Section, Local and Indigenous Knowledge Systems Programme, Natural Sciences Sector, UNESCO

Introduction

The United Nations benefits from an engaged relationship with Indigenous Peoples around the globe, through which it can share and reflect on different pathways and cosmovisions of what a sustainable world could look like. The attention given to Indigenous Peoples' human rights has accelerated attention to the unique and diverse knowledge systems which Indigenous Peoples hold in relation to their territories across the globe in highly diverse biomes, altitudes and latitudes.

This article provides an overview of the diverse ways in which Indigenous Peoples' knowledge systems help shape the United Nations and key platforms and mechanisms that are currently supporting this transformative process. The article also attempts to show how multiple knowledge systems, including Indigenous knowledge, can work together where there is a full commitment to human rights and ethical conduct.

To understand the emerging and dynamic relationship between the United Nations system and Indigenous Peoples, with a particular focus on the recognition, mobilisation and application of Indigenous knowledge systems to the sustainable use and conservation of biodiversity, and adaptive responses to climate instability, it helps to first get an overview of the overall legal and developmental relationship between the UN and Indigenous Peoples.

The current model of resource extraction and consumption to supply economic models of development which are not sustainable is placing the world's most exposed communities and many non-human species at significant risk. A new paradigm for sustainability, which considers economics, social, cultural and biological diversity can help us transform our relationship with nature and with each other. Wealth, good health, a good quality of life, peace and the ability to shape one's own destiny are all possible without having to borrow so heavily from future generations and place humanity and other species on the planet at unnecessary risk.

The relationship between the United Nations and Indigenous Peoples has a history dating back to the time of the League of Nations.[1] As the global platform for organising multilateral relations, the UN was mandated by its members to navigate the complex process of decolonisation which was closely associated with the end of World War II and the establishment of a new world order, the promotion of peaceful coexistence and the elaboration and application of international law. Two founding principles of the UN were the sovereignty of the state and universal human rights.

The characteristics of Indigenous Peoples, being social, cultural, spiritual and sometimes fully fledged political entities before the formation of the modern nation state contribute to a dynamic tension between national sovereignty and the right of peoples to represent themselves in multilateralism and advocate for a multilateral framework to address forms of discrimination and rights violations. Whereas the UN was able to recognise newly decolonised states as full sovereign members, it would take several decades for a new multilateral rights framework to emerge that could recognise Indigenous Peoples distinctly from other national groupings, collectivities or individual rights holders. This instrument which was eventually negotiated was the UN Declaration on the Rights of Indigenous Peoples (UNDRIP). It took twenty-five years to negotiate, culminating in its near universal approval on 13 September 2007.[2]

With the adoption of the UNDRIP by the UN General Assembly a new door was opened for UN entities to engage more directly with Indigenous Peoples and to explore many of the world's most pressing issues of rights, sustainable development, resource governance, cultural and linguistic diversity, and the right to propose alternative views on development, all of these being urgent themes at the close of the 20th century and as we transitioned into the 21st century.

UNDRIP had been preceded and influenced by other influential multilateral mechanisms and instruments, including the ILO Convention 169

[1] Chief Levi General, the Cayuga Deskaheh, attempted to address the League of Nations in 1923: https://www.cbc.ca/news/indigenous/deskaheh-100-haudenosaunee-geneva-1.6913959

[2] There are numerous studies documenting the long negotiations for the UNDRIP. See for example: https://legal.un.org/avl/ha/ga_61-295/ga_61-295.html

and the three 'Rio Conventions', the trio of environmental treaty instruments crafted at the UN Conference on Environment and Development (UNCED) in 1992 in Rio de Janeiro, Brazil. The three Rio conventions, on biodiversity, climate change and desertification respectively, benefited from the presence of Indigenous Peoples during negotiations and as such, established the first major frameworks to recognise that Indigenous knowledge, practices and innovations with regards to the environment would be of significance in achieving sustainability.

In 2002, the UN Educational, Scientific and Cultural Organization (UNESCO) established an intersectoral platform to study and promote Local and Indigenous Knowledge Systems, known as the LINKS programme, which eventually became an integral part of the Natural Sciences Sector, and which engaged in a wide range of projects including helping other UN processes, mechanisms and entities understand the importance of engaging with Indigenous Peoples as expert knowledge holders.

Indigenous Peoples and their knowledge systems

There has been an incremental growth in the attention of the United Nations (UN) system, its entities and its Member States to the relevance of Indigenous knowledge systems in addressing and where possible solving some of the most complex and pressing modern issues about our understanding and relationship with biodiversity, biomes and ecosystems. To understand what is meant by Indigenous knowledge systems, it is helpful to first understand the specific way in which the UN recognises certain communities as Indigenous Peoples.

The term 'Indigenous Peoples' has not been defined in a fixed way by the UN. A seminal document to help set out a global framework for the United Nations was crafted by José R. Martínez Cobo, commonly referred to as the "Martínez Cobo Study". Martínez Cobo, a Special Rapporteur for the UN, conducted an extensive study on the "Problem of Discrimination Against Indigenous Populations" between 1972 and 1983. The results of the study showed that in many countries, there were recognisable characteristics that could be aggregated to create a global framework on specific rights associated with Indigenous Peoples. These rights included, *inter alia*, the relationship between peoples and their territories, self-identification as Indigenous, historical continuity with pre-colonial and/or pre-settler societies, distinct social, economic, or political systems, languages, cultures, and beliefs and ultimately a desire to maintain and reproduce their ancestral environments and distinctive identities.

Recognition of the specificities of Indigenous knowledge, practices, customs and belief systems were woven throughout Martinez-Cobo's study and continued to emerge as central to the conceptualisation of Indigenous Peoples in international law, particularly with regards to knowledge of the environment and the right to use and govern over natural resources, which in some cases went directly against national legal practices. As the logic of colonial economics was to extract wealth from colonised territories for the benefit of the metropolitan power, it is axiomatic that colonial legal heritage was in contradistinction to Indigenous and local legal and territorial traditions, including all forms of customary law.[3]

The terms used to designate systems of knowledge held and reproduced by Indigenous Peoples varies in time and within different regional and national instruments. The UN has several generations of language related to knowledge systems and there is a further body of terminology used outside of the UN, particularly national norms and even legal terms. The UN acknowledges peoples who self-identify as Indigenous Peoples, while there are many grey areas where peoples may or may not self-identify, and contexts where people have multiple heritages even as a community (e.g. Afrodescendant and Indigenous together), and peoples who have collective systems of natural resource governance and are the first peoples of their territory but do not make any legal claims about being Indigenous Peoples (e.g. many African ethnic groups who rely on traditional agriculture). Terms in common use include Indigenous Knowledge, Indigenous and local knowledge, traditional knowledge, ancestral knowledge, traditional ecological knowledge, and so forth.

In the following brief overview of different UN entities and instruments, it is important not to separate the concept of knowledge from the people who hold and transmit that knowledge, and the entirety of their social, linguistic, spiritual and cultural organisation. Further, for the UN, it is critical not to imagine that knowledge sharing, production or coproduction can be discussed apart from a human rights framework.

Overview of UN instruments and programmes

Overall, the UN's engagement with Indigenous Peoples on their Indigenous or traditional knowledge systems is rooted in the acknowledgment of

[3] There are diverse writers on colonial economics and its extractive character. See for example Issa Shivji: https://www.worldhunger.org/articles/05/africa/shivji.htm

the value these knowledge systems bring to global efforts in climate change mitigation, adaptation, biodiversity conservation, and disaster risk reduction. Through the Paris Agreement of the UN Framework Convention on Climate Change (UNFCCC) and the Kunming-Montreal Global Biodiversity Framework of the UN Convention on Biological Diversity (UNCBD), the UN has created platforms and set targets to invite State Parties and Indigenous Peoples' to work together to support and apply Indigenous knowledge in addressing environmental and developmental challenges, with the support of international policy frameworks, ensuring that Indigenous voices are heard and their knowledge respected in global environmental governance.

Despite the overall positive uptake and attention to the rights of Indigenous Peoples and the mobilisation of diverse knowledge systems, in practice, the implementation side has numerous challenges, including the degree to which national scientists and policy makers understand the perspectives, needs and rights of Indigenous Peoples, and how different knowledge systems can have complementarity in their usage, while not subjecting Indigenous knowledge to validation techniques by scientists that are at best unhelpful, and at worst harm trust relationships.

The UN instruments that are both binding and include attention to Indigenous Knowledge systems and human rights are the Rio Conventions.

1. United Nations Framework Convention on Climate Change (UNFCCC)

The primary objective of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system. Having already missed the recommended targets for emissions reduction, the UNFCCC has a series of work streams, including to promote effective adaptation, innovations in mitigation that include nature-based solutions for carbon sequestration, and emerging instruments on loss and damage, including Non-Economic Loss and Damage, which is often important for Indigenous Peoples.

Indigenous Peoples' built-up advocacy capacity under the UNCBD, which they were able to bring into the UNFCCC over time. Attention to Indigenous Peoples' knowledge systems began to take shape under the Nairobi work programme on impacts, vulnerability, and adaptation to climate change (NWP) which was established in 2005 at COP11 in Nairobi. NWP became a dialogue forum and clearing house of adaptation measures.

Adaptation was given a boost with the adoption of the Cancun Adaptation Framework at COP16. The interaction of the NWP and the Cancun Adaptation Framework helped generate a work stream on Indigenous and Local Knowledge, a process formalised at COP19 in Warsaw. COP19 was a key moment, and led to a series of exchanges and technical work that would inform COP21 in Paris.

1.1 UNFCCC Paris Agreement

The Paris Agreement, adopted by Parties at the UNFCCC COP21 in 2015, highlights the importance of respecting the rights and knowledge of Indigenous Peoples in climate action. Specifically, Article 7.5 of the Paris Agreement calls for the consideration of "traditional knowledge, knowledge of Indigenous Peoples and local knowledge systems" in adaptation actions. This is further supported by the subsequent establishment of the Local Communities and Indigenous Peoples Platform (LCIPP) under the UNFCCC, which facilitates the exchange of experiences and best practices on climate actions grounded in traditional knowledge. The LCIPP aims to enhance the mobilisation of Indigenous knowledge in climate policies and practices.

2. Convention on Biological Diversity (CBD)

The CBD's primary objective is the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from the use of genetic resources. The CBD text was the first major international environmental agreement to make specific reference to Indigenous knowledge under Articles 8j and 10c. CBD, with its explicit mandate to work with Indigenous Peoples, was also the first major treaty instrument to welcome the emergence of an Indigenous Peoples' caucus and to establish the right of Indigenous Peoples to speak on items of relevance during Convention meetings.

2.1 UNCBD Kunming-Montreal Global Biodiversity Framework

Following the mixed results of the Aichi Biodiversity Targets (2010-2020), Parties to the Convention adopted a landmark agreement which further emphasises both human rights and the mobilisation of Indigenous knowledge in tackling the biodiversity crisis locally and globally. The Kunming-Montreal Global Biodiversity Framework (KM-GBF), adopted at CBD COP15 in 2022, sets new targets for biodiversity conservation through 2030 and has created an important mechanism for a Joint Programme of Work on the links between biological and cultural diversity that is to be jointly led by the UN and other international agencies in close cooperation with Indigenous Peoples' networks and leadership.

The KM-GBF emphasizes the crucial role of Indigenous Peoples and their traditional knowledge in achieving biodiversity conservation goals. The framework includes specific targets that underscore the importance of respecting and protecting traditional knowledge. For example, Target 22 aims to ensure that Indigenous Peoples have access to, and control over, their traditional territories and knowledge. The framework recognizes that safeguarding and utilizing traditional knowledge is essential for the conservation and sustainable use of biodiversity, thus promoting the full and effective participation of Indigenous Peoples in biodiversity governance.

3. United Nations Convention to Combat Desertification (UNCCD)

The main objective of the UNCCD is to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa. The UNCCD addresses land degradation and promotes sustainable land management practices to prevent desertification, reduce the impact of droughts, and rehabilitate degraded lands.

Unlike the CBD, the original treaty text of the CCD does not make explicit reference to Indigenous Peoples. Articles 16g and 17c make explicit reference to the importance of local and traditional knowledge in understanding and addressing drivers of desertification and sustainable responses. In practice, the CCD has been engaged in numerous dialogues with Indigenous Peoples around the globe, while receiving relatively less international support for ILK initiatives.

In summary, the Rio Conventions represent a comprehensive international framework aimed at addressing three critical global environmental challenges: climate change, biodiversity loss, and desertification. Their creation at the Earth Summit in 1992 marked a significant step forward in international environmental governance. Indigenous Peoples have been engaged in all of the Conventions, and the Rio Conventions have been one of the most important mechanisms for increasing global attention on the role of Indigenous knowledge systems in environmental sustainability. Each has also evolved to give greater attention to the inherent linkages between human rights and Indigenous Peoples.

4. Intergovernmental Platform on Biodiversity and Ecosystems Services (IPBES)

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has been a significant player in engaging with Indigenous Peoples and integrating their knowledge systems into global biodiversity assessments. This engagement is based on the recognition that Indigenous and local knowledge systems (ILK) offer invaluable insights into biodiversity and ecosystem management, which are often overlooked in conventional scientific approaches.

IPBES is primarily a science policy platform, however, as Indigenous and Local Knowledge was included in its founding mandate, it has in practice emerged as a catalyst in the UN system and broader scientific networks. In practice, IPBES methodologies and mobilisation of Indigenous Knowledge in its assessments is creating a new set of norms and standards on Indigenous knowledge and related ethical considerations.

IPBES has established a comprehensive approach to including Indigenous knowledge into its work, which includes the following key strategies:

4.1. Inclusion in Assessment Processes

IPBES explicitly includes Indigenous and local knowledge holders in the preparation, elaboration and review of its assessments. This participatory approach ensures that Indigenous perspectives are considered alongside scientific data and analysis. Indigenous experts and communities are involved in various stages of the assessments, from scoping and drafting to reviewing the findings.

4.2. Thematic Workshops and Dialogues

IPBES organizes thematic workshops and dialogues specifically focused on integrating Indigenous knowledge into its work. These gatherings bring together Indigenous knowledge holders, scientists, and policymakers to share experiences and co-produce knowledge. Such workshops often address topics where Indigenous knowledge is particularly relevant, such as land management, biodiversity conservation, and ecosystem resilience.

4.3. ILK Task Force

IPBES established an ILK Task Force to guide the platform's efforts to incorporate Indigenous knowledge. The ILK Task Force has played a key role in elaborating the IPBES methodological approach to ILK, and the composition of the TF has increasingly represented ILK holders from the North and the South. The Task Force is supported by the Technical Support Unit on Indigenous and Local knowledge, which is hosted and supported by the UNESCO LINKS programme.

4.4. Guidance Documents and Methodological Approaches

IPBES has developed specific guidance documents and methodologies for including Indigenous knowledge in its assessments. These guidelines ensure that the integration of Indigenous knowledge is done respectfully and effectively, recognizing the unique contributions and intellectual property of Indigenous Peoples.

4.5. Policy Recommendations

The inclusion of Indigenous knowledge has also led to more nuanced and culturally appropriate policy recommendations. IPBES assessments that incorporate Indigenous perspectives tend to advocate for policies that respect Indigenous Peoples' rights, promote community-led conservation, highlight the need for Indigenous resource tenure and recognize the value of traditional ecological knowledge in sustainable development.

In summary, IPBES's engagement with Indigenous Peoples and their knowledge systems has profoundly shaped its assessments, leading to a more inclusive and accurate understanding of global biodiversity and ecosystem services. This collaborative approach has not only enriched the scientific foundation of IPBES assessments but has also reinforced the importance of Indigenous knowledge in global environmental governance.

5. Biodiversity and Ecosystem Services Network (BES-Net)

Biodiversity and Ecosystem Services Network (BES-Net) is a UN interagency initiative of the UN Development Programme (UNDP), UN Environment Programme World Conservation and Monitoring Centre (UNEP-WCMC), and UNESCO. It aims to support the capacity-building work of IPBES by strengthening the interface between science, policy, and practice in conservation of biodiversity and ecosystem services. It provides support and capacity-building for national research entities, decision-makers and stakeholders to integrate biodiversity considerations into policies and actions on the ground.

BES-Net picks up key themes from the IPBES assessments and assists national governments and stakeholders in understanding, researching and bringing these into policy. One the key components of the BES-Net is the technical support to developing countries to undertake National Ecosystem Assessments using a combination of science and Indigenous and local knowledge. The NEA Initiative is led by UNEP-WCMC.

UNESCO's LINKS programme hosts the BES-Net technical support unit on Indigenous and Local Knowledge (ILK). Overall, BES-Net champions the mobilisation of ILK for inclusive and evidence-based biodiversity and ecosystem services policies and decision-making.

BES-Net facilitates dialogue between Indigenous and local knowledge holders and scientists, fostering an exchange that respects and incorporates Indigenous perspectives into broader biodiversity discussions. Through "Trialogues", a unique approach developed by BES-Net, Indigenous and local communities, scientists, and policymakers engage in multi-way dialogues to share insights and co-create solutions on biodiversity and ecosystem management issues.

BES-Net is a key process for capacity building for national research agencies and for holders of Indigenous and local knowledge. Whereas the IPBES Assessments are at a certain level of generationalisation, the BES-Net process focusses on national particularities of both ecosystem diversity and linguistic / cultural / land use diversity. BES-Net is an engine for innovations and emerging practices of transdisciplinary cooperation and knowledge production.

6. Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) has increasingly recognized the importance of Indigenous knowledge systems in its work, assessments, and special reports. This inclusion reflects a growing understanding that Indigenous knowledge offers valuable insights into climate change impacts, adaptation strategies, and resilience, which are often complementary to scientific findings.

IPCC, unlike its sister entity the IPBES, did not include a founding mandate to include Indigenous knowledge in its assessments and reports. There are authors who have been dedicated to ILK inclusion, while overall, the IPCC approach has been *ad hoc* and has not been able to establish the same methodological precision as IPBES. IPCC has also less flexibility with 'grey literature', sources of information and knowledge that do not occur in peer reviewed scientific publications.

6.1. Assessment Reports

Fifth Assessment Report (AR5, 2014): The IPCC's AR5 was one of the first to explicitly recognize the value of Indigenous knowledge. The report highlighted how Indigenous Peoples, particularly those in climate sensitive regions, have developed adaptation strategies based on a deep understanding of local ecosystems and long-term environmental changes. AR5 noted that these communities are often on the front lines of climate change and that their experiences and knowledge systems provide critical information for understanding local impacts and responses.

Sixth Assessment Report (AR6, 2021-2022): In AR6, the IPCC further integrated Indigenous knowledge, particularly in Working Group II's contribution, which focuses on impacts, adaptation, and vulnerability. AR6 acknowledged Indigenous knowledge as crucial for developing locally appropriate adaptation strategies and understanding the socio-cultural dimensions of climate change. The report underscored that Indigenous Peoples' historical and ongoing management of their environments contributes to climate resilience and biodiversity conservation. AR6 also emphasized the need for more inclusive governance processes that recognize and protect Indigenous knowledge and rights.

6.2. Special Reports

Special Report on Global Warming of 1.5°C (2018): This report extensively discussed the role of Indigenous knowledge in understanding climate impacts and developing adaptation strategies, particularly in relation to maintaining global warming within 1.5°C. The report highlighted case studies from various Indigenous Peoples that demonstrate how traditional knowledge can inform sustainable land management, ecosystem restoration, and climate resilience efforts.

Special Report on Climate Change and Land (2019): This report paid special attention to the contributions of Indigenous Peoples to land management and their role in sustainable land use practices. It recognized that Indigenous knowledge systems are integral to managing land in ways that enhance resilience to climate change, particularly in relation to agriculture, forestry, and water management. The report advocated for the inclusion of Indigenous knowledge in policymaking and land-use planning to achieve sustainable outcomes.

Special Report on the Ocean and Cryosphere in a Changing Climate (2019): Indigenous knowledge was highlighted as essential for understanding the impacts of climate change on marine and cryosphere systems, particularly in the Arctic and small island developing states (SIDS). The report noted that Indigenous communities often have centuries of experience in managing and adapting to changes in these environments and that their knowledge is crucial for informing global responses to climate change.

The IPCC's reports increasingly recognize the importance of Indigenous Peoples' rights and governance in climate action. This recognition helps raise awareness that climate policies are more equitable, and that Indigenous Peoples are empowered to contribute to and benefit from climate solutions.

While the IPCC has made significant strides in incorporating Indigenous knowledge, challenges remain. These include the need for better representation of Indigenous Peoples in IPCC processes, ensuring that Indigenous knowledge is not misappropriated or decontextualized, and addressing the barriers that Indigenous communities face in contributing to global climate assessments.

7. Intergovernmental Oceanographic Commission (IOC)

The Intergovernmental Oceanographic Commission (IOC) at UNESCO has recognized the importance of Indigenous knowledge systems, particularly in the context of the UN Decade of Ocean Science for Sustainable Development (2021-2030). This recognition is part of a broader effort to integrate diverse knowledge systems into ocean science and governance to ensure sustainable and inclusive ocean management.

The IOC has acknowledged that Indigenous knowledge systems are crucial for understanding and managing marine environments. Indigenous communities often have a deep, long-standing connection with the ocean, possessing extensive knowledge about marine ecosystems, species behavior, and environmental changes. This knowledge is based on centuries of observation, interaction, and stewardship, making it invaluable for ocean science. IOC works closely with the LINKS programme and other partners.

7.1. Programme engagement with Indigenous Peoples

The IOC has actively engaged with Indigenous Peoples through various platforms and initiatives, aiming to include their voices and perspectives in global ocean governance. This engagement is reflected in consultations, workshops, and partnerships that bring together scientists, policymakers, and Indigenous knowledge holders. Along with the Ocean Decade processes, IOC has undertaken an initiative on Indigenous Peoples perspectives on Marine Spatial Planning (MSP) and has coproduced two publications on MSP involving Indigenous Peoples including a guide on best practices and case studies.

7.2 The UN Decade of Ocean Science for Sustainable Development

The UN Decade of Ocean Science for Sustainable Development, led by the IOC, emphasizes the need for inclusive and participatory approaches to ocean science. Indigenous knowledge systems are recognized as essential contributors to achieving the Decade's goals, which include understanding ocean ecosystems, addressing climate change, and ensuring sustainable ocean use.

One of the core principles of the Decade is to ensure that ocean science benefits all of humanity, including Indigenous communities. The Decade seeks to bridge the gap between scientific and Indigenous knowledge by fostering collaborations that respect and incorporate traditional knowledge into ocean research and policy-making.

The Decade promotes the co-design and co-production of knowledge, encouraging the collaboration between scientists and Indigenous communities. This approach ensures that research agendas are developed in partnership with Indigenous Peoples, reflecting their priorities and knowledge systems.

Specific initiatives within the Decade have been designed to include Indigenous knowledge. For example, programs focused on marine biodiversity, ecosystem restoration, and climate resilience often integrate Indigenous knowledge to enhance the relevance and effectiveness of scientific outcomes.

While significant progress has been made in recognizing and integrating Indigenous knowledge systems, challenges remain. These include ensuring meaningful participation of Indigenous Peoples, overcoming differences in knowledge systems and methodologies, and addressing power imbalances in decision-making processes. The IOC continues to work on creating frameworks that respect and protect Indigenous knowledge while facilitating its integration into global ocean science.

8. Food and Agriculture Organization

The Food and Agriculture Organization of the United Nations (FAO) works extensively with Indigenous Peoples to recognize their critical role in sustainable agriculture, biodiversity conservation, and food security. FAO's collaboration with Indigenous Peoples is built on the recognition that Indigenous communities are vital custodians of traditional knowledge and sustainable practices that have been passed down through generations.

This partnership seeks to promote and protect Indigenous Peoples' rights, knowledge systems, and livelihoods, ensuring they can contribute meaningfully to global agricultural and environmental goals.

Through initiatives such as the Global Hub on Indigenous Food Systems, FAO promotes the exchange of knowledge and experiences, ensuring that Indigenous voices are heard in the global dialogue on food security, sustainability, and climate resilience. The Global Hub has been an important innovation for FAO, arising from advocacy efforts during the 2021 World Food Systems Summit. The Global Hub supports the Coalition on Indigenous Peoples' Food Systems which allows Indigenous Peoples to work with Member States, UN agencies, the private sector, bilateral and multilateral development institutions to build healthy, equitable and sustainable food systems. The Global Hub and the Coalition have engaged in transdisciplinary dialogues with food and agriculture scientists and have include Indigenous knowledge as a key component of the advocacy.

In addition to FAO's programmes and policy framework, two other Rome-based UN agencies have been important actors in relation to Indigenous Peoples and inherently with regards to Indigenous knowledge systems.

The International Fund for Agricultural Development (IFAD) recognizes the unique relationship Indigenous Peoples have with their land and natural resources, and it seeks to support their traditional livelihoods while enhancing their resilience to climate change and other challenges. Through its Indigenous Peoples' Forum and dedicated Indigenous Peoples Assistance Facility, IFAD provides grants and technical assistance to help Indigenous communities strengthen their governance, protect their land rights, and promote sustainable agricultural practices. Additionally, the World Food Programme works with Indigenous Peoples to improve food security and nutrition while respecting their unique cultural practices and traditional knowledge. WFP collaborates with Indigenous Peoples to ensure that their needs and priorities are integrated into food assistance programs, particularly in regions affected by hunger, conflict, and climate change. increasingly engages with Indigenous Peoples on their food and knowledge systems. WFP is active in the Coalition on Indigenous Peoples' Food Systems.

9. Biodiversity Beyond National Jurisdiction (BBNJ)

The High Seas Treaty, officially known as the Biodiversity Beyond National Jurisdiction (BBNJ) Agreement, represents a significant milestone in the global effort to protect and manage the biodiversity of the high seas –

areas of the ocean that lie beyond any country's jurisdiction. One of the most groundbreaking aspects of this treaty is its formal recognition of Indigenous and traditional knowledge as a crucial component in the conservation and sustainable use of marine biodiversity.

The High Seas Treaty explicitly acknowledges the importance of Indigenous and local knowledge systems alongside scientific research. This recognition marks a significant shift from previous international agreements, which often prioritized scientific data over traditional knowledge. The treaty highlights that Indigenous and traditional knowledge can provide valuable insights into marine ecosystems, species behavior, and environmental changes, particularly in areas where scientific data might be limited or unavailable.

The treaty establishes mechanisms to ensure that Indigenous Peoples and local communities (IPLCs) are involved in the governance and decision-making processes related to the high seas. This involvement is intended to be inclusive and participatory, ensuring that the voices and knowledge of these communities are considered in the management of marine biodiversity.

The treaty introduces benefit-sharing mechanisms that acknowledge the contributions of Indigenous and traditional knowledge to the conservation and sustainable use of marine biodiversity. These mechanisms ensure that IPLCs receive equitable benefits from the use of their knowledge, particularly in the context of marine genetic resources, which are a key focus of the treaty.

The High Seas Treaty makes a landmark recognition of Indigenous and traditional knowledge, integrating it into the fabric of international ocean governance in a way that respects and values the contributions of Indigenous Peoples and local communities to the stewardship of marine biodiversity.

10. World Intellectual Property Organization (WIPO)

The World Intellectual Property Organization (WIPO) has been actively engaged in efforts to safeguard Indigenous knowledge and related practices through its work on traditional knowledge, genetic resources, and traditional cultural expressions (TCEs). These efforts aim to protect the intellectual property (IP) rights of Indigenous Peoples and prevent the misappropriation of their knowledge and cultural heritage.

In May 2024, WIPO member states adopted the first WIPO Treaty to address the interface between intellectual property, genetic resources and traditional knowledge which is also the first WIPO Treaty to include provisions specifically for Indigenous Peoples as well as local communities.

10.1 Progress in Safeguarding Indigenous Knowledge

The primary mechanism under WIPO is the Intergovernmental Committee (IGC) on Intellectual Property and Genetic Resources, Traditional Knowledge, and Folklore. WIPO established the IGC in 2000 to facilitate discussions on the protection of traditional knowledge, genetic resources, and traditional cultural expressions. The IGC is a key platform where member states, Indigenous groups, and other stakeholders negotiate and discuss the development of international legal frameworks to protect Indigenous knowledge.

WIPO has also developed databases and registries to document and protect traditional knowledge and cultural expressions. These databases aim to prevent the misappropriation of Indigenous knowledge by providing evidence of prior art, which can be used in legal defences against unauthorized IP claims.

Conclusion

The long process of building consensus for the adoption of the UNDRIP, in combination with the shift by the UN to see human rights, environment and sustainable development as inseparable and complementary processes, provided an ideal foundation for a new relationship to emerge between the UN system and Indigenous Peoples as rights holders and knowledge holders.

Through advocacy and joint actions, most UN agencies working on environmental issues, including the wider range of themes such as food systems or cultural practices related to the environment, have recognised the key role of Indigenous Peoples and established a range of platforms, mechanisms, and elaborated norms and standards for the recognition and application of their respective knowledge systems.

While there has been near universal responsiveness from the UN system, the practicalities of greater cooperation between formal science, professional nature conservation and Indigenous ways of knowing and taking care of territory remain an ongoing challenge and opportunity. There is a particular challenge in how rigid and bureaucratic institutions can understand and adjust to the highly adaptive and almost entirely oral Indigenous institutions where knowledge is produced, reproduced and sustained.

UNESCO, which is mandated to work on both science and culture, has been a natural candidate to help stimulate the UN system to better understand the significance of diverse knowledge systems. Over its twenty years of existence, the LINKS programme has been able to gather particular expertise, partnerships and credibility to continue expanding its work into new domains. UNESCO continues to develop its complementary relationships within the UN system, to provide dedicated technical assistance at different scales, and aligns its programming with the principles of the UNDRIP.

The dialogue on the relationship between science and Indigenous knowledge systems, sponsored by the Pontifical Academies of Sciences and of Social Sciences is an important opportunity for a stock-take of the progress that has been made and visions and principles that can lead to improved cooperation, learning and innovation.

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Traditional Knowledge of Indigenous Peoples: Voices of Respect for Sacred Nature and Transdisciplinary Stewardship of Mother Earth

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Introduction

According to Vine Deloria (1999), "life is not scientific, social scientific, mathematical, or even religious; life is a unity, and the foundation for learning must be the unified experience of being a human being." In this article, we propose that transdisciplinary education is a decolonizing methodology since it serves as an antidote to the reductionism that is an artifact of Western scientific approaches to knowledge whereas traditional knowledge is holistic, synthetic and multi-contextual. This article seeks to uncover educational approaches that transcend standard reductionist and analytical approaches in favor of Indigenous methodologies (Smith, 1999). We introduce a transdisciplinary climate change education module that can serve as a model of "true learning" which, according to Cajete (2005), incorporates technical knowledge as well as an emphasis on reciprocal relationships with both human and natural communities. The movement toward a culturally responsive understanding of global climate change interpreted through an Indigenous lens has been limited and this work aims to shed light on methodologies and approaches that incorporate Indigenous worldviews in the context of education of American Indian/Alaska Native students at tribal colleges. We believe that these approaches are critical to providing holistic, culturally sustaining science education and it is our hope that this work will serve as a guide for others engaged in this work.

Global climate change is inherently a transdisciplinary problem that requires input from multiple scientific disciplines and consideration of socio-ecological systems in order to achieve sustainable, long-term solutions. While the differentiation and fragmentation of science into separate disciplines over the past several 100 years has yielded essential knowledge, methods and tools, an integration of knowledge is now required to address complex scientific problems (Buizer, Arts, & Kok, 2011; Holm et al., 2013; Lang et al., 2012; Mauser et al., 2013). This can explain the current trend toward transdisciplinary research in climate change science (Hellstein & Leydesdorff, 2016). Transdisciplinary research is defined by Brandt et al. (2013) as research that incorporates multiple scientific disciplines as well as input from practitioners outside of academia. Similarly, transdisciplinary education goes beyond interdisciplinary content and includes the interactions between knowledge from academics and knowledge from practitioners in order to promote a mutual learning process (Mitchell & Moore, 2015; Steiner & Posch, 2006). The need for diverse perspectives underscores the paramount importance of incorporating traditional ecological knowledge (TEK) or Indigenous knowledges (IK) in understanding and finding solutions to global climate change. In addition, leading scholars in science and environment education for Native Americans agree that pedagogy that incorporates traditional Indigenous knowledge is a crucial component of Native American student success in math and science courses.

TEK is "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, 2008). TEK is a form of knowledge based on relationships and connection (ways of being in the world), in contrast to the "parts and wholes" reductionist approach typically employed under Cartesian-influenced aspects of Western science (Pierotti & Wildcat, 2000). This means that TEK can provide insights into the functioning of local ecosystem processes and to organismal responses to changing environmental conditions, both of which are important in understanding some of the major environmental problems facing all societies in today's changing world. One of the strengths of TEK is that it assumes that local environments and climate are continuously changing in a non-equilibrium fashion and that living organisms, including humans, must be flexible in their ability to respond.

IK is a bit broader than TEK and refers to a complete body of knowledge and practices maintained and developed by peoples who are locally bound and Indigenous to a specific area (Battiste & Henderson, 2009; Berkes & Berkes, 2009; Brayboy & McCarty, 2010; Nakashima, 2000; Sillitoe & Marzano, 2009). IK is situational, tacit, culture and context specific knowledge that is orally transmitted from generation to generation, and is dynamic, adaptive and holistic in nature. IK is rooted in the community and incorporates Indigenous goals of living "a good life", which is sometimes referred to as striving "to always think the highest thought." This metaphor refers to the framework of a sophisticated epistemology of community-based, spiritual education in which the community and its traditions form the primary support for its way of life and quality thinking. Thus, the community becomes a kind of center and context for learning how to live spiritually (Cajete, 2000) and Indigenous education is always situated within a community context.

Indigenous cultures possess vital place-based knowledge, which includes a history of adapting to highly variable and changing social and ecological conditions, concepts of adaptation and change at much longer time scales than sometimes available via methods in the natural sciences (Intergovernmental Panel on Climate Change, 2014; McNeeley & Schultzski, 2011; Maldonado et al., 2016). Transdisciplinary approaches that incorporate TEK and IK ensure its inclusion in the generation of new knowledge (Gould, González, Walker, & Ping, 2010).

Ways That Transdisciplinary Approaches Promote Student Educational Success

Legitimizing Traditional Knowledge

Transdisciplinary research and education reflects a move from the investigation of science on society but with society and a shift toward equivalencies of competencies from academic expertise and expertise of non-scientists including values (Steiner & Posch, 2006). Hence, transdisciplinary curriculum serves to legitimize the knowledge of students through the incorporation of local, cultural knowledge and by allowing students to become co-constructors of knowledge. Transdisciplinary approaches are an antidote to the deficit model, which only recognizes knowledge from European/Western societies and instead promotes transformational learning (Habermas, 1979; Mezirow, 1994; Mezirow, 1996) that values multiple perspectives and removes hierarchical frameworks for knowledge, thereby empowering Indigenous students as legitimate knowledge holders.

Mediation of Border Crossings

For Native students, everyday life is situated in Indigenous worldviews and there is an apparent great cultural divide between their culture and the culture of science. For these reasons, success in science is dependent on how well students can transcend the cultural borders between the disparate worldviews of their everyday life and science (Ezeife, 2003; Jegede & Aikenhead, 1999).The predominant mainstream perspective in science education typically results in an assimilationist approach and can result in Native students feeling alienated by science (Aikenhead, 1996) and perceiving success in science as an either/or proposition (Gates, 2006). In order to be successful in science many students are faced with a potential loss or erosion of identity, in order to perform in a knowledge system that does not value or incorporate their cultural heritage. According to Jegede and Aikenhead (1999), culturally sensitive curriculum supports the students' life view and mediates a smooth border crossing, whereas science curriculum that is incongruent to the students' life-world culture can be disruptive to a student's worldview and lead to abandonment and marginalization of their culture. This might result in short-term success in science, but ultimately leads to loss of culture and assimilation.

Collateral learning refers to how students resolve two or more schemata simultaneously held in long-term memory (Jegede & Aikenhead, 1999). Transdisciplinary approaches to science education can mediate border crossings and promote desirable collateral learning. Since transdisciplinary curriculum presents content in a high-context, integrated manner, it prevents compartmentalization of knowledge where the student masters the concept in the classroom but is unable to apply it within their everyday life that is part of their life-world experience. Instead, it facilitates the students' ability to achieve simultaneous collateral learning wherein learning a concept in one domain of knowledge or culture can improve the learning of a similar concept in another domain (Aikenhead & Jegende, 1999). In this latter situation, the two worldviews can act to augment and enrich knowledge in the other domain. Transdisciplinary approaches also promote simultaneous collateral learning because transdisciplinary education incorporates real-world, authentic learning, giving the students the opportunity to connect their learning to their own unique life-world culture. It also includes opportunities to explore answers using all their knowledge, including relational knowledge, value systems and spiritual interconnectedness; thus, reinforcing connections between the two knowledge systems and empowering students to make their own unique connections and bridges between Western science and Indigenous knowledges.

Incorporation of Core Values

Gregory Cajete (1999), arguably the foremost scholar in this area, contends that for science and math courses to be effectively taught for American Indian students, they must use instructional strategies that incorporate values common to most Native American tribal nations and connect mathematical and scientific concepts to real-world issues and problems. Cajete (1999) argues:

> Because core values invariably affect education outcomes, it is important that the teacher, teaching methods, and curricular content reflect this dimension of the learner. It follows then, that an effective and natural way for learning to begin is to help students become aware of their core values. This can be accomplished when the teacher shows the students how the content presented in a particular subject area (such as science) is relevant to or otherwise enhances an understanding of the student's core values (p. 139).

TEK is by its very nature holistic knowledge, which not only includes multiple discipline areas but also integrates spiritual and ethical dimensions in its knowledge system. Therefore, transdisciplinary approaches that include TEK provide mechanisms for the inclusion of value systems.

Incorporation of High-Context, Problem-Based Learning

In identifying traditional Native American values and behaviors, Cajete includes several that are congruent with both problem-based learning and characteristics of high-context learners and three are particularly relevant: "orientation to the present, practicality, and holistic orientation." Those same three factors are also components of an approach to learning that has gained attention of educators from K-12 to colleges and universities, known as "engaged civic learning." Engaged civic learning is an approach to learning that is problem centered, using authentic problems, inter- or multidisciplinary, and connected to communities (holistic, to use Cajete's term). Problem-based learning is an approach to educating students where they are presented with real-world problems that require solutions. Students evaluate the problem, gather data, identify possible solutions and present their conclusions. Because of the problem/solution focus, education in this context usually crosses academic disciplinary borders, a characteristic of transdisciplinary education.

Cajete's call for an Indigenous pedagogy also resonates with Ibarra's (2001) argument for pedagogy that is effective for multi-contextual student populations. As Ibarra (2001) notes, both low-context learners and high-context learners exist in society, but pedagogy in institutions of higher education is often effective only for low-context learners. According to

Ibarra (2001) and others, low-context learners are those who learn best by following directions, where learning is oriented toward the individual, information is compartmentalized and can be separated from social and other context, and where culture is not critical in reasoning and new ideas. In contrast, according to Ibarra (2001) and others, high-context learners are those who learn best by demonstration, application and experience; where comprehensive thinking is important; where learning is collaborative and practical; where interconnected thinking is important; where culture is critical to understanding difference and new ideas; and where information is unreliable if it is separated from context. Ibarra (2001) further notes that Native American and Hispanic students, in particular, tend to be high-context learners. In summary, curriculum must be culturally relevant and include practical applications of the complex theoretical concepts being taught to authentic problems that resonate with students' lives.

Monhardt (2000) contends that effective educational practices for minority students (including Native American students) and women in science must create and include "equitable contexts for learning," including discussions of incorporating traditional Indigenous knowledge into curricula and instruction. Other scholars have noted the importance of context for effective learning in mathematics for particular groups, including Barton and Frank (2001), who explore how Indigenous languages may explain differences in how Indigenous students understand spatial relationships, quantity concepts and more. Barton and Frank (2001) reviewed the literature in ethnomathematics and noted that some have explored the idea that "mathematics manifests itself differently in different social or cultural contexts" as part of understanding the puzzle of differences among groups in mathematics achievement (Barton & Frank, 2001, p. 136). Cajete, as well as other leading scholars in the field of American Indian Education, particularly STEM education for Native American students, continue to point to the need for effective pedagogies for American Indian student success in higher education.

Overview of the Curriculum and Tribal Colleges and Universities

Thirty-eight Tribal Colleges and Universities (TCUs) serve over 20,000 Native American undergraduate students across the US. The tribal college movement began in response to the need for self-determination and tribal sovereignty; therefore, tribally controlled education is an act of cultural restoration (Crazy Bull, 2010) and reconciliation through deconstructing and challenging the dominance of Western knowledge (Kanu, 2006; Wilson, 2004). Each tribal college has a dual mission to preserve tribal culture and to provide students a high quality post-secondary education while serving the needs of its community and tribal members (Tierny, 1992; American Indian Higher Education Consortium, 2001). Tribal community colleges play a pivotal role in training Native American ecologists by providing them with the expertise to address the environmental challenges faced by their communities, such as climate change. Undergraduate science curriculum at tribal colleges is designed to be relevant to the culture of Native students because this is essential for developing the local experts and scientifically literate populace needed to address specific challenges faced by Native communities.

Tohono O'odham Community College (TOCC) is one of the 38 tribally controlled colleges and universities in the US and is the institution of higher education of the Tohono O'odham Nation. Located in the heart of the Sonoran Desert of southern Arizona and northern Mexico, the Tohono O'odham Nation is home to the Tohono O'odham, or "Desert People." At TOCC, the science curriculum has been developed under the premise that science is part of the cultural heritage of each student, as every culture has relied upon processes for gathering and making meaning of information about the natural world (TEK). A cornerstone of TOCC's science program is a global change biology course. which teaches climate change from an Indigenous perspective. This is accomplished through the incorporation of the Tohono O'odham language and stories, an analysis of Western science and Indigenous ways of knowing, inclusion of traditional ecological knowledge and place-based learning. This course includes a transdisciplinary module that was developed as part of a cross-institutional collaboration with Northern Arizona University for the National Council for Science and the Environment's Climate Change Adaptation, Mitigation and eLearning (CAMEL) site and piloted in TOCC classes in spring 2012 (Newberry & Trujillo, 2012). The module was enhanced through the incorporation of a mathematical component under the Southwest Native Lands Project funded by the National Science Foundation and, most recently, has continued to be refined and adapted based on the unique "Man in the Maze" education model for problem-based learning (Newberry, Quijada, Guarin, & Lopez, 2016).

Climate Change, Water and Traditional Ecological Knowledge in the Southwest: A Transdisciplinary Approach to Climate Education

Since the impacts of climate change are falling disproportionately on tribal communities in the US –particularly in Alaska and the southwestern states (Wildcat, 2013) – our motivations for the curriculum include addressing issues of climate justice, legitimizing traditional knowledge, and encouraging interdisciplinary dialogue across science, policy, student and elder circles. The fundamental problem addresses adaptation to changes in water availability due to climate change impacts and exploring strategies for including Indigenous knowledge and cultural traditions that respect the rights of nature in water policy. We created a model that incorporated elder input, science input and policy input to meeting future water needs in the Southwest under current and project climate change scenarios.

Specifically, this transdisciplinary module integrates social science, water policy, traditional ecological knowledge and climate change science in the context of the Tohono O'odham Nation. The goal of this module is to examine strategies for including Indigenous knowledge and cultural traditions into water policy and environmental decision-making. This is accomplished by providing the students a background on the Tohono O'odham cultural perspectives on water from the perspectives of Tohono O'odham elders, geographical orientation and creation stories. It incorporates the spiritual values related to water as sacred and central to the Tohono O'odham culture. It includes traditional uses of water in the context of traditional lifeways and farming as well as the modern uses of water by the Tohono O'odham. The students then learn about current and predicted climate change patterns such as drought, increased temperature, changes in overall and seasonal precipitation patterns, and extreme weather events. The students then apply this knowledge to predicting potential impacts of these environmental changes to each water source on the Tohono O'odham Nation. Finally, using the model that incorporates elder knowledge, water policy, and climate change science, they develop water policy scenarios, adaptation plans and tribal resolutions addressing climate change impacts on the food and water resources on the Tohono O'odham Nation. The students are required to incorporate Indigenous viewpoints on water and Tohono O'odham cultural core values (T-So:son) in their final projects. Since this curriculum is available to mainstream institutions via the CAMEL site, mainstream students are also afforded the opportunity to learn science from a multicultural perspective.

Conclusion

We feel that transdisciplinary approaches to climate change education are vitally important to promoting resiliency in Indigenous communities (Aldunce, Bórquez,Adler, Blanco, & Garreaud, 2016). Transdisciplinary approaches provide students opportunities to make connections between different types and forms for knowledge and allow them to examine concepts of culture, knowledge and power through an Indigenous lens, which in turn promotes self-education and sovereignty (Brayboy, 2006). Transdisciplinary education trains students to be active and competent participants in transdisciplinary research since they will be competent in both IK and community knowledge as well as scientific knowledge. Furthermore, they will know how to navigate between the two knowledge systems and be well versed in methodologies to incorporate IK and community knowledge alongside scientific knowledge toward the production of new knowledge. This is vitally important because the resilience of Indigenous communities facing threats of climate change is strengthened when Indigenous peoples shape climate policies, are included in natural resource management, strengthen tribal economies, and engage in sustainable development (Maldonado et al., 2016).

On a broader scale, well-trained Indigenous ecologists who also have a strong grounding in their own cultural knowledge can provide the scientific community with unique multi-contextual, Indigenous perspectives on the science of ecology through TEK. Since TEK includes human interactions and is holistic in nature, transdisciplinary curriculum including the social science dimension is a natural outcome of teaching science from an Indigenous perspective. Furthermore, the inclusion of traditional ecological knowledge across disciplines encourages integrative, multi-contextual thinking and promotes the interdisciplinary dialogue necessary to finding solutions to the global environmental problems facing humanity.

Acknowledgement

Indigenous Peoples of North America have been the traditional guardians of Turtle Island and traditional knowledge holder Camillus Lopez has guided us in "braiding" Indigenous Peoples knowledge and sciences. Our work at Tohono O'odham Community College transcends scientific, spiritual, cultural, philosophical, linguistic and religious boundaries. We believe in reciprocal listening and learning; this body of work is part of decolonizing studies in education. Growing opportunities and platforms to advance sustainability, justice and equity has been essential in our work: we thank the entire community college and allies on the Tohono O'odham Nation for their guidance and encouragement.

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YOUTUBE PRESENTATION

Keynote on Indigenous Peoples' Knowledge and the Sciences

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https://youtu.be/QDa6-aKvxVI?si=x282wAne6X-HVerI

2. REGIONAL INSIGHTS AND OUTLOOKS BY INDIGENOUS PEOPLES

2.1. PERSPECTIVES FROM AFRICA

Traditional Knowledge of Weather Forecasting among Maasai Pastoralists in Northern Tanzania: Navigating Climate Change and its Impacts

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1. Introduction

In recent years, the role of traditional knowledge has received increasing attention as climate scientists, policy makers, academics and community advocates have acknowledged its significant contribution to ecosystem stewardship and mitigation of climate change impacts. Yet the central role played by weather forecasting knowledge in fostering traditional or indigenous economies in the context of climate change, as well as the associated ecological and policy barriers, remain scantly documented. This paper intends to contribute to filling this knowledge gap. It explores how Maasai pastoralists in Northern Tanzania draw upon traditional knowledge to forecast weather variabilities and adapt to the impacts of climate change. The paper also outlines ecological and the policy barriers impeding the traditional herders' adoptive capacities.

The remainder of the article is structured as follows: Part two summarizes the Maasai traditional knowledge of weather forecasting. Part three discusses how pastoralists use the knowledge to enhance their traditional economy and enhance food security and sustainable development in the age of climate change and its impacts. Factors weakening forecasting skills and corresponding decisions to enhance survival of the traditional economy are contained under part four. They include disappearance of plant species and the spread of invasive species, compounded by legal and policy frameworks

[1] Preparation for this presentation benefited from an empirical Study I conducted in 2016, with the support of UNESCO's Local and Indigenous Knowledge System (LINKS). I am thus thankful to UNESCO and my field researcher assistants Lucas Yamat, Saitoti Parmelo and Bahati Singo, as well as my student research assistants (as they were then) from the Faculty of Law, Tumaini University Makumira-Gift Joshua, and Elizabeth Kabwe.

that limit communal land ownership and the sharing of rangeland resources. Part Five discusses coping mechanisms. Part six contain the conclusion and recommendation.

2. Maasai Pastoralists' traditional their weather forecasting skills

Like other Indigenous peoples around the world, Maasai pastoralists in Northern Tanzania have well developed and robust traditional knowledge systems that are key to their survival and central to their roles in stewarding lands, territories, and resources. One key skill set relates to understanding and predicting weather patterns or variabilities. The predictive capacity is thus key to the pastoralists' survival. To exemplify this, a constant question a person understandably asks oneself upon hearing about the nomadic lifeway of pastoralists is: how do they know there would be rainfall where they intend to relocate in search of "greener pastures"? The answer to this question points to the existence of a body of traditional knowledge and wisdom which is passed from one generation to the next through oral tradition or storytelling.

Growing up in a rangeland young Maasai adults are trained to curiously observe changes in vegetation, livestock behaviors and other astronomical signs as important predictors of how a season would turn out to be and prepare accordingly. The training takes the form of experiential learning or learning by doing, and is highly dependent on the environment, hence the local environment is regarded as the "lab". For enforcement of the traditional knowledge imparted, trainings combine raising awareness on norms, rules, beliefs and practices, which achieve sustainable resources use within fragile environments, and which are responsive to community values and processes. In the next paragraphs examples are given of the weather forecasting skills in question.

2.1 Studying clues embedded in goats' small intestines

For Maasai pastoralists, goats provide and important source of food, specifically much needed protein, and milk. However, it appears the utility of goats goes beyond merely providing traditional food. In addition, goats when slaughtered serve as labs for studying climate variabilities. So, during goat slaughtering, small intestines are carefully studied whenever unusual features are noticed. If for example, bubbles are more than usual that is a clue for the good news that the rainy season is drawing closer.

Unlike cattle slaughtering which is done on rare occasions to mark traditional ceremonies, goats and sheep are kept primarily for easy access as a food source. Accordingly, they provide important and timely labs because clues can be known before it is too late to take decisions.

2.2 Signs observable in vegetation changes

In addition to grasses for livestock, rangelands are also replete with other vegetations such as fruits, trees and flowers. When *Olekitenyi (Abutilon Sp.)* start flowering, this is a wakeup call that a dry period (which is more likely to last longer than usual) is underway. The same message is conveyed by the ripening of fruits of *Ormesera* (*Adansonia digitata*).

3. Safeguarding traditional livelihood and fostering sustainability

Maasai Pastoralists use traditional knowledge of the weather forecasting to guide day-to-day decisions, enhance their traditional economy, foster sustainable development, and enhance food security. The main decision revolves around mobility: where, when and how to relocate to a new area once certain weather indicators discussed above become apparent. This is the essence of the nomadic lifeway and mobility is its central pillar.

By moving away from a place of prolonged droughts, Maasai pastoralists rescue their traditional economy from decimation. Mobility also enhances sustainable environmental management through land fallowing and reduced degradation. Pastoralism and its products comprise larger part of food sources, hence more animals mean more secure food reserve as an informal insurance scheme. This fact calls to question uncritical policy prescriptions and academic narratives requiring pastoralists to reduce the number of livestock and align with the rangelands “carrying capacity”.

Based on the above, it is thus self-evident that pastoralists could historically avoid losing their herds during drought because of their ability to forecast weather variabilities and make timely decisions. Weather forecasting skills as a critical traditional knowledge tool has over the years played a pivotal role as a strong basis for decisions taken by the pastoral communities from day-to-day. In the next part, this paper outlines barriers hampering pastoralists from implementing findings of weather forecasting. The factors can broadly be categorized as ecological and policy. The former relates to landscape-based developments, while the latter reflects decisions taken by policymakers as observed in legislative frameworks.

4. Barriers to implementing Weather Forecasting Findings

(a) Ecological barriers

Across rangelands in Northen Tanzania, there is an alarmingly notable disappearance of plant species the Maasai pastoralists have traditionally used to predict weather variabilities. Conversely, there is a surge of invasive species, mostly exotic. As a testament to their exotic nature, most of the invasive plant species have no common Maasai names. Instead, they are named according to how they look. A towering example is *Parthenium hysterophorus*, named in Maa (the language of the Maasai peoples) as *oloibor lukunya* (literally translated as white-headed because it blossoms white flowers).

While the origin of *oloibor lukunya* remains unknown, car dust propagates the invasive plant even further. The plant is testament to changes in weather patterns, and highly destructive to the pastoral indigenous livelihood because it competes with pastures for livestock and causes disappearance of plants used to predict the weather.

Apart from *oloibor lukunya,* a number of other local plant species are intruding in the grasslands. In the past, rangelands were evenly divided into bushes, trees and grasslands but currently grasslands are increasingly shrinking as a result of growing bushes of invasive species. They include *Iltepes,* which are very prevalent in Armanie sub-village of Terrat in Simajiro. This plant species is growing at an alarming proportion, and herders attribute it to change in the weather patterns over the last one decade. Compounding this, some disappearing species constitute very nutritious feeds for livestock and once completely lost, pastoral life in the rangeland will be more stressful.

(b) Policy barriers

Tanzania is characterized by overlapping legislative frameworks whose net-effects is to favor wildlife conservation over pastoralism. They include the Wildlife Conservation Act, 2009, the Ngorongoro Conservation Act, 1959 and National Parks Act, 1959. The interpretation and enforcement of the laws in question has resulted in forceful evictions and shrinking of pasturelands hence restricting mobility which is central to the pastoral lifeway.

Additionally, categorizing land used by pastoralists as village land (pursuant to the Village Land Act, no. 5 of 1999) has weakened traditional land use patterns and their supporting traditional institutions. This is largely through the creation of village governments which are semi-autonomous institutions on land management, accompanied by insistence on respecting village boundaries. While the Village Land Act allows for sharing of resources by neighboring villages, the process is easily reversible, cumbersome and too legalistic.

Another barrier is the introduction into the Tanzanian statute book, of the concept of 'unused' land (equivalent to the colonial concept of *terra nullius*). Specifically, the Land Act no. 4 of 1999 describes general land (which is available for allotment to the general public, including for the purpose of foreign direct investments) to include "unused village land". This concept disproportionally affects mobile pastoralists hence discourages them from moving lest their land be seen as 'idle' or unused.

5. Conclusion and Recommendations

Pastoralists have, from time immemorial, used traditional knowledge as an important tool kit for managing their traditional economy. A key skill set relates to weather forecasting, enabling them to make decisions on when and where to relocate as part of mobility. In the Context of Climate Change however, both the "raw materials" needed to make the predictions more accurately are highly affected. Additionally, what they do with the findings of their prediction remain highly affected by restrictive legal and policy frameworks that are unfriendly to pastoralism. This paper recommends implementation, in good faith, of various articles of the UNDRIP requiring protection of traditional livelihoods such as Article 20, 29 and 32.

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Building a Resilient Future through Indigenous Knowledge: The Case of the Mbororo People from Chad[1]

Hindou Oumarou Ibrahim
AFPAT President, Chad

Introduction

I come from the nomadic pastoralist community in Chad and my People are called Mbororo. They are cattle herders and live across 6 countries in Africa: Chad, Cameroon, Niger, Nigeria, Central African Republic, Sudan and, recently, due to the impacts of climate change, we also have a presence in Ghana and other countries. This has been our land for ages, even if today, due to the recent existence of countries and artificial national boundaries, within my family (cousin, uncles, aunties) we all have different nationalities.

My people live in harmony with all the natural species. We depend on rainfall, water and pastures for our cattle. Through centuries of practicing pastoralism, we have learned from our environment. Listening and observing different natural species has given us powerful assets to survive and understand our land. Where scientists see an "unstable" ecosystem, and Western representations see a "hostile" environment, Mbororo see a place where life and development are a reality. We know that for every environmental

[1]All the photos are from AFPAT, www.afpat.net

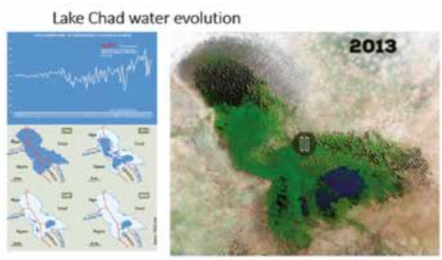
phenomenon that may involve a risk for our people, Nature has also given us a solution to cope with it. It has helped us to develop a wisdom and traditional knowledge that have been passing from one generation to another. We use this wisdom of our ancestors and modern science and technology to help communities build resilience. That is what we will share through this paper.

In this presentation I would like to show that, despite this complex situation involving Mbororo, their knowledge is proving to be a tool for us to cope with the environmental crisis. The first part of my presentation discusses some of the key findings that emerge from the community-led research that I did with my organization, the Indigenous Women and Peoples Association of Chad (AFPAT),[2] which has done so for more than 10 years, about the knowledge they have on climate and biodiversity. In particular, I will show some of the most important elements that they use to predict weather forecasts. The second part will focus on a specific example: on how the Mbororo people are currently working on their knowledge as the main resource to face the environmental challenges brought about by climate change.

Climate Change Impact

Due to climate change, our life and livelihood are being threatened. The resources that have been given to us are rapidly changing, and in this context our closeness to our environment is becoming an element of vulnerability vis-à-vis climate change impacts, biodiversity loss and desertification advance, and so our home is under threat.

The extent of our land's environmental degradation is clear when we observe one of the most precious environmental spots in the region, Lake Chad. It used to be one of the top five freshwater lakes of Africa; when my



[2] http://www.afpat.net

mother was born, the lake was about 25,000 square kilometers of freshwater. Today, in less than two generations, the lake has lost 90% of its water. What is happening to the lake has a huge impact for about 40,000,000 people living and depending on its fragile ecosystem. It has entailed the multiplication and intensification of conflicts between communities who are fighting against each other to get access to the remaining resources.

Mbororo Knowledge to Predict Weather

The Mbororo people do not have access to modern science or to Western technology, but we have access to the best science and technology ever, Nature. Nature has given us all the knowledge that we have needed to find, grow and choose our food, our medicine; to practice transhumance around places during a drought or during a flood, or even to forecast weather.

Our research showed that the Mbororo people use different components to predict weather, some ecological, and others astronomical. The ecological components include trees, flowers, plants, and fruits. We observe their size and their colors, and they help us do a forecast, to know if the coming rainy season is going to be good for us or not. We also observe animals, insects, and lizards.

Unlike the modern science forecast, our forecast is qualitative, and allows us to know if we will have a “good season” or not. While the science forecast focuses on the quantity of millimeters that a rainy season will bring, our forecast produces data that is important for our livelihood, which is mainly if the rains that the season will bring can penetrate the soil and therefore, if they will allow the vegetation to grow. For us, a quantitative rain forecast can be misleading, as a forecast for a generous quantity of rain may not exclude the possibility of floods, which cannot be considered a good season.

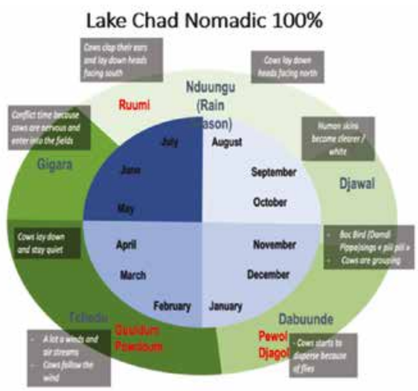
For Mbororo, the start of each season is determined by ecological and astronomical components. The start of the season is announced by our own cattle, by the flowers, by the trees, by the wind. We observe all that and we know exactly when the season is starting. Knowing when the season starts is important, because our transhumance system is seasonal but also because our vaccination plans are also dictated by the seasons. When the season is coming, we know there are some sicknesses that can come with it, so there are specific kinds of food that are recommended to be taken at given days and given hours of the day. You may eventually get the sickness, but it will be lighter than if you didn't have your vaccine.

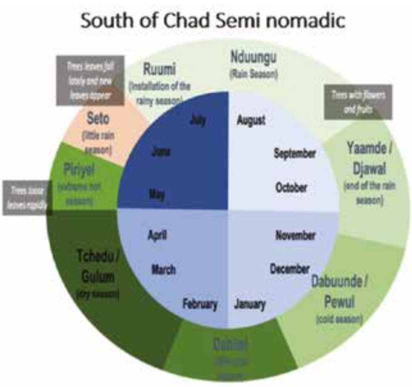
We Mbororo also observe the different winds. There are many winds, and we observe their direction, if they are heavy, if they are dry, etc. We observe the cloud position and stars in the sky and we make predictions from astrological observation.

The research we have been doing is also focused on our seasonal calendars, which are based on the different ecosystems existing in our territories, including the Sahel, the savannah and the tropical forest. Each of those ecosystems involves different ecological dynamics, and understanding them demands specific knowledge about the weather. Even the way the knowledge that each ecosystem is used changes from one region to another.

Mbororo Seasonal Calendar

For the seasonal calendar, we have captured that knowledge in representations and here you can see the seasonal calendar from the Lake Chad region (left) and the South Chad area, where seminomadic groups live (right). This model is only a very brief summary of the research showing, as





the full calendar is not yet published while we need to ensure the safeguard and protection of this unique knowledge of our people.

Our seasons are ecosystemic-based, which means that each region has its own calendar. Around Sahel and in the savannahs, which means around Lake Chad, the seasonal calendar has five seasons, and seven seasons in between the savannahs and the tropical area of southern Chad. Unlike the seasonal calendar in Europe or, in general, in Western culture, where they refer to four seasons in a very extended area, for Mbororo the season you have depends on the place where you are.

Astrological and Constellation Observation

The Mbororo also observe stars and constellations in the sky. There are millions of stars, and we follow the stars day or night to guide our displacements. Stars give us the predictions that we need, and insights on how we can adapt our life to different scenarios. For example, when it rains, we need to have a shelter to cover our people and our cattle. When you are a pastoralist, you know you need to be in the grasslands but there are not many shelters in those lands. As nomadic people, you need to predict the weather so you know when exactly it is raining, and can be close to a place where you can hide. You need to know that very precisely, as you also know that, if it is not raining, you have to be outside feeding your cattle and, if it is a dry season, to hide from the hot weather and water scarcity. This is why it is so important for nomadic people to predict the weather.

From the millions of stars in the sky, our people have identified 28 stars that are really crucial. We know each of them and we know when they will come up and go down. Twenty-seven of them are visible in the sky for 13



Star numbers	Numbers of days appearance of stars	Total
27	13	351
1	14	14
Total		365
One year = 365 days		

days and during that time they provide information to us, but one of them is visible for 14 days. This happens during the heavy rainy season. The cycle of those 28 stars is equivalent to 365 days, which corresponds to a 1-year cycle. Our people do not have yearly calendars, but we calculate our years based on the stars, and they guide us to know exactly how we can travel.

2D/3D Participatory Mapping: Using Science, Indigenous Peoples' Knowledge and Technologies

Our research has identified key challenges that our knowledge is facing nowadays. The Mbororo people are wondering how, in this context, it would be possible to transfer their knowledge to the next generations. Our knowledge is oral and it is not for us, it is also for the next generations who are the young people that can now use the technology and the science to safeguard it.

Having that as a context, I, through my organization, initiated to combine and marry the three different knowledge systems: the traditional knowledge of our people, modern science and technology. This initiative is to tap their knowledge and reinforce it through 2D or 3D participatory mapping, also engaging some science and technology tools. This experience will be explored in the following second section.

The use of 2D and 3D participatory mapping has revealed itself to be an experience with tangible results in terms of strengthening resilience for the Mbororo people and other communities living together. I will share some findings from the most recent experience, which is 2D participatory mapping. Unlike 3D participatory mapping, which requires engaging a baseline of geographical information to build the map with the community, 2D participatory mapping can be built with a satellite image. We worked with a database organization that provided us with the relevant images.

In the last three years, the Mbororo people have focused on two maps. One of them, in the southern part of Chad, represents an area of 2,500 kilometers square and involved 116 communities' chiefs from villages and the nomadic stopping areas. While a second one represents the area around the Lake Chad, and covers 3,500 kilometers square, the latter has involved working with more than 556 community villages (who represent a few thousand people), nomadic stops, villages and islands because it is around Lake Chad.

The process is, after printing the satellite images at the exact scale, I went to the community. We first worked with the communities in the elaboration of legends that could be designed and agreed by everyone and decided on the one we can translate through the general languages and the one that we have to keep only in our indigenous language to protect it. Our project encountered some challenges when trying to engage our knowledge in this collaboration with science and technology. Our knowledge is based on oral traditions, and the way we speak about it or explain it are quite different from the methods used by science. This is a challenge when it comes to trying to work with the knowledge of the Mbororo people in contexts that are different from the ones in which it originated, and especially when trying to engage our knowledge in a dialogue with science, to translate this knowledge in order to reinforce both knowledge systems in a way that can save us for long.

From that perspective, it was very important to respect and be faithful to the way the knowledge was expressed and shared by the community. Sometimes they said, for example, that the water was green in a place, and so the legend has to reflect that, as the legend has to mean something to the community as it is them who know better their environment.

At the end of the work on the legends, we open the map, and we put them in specific places on the map. When you start matching the map with

the knowledge the people have about it, you realize that the best satellite image is nothing if it is not populated by the data of the community. At the end of the exercise, I take a photo of the map, and I digitalize it. The result is the map that you can see on the left of the image below.

Indigenous Knowledge for Decision and Policy-Making

The next stage of the process was to go back with the printed map to the community, and work with them to produce a charter of principles to guide their action on the basis of the knowledge captured in the map. The last charter we did has 20 articles in 3 chapters: chapter one focuses on how they can better manage the natural resources and share them; chapter 2 focuses on how they can mitigate the conflict over the resources, and chapter 3 looks at how they can protect and share and save the traditional knowledge that they have. At the end of the drafting, each community chief agrees, signs the charter and we then develop a workplan of implementation. The main activities of the work plan include the restoration of the land, the strengthening of women and youth participation, women's land rights, a conflict resolution committee, etc.

Every member of the community took the charter and a copy of the digital map with them, as a document that will help the community to solve conflict, guide land and natural resource management, and live in harmony between them. A salient outcome of this exercise is, for example, that two months ago, a community chief gave land rights to women in his community and, for the first time, women got land rights. Since then, different communities want to walk in that direction and we are now working in getting them an official paper for their land. Communities involved in the project have also agreed to do a collective agroecology project to transfer relevant Indigenous Peoples' knowledge to their children, while also ensuring to have an income to send the children to school and protect their area from environmental hazards.

At the national level, the experience I have just explained has also been very powerful. Our research and experience has helped the national government of Chad to better work with the Indigenous communities, and to include them in decision-making processes when they are planning adaptation and mitigation. We have achieved that, when you look at the Chad National Adaptation Plan, there is a paragraph that recognizes the work of the Mbororo people on participatory mapping, and recognizes community knowledge, which is important for a National Adaptation Plan.

The experience I brought to you today shows that by putting modern science knowledge together with Indigenous Peoples' traditional knowledge and technology, we can really build a better place for the communities and include the communities who did not go to school, to get the chance to contribute and also to safeguard their knowledge.

YOUTUBE PRESENTATION

Indigenous Knowledge and Climate Change Adaptation Strategies: Lessons from Maasai Pastoralists of East Africa

STANLEY KIMAREN OLE RIAMIT
Indigenous Livelihoods Enhancement Partners (ILEPA)

https://youtu.be/ae6amoyCuqI?si=Gnun4nsY20gGK5jP

2.2. PERSPECTIVES FROM THE AMERICAS

Los conocimientos tradicionales de los Pueblos Indígenas en experiencias de salud y educación intercultural en Abya Yala

Myrna Cunningham Kain
Chair of Pawanka Fund and Vice President of Fund for Development of Indigenous Peoples in Latin America and the Caribbean-FILAC. Former chair of the Center for Autonomy and development of Indigenous Peoples-CADPI

Presentación

Cada Pueblo Indígena ha podido enfrentarse a múltiples desafíos y sobrevivir, gracias a poseer y aplicar sus sistemas de conocimientos en sus territorios, con sus recursos culturales y naturales, mediante sus instituciones, estructuras y normas de gobernanza. Esos conocimientos son fundamentales para la soberanía alimentaria, la salud, la conservación de especies animales y vegetales y han dado pruebas continuas de que no se oponen ni rechazan a los cambios y se adaptan mediante innovaciones ante diversas circunstancias.

Sin embargo, esos sistemas de conocimientos requieren un entorno favorable para continuar desarrollándose y aplicarse, que debe estar constituido principalmente por marcos legales e institucionales que respondan a los derechos humanos, estar expresados principalmente mediante políticas públicas y programas interculturales, y contar con mecanismos sistemáticos de participación de los Pueblos Indígenas.

Los derechos de los Pueblos Indígenas han tenido avances significativos en las últimas décadas en América Latina, respondiendo a las características y especificidades de cada país, la lucha de los propios Pueblos Indígenas, así como con la evolución de las normas internacionales de derechos humanos, especialmente el Convenio No. 169 de la OIT y la Declaración de la ONU sobre los derechos de los Pueblos Indígenas.

Este documento hace un recorrido sobre experiencias de promoción y aplicación de políticas y programas de salud y educación interculturales en América Latina y el Caribe; experiencias que buscan aplicar los derechos de los Pueblos Indígenas, promover las relaciones y el diálogo inter-científico entre los sistemas de salud y educación indígenas en el marco de la armonía y del respeto, reciprocidad e igualdad con los diversos sistemas de conocimientos y prácticas existentes, con el objeto de alcanzar la plenitud y armonía de los Pueblos Indígenas, en un marco de convivencia respetuosa entre culturas.

Para los Pueblos Indígenas, el bienestar equivale a la convivencia armónica entre los seres humanos con la naturaleza, consigo mismo y con los demás, encaminada al bienestar integral, a la plenitud y tranquilidad espiritual, individual y social; por lo tanto, para la salud intercultural, todas las personas y comunidades deben comprometerse en la lucha por alcanzar y mantener el equilibrio interior y exterior, recuperar y mantener el equilibrio entre todos los elementos de su entorno natural, social y espiritual, para responder a las leyes naturales y espirituales de los Pueblos Indígenas y alcanzar el bienestar.

Las experiencias de educación intercultural parten del concepto indígena de educación, en el cual el aprendizaje de los conocimientos, saberes, habilidades físicas, mentales, espirituales y emocionales, son necesarios para vivir como personas, pero principalmente para vivir como miembros de una comunidad, como miembros de un Pueblo; por lo tanto, la educación intercultural involucra componentes políticos, económicos, sociales y culturales en la búsqueda por asegurar su continuidad como Pueblos.

Para salud y educación intercultural, desde la visión de los Pueblos Indígenas, lo primordial es, "cuidar a la comunidad, para que pueda seguir viviendo en armonía, en su territorio, fuente de riqueza, vida y conocimientos".

Los Pueblos Indígenas en LAC

En la región de América Latina y el Caribe hay más de 800 Pueblos Indígenas, con una población cercana a 60 millones de personas, que se caracterizan por su amplia diversidad demográfica, social, territorial y política; incluyen Pueblos en aislamiento voluntario, más de 100 pueblos transfronterizos y Pueblos creciendo cada vez más en asentamientos urbanos.[1]

Se observan importantes cambios socio demográficos: puesto que las y los pobladores indígenas continúan siendo más jóvenes que los no indígenas, están viviendo procesos de desplazamiento, migraciones y urbanización progresiva y aunque aún prevalece la ruralidad, ya hay se hay predomi-

[1] Fabiana Del Popolo (ed.), *Los pueblos indígenas en América (Abya Yala): Desafíos para la igualdad en la diversidad*, Libros de la CEPAL, N° 151 (LC/PUB.2017/26), Santiago, Comisión Económica para América Latina y el Caribe (CEPAL), 2017.

nio urbano, especialmente en Chile, Perú y Uruguay[2] por diversos factores, tales como la expansión de las ciudades, el traslado voluntario en búsqueda de empleo y educación, hasta la expulsión de sus territorios por despojo, desalojo, militarización, conflictos armados, degradación de suelos, ausencia de agua, y desastres ambientales por cambio climático.

La cantidad de habitantes y Pueblos varía mucho entre países; en Bolivia y Guatemala más del 40% de la población son indígenas; en Perú con 8 millones de personas representan el 26% y en México con 27 millones de personas indígenas representan el 21,5% de la población. En el resto de los países, menos del 10% de la población son indígenas. De igual manera, el número de Pueblos por país varía ampliamente, desde Brasil, con 305 Pueblos, Colombia con 102 pueblos, hasta El Salvador con sólo 3 Pueblos.

Los territorios de los Pueblos Indígenas contienen alrededor de un tercio de los bosques del continente, lo cual representa el 14% del carbono almacenado en los bosques tropicales de todo el mundo; también albergan una enorme diversidad de fauna y flora silvestres y juegan un papel clave en la estabilización del clima local y regional,[3] lo cual también contribuye a la fragilidad demográfica de muchos Pueblos Indígenas, puesto que enfrentan factores de vulnerabilidad socioambiental y territorial, tales como los desplazamientos forzados, la escasez de alimentos por sequías y desastres ambientales, contaminación de aguas, degradación de suelos, desnutrición, transición epidemiológica y elevada mortalidad, entre otros.

Las principales amenazas que enfrentan actualmente están vinculadas a los impactos de cambio climático, el modelo económico (más concesiones mineras, agrícolas, forestales), la desigualdad tecnológica, el empobrecimiento y la brecha entre los derechos reconocidos y su implementación. En la Región, la pandemia de COVID-19 exacerbó las manifestaciones de racismo y discriminación, así como la transición minera y energética, entre otras expresiones del modelo económico extractivista, cual se expresa a través del cierre de espacios de diálogo, limitados mecanismos de consulta, Consentimiento Previo Libre e Informado-CPLI y participación real, a lo cual se suma el incremento de la violencia y asesinatos contra líderes indígenas.

A pesar de lo anterior, los Pueblos Indígenas cuentan con modalidades organizativas diversas para promover sus derechos en distintos niveles. Se

[2] CEPAL. CELADE. *Los pueblos indígenas en América Latina. Avances en el último decenio y retos pendientes para la garantía de sus derechos*. Naciones Unidas, noviembre de 2014.

[3] FAO. FILAC. *Forest governance by indigenous and tribal peoples. An opportunity for climate action in Latin America and the Caribbean*. FAO. Santiago, 3031.

encuentran Pueblos en procesos de autonomía y autogobierno, organizaciones nacionales, sub regionales y procesos de articulación en distintos niveles para la promoción de temas fundamentales para la gobernanza global como el cambio climático, la biodiversidad, la Agenda 2030 y los Objetivos de Desarrollo Sostenible-ODS, entre otros. Las mujeres y juventudes indígenas han establecido diversas modalidades organizativas para incidir sobre aspectos particulares y complementar las demandas de sus respectivos pueblos. La revitalización de las estructuras ancestrales en algunos casos ha permitido incorporar en la conducción de los procesos de autogobierno componentes de espiritualidad, ritos, códigos y símbolos, que han dado pasos a la revitalización de sistemas de conocimientos propios.

Sistemas de conocimientos y salud de los Pueblos Indígenas

Los sistemas de salud de los Pueblos Indígenas están basados en sus conocimientos tradicionales y se entienden como el resultado de relaciones armoniosas del ser humano consigo mismo, con la familia, la comunidad, la naturaleza y los espíritus; en tanto, la enfermedad se define como la pérdida de equilibrio de esas relaciones. Ese concepto de salud articula elementos físicos, mentales, espirituales y emocionales e involucra aspectos políticos, económicos, sociales y culturales; forma parte de las normas respetadas, transmitidas entre generaciones y aplicadas por los miembros de las respectivas comunidades, que son la base de sus formas propias de gobernanza.

a) Enfermedades provocadas por los espíritus de los muertos;

b) Enfermedades ocasionadas por el dueño de la montaña, el espíritu protector del agua, del pantano, los duendes;

c) La relación entre la temperatura del cuerpo humano y el medio ambiente con la presencia o ausencia de espíritus, que son atraídos o repelidos por el frío o calor del cuerpo humano o el entorno provoca enfermedades;

d) El papel de los astros: especialmente la luna o los eclipses inciden sobre la salud;

e) Enfermedades ocasionadas por el uso de veneno, energías negativas y el libro negro usado para maldades, envidia o venganza; y,

f) Enfermedades por el incumplimiento de las normas culturales comunitarias.

En la medicina tradicional indígena hay que considerar, al menos:

a) A las y los portadores de dones y conocimientos tradicionales. Estas personas utilizan plantas medicinales, rituales, animales, se comunican con los espíritus, otros. Adquieren sus conocimientos a través de sueños, las plantas, trasmisión oral, oraciones, así como mediante la relación con la naturaleza, los ancestros o los espíritus;

b) Las normas, ceremonias comunitarias y de crianza familiar incluyen los conocimientos y prácticas tradicionales para prevenir, curar, rehabilitar y sanar; y,

c) La confianza, creencia y práctica colectiva de los miembros de las comunidades para respetar y cumplir las normas.

En la medida en que ha avanzado el reconocimiento de los derechos de los Pueblos Indígenas, se ha comenzado a valorar sus conocimientos y sistemas de salud, surgiendo el concepto de salud intercultural vinculado a las políticas y programas de salud que permiten a las y los usuarios utilizar la biomedicina convencional y la medicina indígena tradicional de forma complementaria, permitiendo la referencia y contra-referencia y el aprendizaje mutuo.

Experiencias de salud intercultural en LAC

El surgimiento de sistemas de salud interculturales se sustentan en el reconocimiento de los "*métodos de prevención, prácticas curativas y medicamentos tradicionales*" de los Pueblos Indígenas en las normas internacionales de derechos humanos. El Convenio No. 169 de la OIT, aprobado en 1989, fue uno de los primeros, puesto que reconoce la medicina indígena tradicional, el enfoque holístico de salud y consigna el derecho a la organización y prestación de los servicios de salud bajo la responsabilidad y control de los Pueblos Indígenas.[4]

A lo largo de varias décadas, los Pueblos Indígenas negociaron con los Estados en el seno de la ONU la Declaración de la ONU sobre derechos de los Pueblos Indígenas, adoptada en 2007, logrando igualmente incluir el derecho a sus medicinas tradicionales y a mantener sus prácticas de salud, incluyendo la conservación de sus plantas, animales y minerales medicina-

[4] ILO. C 169. Convenio sobre Pueblos Indígenas y Tribales, 1989 (num 169). Ver Arto. 25.

les y establece que las personas indígenas tienen el derecho al acceso de esos servicios, sin discriminación alguna.[5]

En 1999 la Organización Mundial de la Salud da los primeros pasos para analizar los desafíos en salud, derechos humanos, investigaciones y las estrategias para enfrentar la situación de salud de Pueblos Indígenas, reconociendo la importancia de la sabiduría de los Pueblos Indígenas transmitida entre generaciones sobre plantas, hierbas y flores que tienen el poder de curar.[6] En las Américas, ese proceso había iniciado desde 1993, en el marco del Año Internacional de Pueblos indígenas de la ONU, cuando la Organización Panamericana de la Salud-OPS/OMS, con el auspicio de la Sociedad Canadiense para la salud internacional y otros organismos, celebró una reunión de consulta sobre la salud de los Pueblos Indígenas. Como resultado, definió cinco principios para el trabajo en salud con Pueblos Indígenas; a saber:

– La necesidad de adoptar un concepto holístico de la salud;
– El derecho a la autodeterminación de los Pueblos Indígenas;
– El derecho a la participación sistemática;
– El respeto de las culturas indígenas y su revitalización; y,
– La reciprocidad en las relaciones.

Las recomendaciones fueron incorporadas en la Resolución V, "SALUD DE LOS PUEBLOS INDIGENAS",[7] que constituyó un compromiso político de los Gobiernos Miembros, de otorgar prioridad al mejoramiento de la salud de los Pueblos Indígenas, respetar su cultura y sus conocimientos ancestrales.

Ese proceso coincidía en la región con importantes avances en el reconocimiento de derechos individuales y colectivos de los Pueblos Indígenas en instrumentos jurídicos, cambios institucionales, políticas y programas en diversos temas. En cuanto a la salud, al menos cuatro países han recono-

[5] UN. 61/297. United Nations Declaration on the Rights of Indigenous Peoples. 13th September, 2007. Ver Arto. 24. See Official Records of the General Assembly, Sixty-first Session, Supplement No. 53 (A/61/53), part one, chap. II, sect. A.

[6] Bruntland, G., International consultation on the health of Indigenous Peoples. No. 23, 1999. Geneva, Switzerland. Archives of Women's Political Communication. Iowa State University.

[7] Pan American Health Organization (PAHO). HSS/SILOS-34 IRIS PAHO. Resolución V; salud de los pueblos indígenas-IRIS-PAHO. 1993. https://iris.paho.org/handle/10665.2/40395

cido el derecho a la salud de los Pueblos Indígenas en sus Constituciones Políticas, siendo éstos el Estado Plurinacional de Bolivia, Ecuador, México y la República Bolivariana de Venezuela; por otro lado, varios países han reconocido el derecho a la salud de los Pueblos Indígenas en legislaciones y decretos, mientras otros, han promulgado leyes sectoriales que incorporan el derecho a la salud de los Pueblos Indígenas,[8] o casos como Panamá, que protege los conocimientos de medicina tradicional indígena.

Hay al menos 14 países en la región que cuentan con instancias estatales que gestionan la salud intercultural, mediante instancias como viceministerios, direcciones nacionales y programas de salud intercultural, siendo éstos: Bolivia, Brasil, Chile, Costa Rica, Ecuador, México, Nicaragua, Panamá, Perú, Venezuela, Colombia, Guatemala, Honduras y Paraguay.[9] Brasil cuenta con el Subsistema de Atención a la Salud Indígena; en México, está la experiencia de Casas de las mujeres que ofrecen servicios interculturales o, en Paraguay, se crea el Consejo Nacional de Salud de los Pueblos Indígenas y la Dirección Nacional de Salud de los Pueblos Indígenas (DINASAPI).

Otros países cuentan con medidas especiales de administración de los sistemas propios de salud de los Pueblos Indígenas, como Colombia que se sustenta en la concepción de vida colectiva en armonía con la Madre Tierra, acorde a la cosmovisión de cada Pueblo. El Estado Plurinacional de Bolivia ha generado instrumentos normativos específicos y ha adoptado la Ley N°459 de Medicina Tradicional Ancestral Boliviana que tiene por objeto regular el ejercicio, la práctica y la articulación de la medicina tradicional ancestral boliviana en el Sistema Nacional de Salud; de igual manera, crea el Sistema de Registro Único de Medicina Tradicional Ancestral Boliviana-RUMETRAB, el Sistema de Registro de Plantas Medicinales y el Viceministerio de Medicina Tradicional e Interculturalidad con la atribución de promover "la medicina tradicional y su articulación con la medicina occidental, respetando los preceptos de interculturalidad".[10]

[8] FILAC. 2024. Sistema de monitoreo paritario en seguimiento a la implementación de la Recomendación General Num, 39 de la CEDAW y la medición de los indicadores del capítulo indígena del Consenso de Montevideo sobre población y desarrollo con énfasis en mujeres y niñas indígenas. La Paz, Bolivia.

[9] CEPAL. Los Pueblos Indígenas en América Latina. Avances en el último decenio y retos pendientes para la garantía de sus derechos. Naciones Unidas. Noviembre del 2014. Santiago, Chile.

[10] Ministerio de Salud y Deportes. Ley No. 459. Ley de Medicina Tradicional Ancestral Boliviana, diciembre de 2013. www.gacetaoficialdebolivia.gob.bo

Nicaragua cuenta con la Ley de Medicina Tradicional ancestral, que tiene por objeto reconocer el derecho, respetar, proteger y promover las prácticas y expresiones de la medicina tradicional ancestral de los Pueblos Indígenas y afro-descendientes en todas sus especialidades y el ejercicio individual y colectivo de los mismos, en función de la salud propia e intercultural y establecer las garantías adecuadas que corresponden al Estado para su efectiva aplicación y desarrollo.[11] Esa ley complementa las disposiciones tanto de la Ley General de Salud (Ley No. 423 del 2002)[12] y el Estatuto de Autonomía (Ley No. 28 de 1987) de las Regiones Autónomas de la Costa Caribe que establece que los Pueblos Indígenas, comunidades afrodescendientes y étnicas, pueden definir un modelo de atención de salud conforme a sus tradiciones, cultura, usos y costumbres.[13] Ese modelo está en práctica y se conoce como Modelo de Salud Autónoma e intercultural.

En las diversas experiencias de salud intercultural en la región se encuentran casos en los cuales se han incorporado a portadores de conocimientos de salud indígena – *sukias*, shamanes, curanderos y parteras – en los servicios de atención primaria de salud.[14] En otros casos, se ha organizado la oferta conjunta en unidades de salud: por ejemplo, en Ecuador se identifican casos del Hospital Indígena de Tungurahua, el Hospital Andino de Riobamba y el Centro Jambi Huasi de Cañar; o en Chile, se cuenta con las experiencias del Hospital Mapuche Rural de Makewe, el Centro de Salud Intercultural Boroa Filu Lawen y el Complejo de Salud Intercultural de Nueva Imperial. Las mejores experiencias organizan modelos de gestión intercultural en paralelo, en donde los diversos sistemas de salud cuentan con mecanismos de referencia-contrarreferencia o acciones conjuntas acordades.

También se han establecido Sistemas de Información de Atención y registro de enfermedades indígenas. En el caso de Guatemala hay experiencias de vigilancia epidemiológica sociocultural de enfermedades Mayas y 53 riesgos individuales, familiares y del medio ambiente, que permiten a

[11] Asamblea Nacional de Nicaragua. 2011. Ley No. 759, Ley de medicina tradicional ancestral. Marzo 2011.

[12] Asamblea Nacional de Nicaragua; Ley No. 423, Ley general de salud. Marzo 2002.

[13] Ver Asamblea Nacional de Nicaragua. Ley No. 28 de Autonomía de las Comunidades de la Costa Atlántica de Nicaragua. 1987; Consejos Regionales Autónomos RAAN y RAAS. Resolución de Modelos de Salud autónomos e interculturales. 1997; Guía para la Organización del Modelo de Atención de Salud Intercultural de las Regiones Autónomas de la Costa Caribe Nicaragüense MASIRAAN-MASIRAAS. Mayo, 2009.

[14] Argentina, Bolivia (E. Plurinacional), Brasil, Chile, Colombia, Ecuador, El Salvador,Guatemala, México, Nicaragua, Panamá, Paraguay, Perú. En FILAC, 2024.

los equipos de salud analizar periódicamente con terapeutas tradicionales y organizaciones comunitarias.[15] En el caso de Nicaragua igualmente se han incorporado en las enfermedades de información obligatoria los casos de Blakira o Grisi siknis que generan ciclos epidémicos agudos, así como otras enfermedades indígenas.

La documentación y promoción de las terapias indígenas ha sido ampliamente utilizada, principalmente por las mismas organizaciones indígenas. Durante la pandemia de COVID-19, la Plataforma de Pueblos Indígenas contra COVID-19 promovida por el Fondo para el desarrollo de los Pueblos Indígenas de América Latina y el Caribe-FILAC y el Foro Indígena de Abya Yala-FIAY documentó decenas de experiencias de medicina tradicional utilizados como terapia y para fortalecer el sistema inmunológico de las personas.[16] Igualmente, hay experiencias como el Ministerio de salud y deportes del Estado Plurinacional de Bolivia que elaboró una Guía de medicina tradicional para abordaje de la COVID-19.[17] La experiencia de investigación en México es de larga data y cuenta con una biblioteca de Medicina Tradicional Mexicana, hoy Biblioteca Digital de la Medicina Tradicional Mexicana,[18] con una amplia documentación compilada.

Por lo tanto, la promoción de la educación intercultural busca potenciar los conocimientos autóctonos, y servir de instrumentos para el fortalecimiento de sus familias y comunidades, tanto por el dominio de sus propios sistemas de conocimientos, como de otros sistemas de conocimientos. Diversas experiencias en la región han permitido aprender que se obtienen mejores resultados cuando el hilo conductor de la educación es la generación de nuevos conocimientos, mediante la actividad investigativa que permite unir lo autóctono o endógeno con lo foráneo o exógeno, lo nuevo con lo viejo.

[15] Medicus Mundi-Navarra. Claves para la transformación de los sistemas de salud en América Latina. Bolivia, Guatemala y Perú. Tres experiencias, una sola acción integral e incluyente en atención primaria de salud. http://www.saludintegralincluyente.com/ftp/saludintegralincluyente/DOCUMENTOS/PDF/Libro/LIBROsaludintegralincluyente.WEB.pdf

[16] FILAC. FIAY; 2020. Tercer informe regional. Plataforma indigena regional frente a COVID-19. Buenas prácticas de los Pueblos Indígenas frente a la pandemia. Comunidades resilientes. https://indigenascovid19.red/wp-content/uploads/2020/09/FILAC_FIAY_tercer-informe-PI_COVID19_final.pdf

[17] Ministerio de Salud y Deportes. 2021. Direccion general de Medicina tradicional. Guia de medicina tradicional para abordaje de la COVID-19. La Paz: Stigma, 2021.

[18] Zolla, C. *Diccionario enciclopédico de la medicina tradicional mexicana*. 1994.

Las primeras experiencias de educación intercultural en la región datan de mediados del Siglo XX, y se caracterizaron por promover el uso de las lenguas indígenas, bajo diversos formatos y con distintos matices y propósitos, lo cual no ha sido casual, puesto que, para los Pueblos Indígenas, las lenguas son el medio de transmisión de sus sistemas de conocimientos. Consideran que un pueblo que no practica su lengua, ya sea por imposición o por decisión para evitar ser discriminados, desaparece como cultura.

A pesar de los múltiples esfuerzos, las 500 lenguas indígenas que aún se hablan en América Latina están todas en situación de mayor o menor amenaza o riesgo y al menos 25% de ellas están en riesgo de extinción.[19]

Las experiencias de educación intercultural buscan reconocer el valor de la diversidad como un elemento indispensable para un aprendizaje integral y de calidad; tratan de que se valoren todas las culturas por igual y buscan superar la discriminación que sufren los Pueblos Indígenas, generando condiciones para cambiar las relaciones hasta ahora desiguales entre los Pueblos Indígenas, con el resto de la población y los Estados.

Los Pueblos Indígenas enmarcan la discusión sobre la interculturalidad en la educación en el campo de los derechos humanos y la necesaria complementariedad entre los derechos individuales de sus miembros y sus derechos colectivos como Pueblos, por lo tanto, han promovido políticas de interculturalidad acorde al derecho internacional y sus distintos instrumentos, tales como el Convenio Núm. 169 de la OIT y la Declaración de las Naciones Unidas sobre los Derechos de los Pueblos Indígenas.

La Declaración reconoce que los Pueblos Indígenas tienen derecho a establecer y controlar sus sistemas e instituciones docentes, que impartan educación en sus propios idiomas, en consonancia con sus métodos culturales de enseñanza y aprendizaje; que las personas indígenas, en particular la niñez, tienen derecho a todos los niveles y formas de educación del Estado sin discriminación; y que los Estados deben adoptar medidas eficaces, junto con los Pueblos Indígenas, para que las personas indígenas, en particular la niñez, incluidos los que viven fuera de sus comunidades, tengan acceso, cuando sea posible, a la educación en su propia cultura y en su propio idioma.[20] Otros derechos reconocidos en la Declaración son:

[19] FILAC, 2020. Informe Regional. Pueblos e idiomas indígenas en América Latina y el Caribe: situación actual y perspectivas. La Paz, Bolivia. Diciembre de 2020.

[20] UN.61/297. United Nations Declaration on the Rights of Indigenous Peoples. 13th September, 2007.

a) El derecho a practicar y revitalizar sus tradiciones y costumbres culturales (Artículo 11);

b) El derecho a manifestar, practicar, desarrollar y enseñar sus tradiciones, costumbres y ceremonias espirituales y religiosas; a mantener y proteger sus lugares religiosos y culturales (Artículo 12);

c) El derecho a revitalizar, utilizar, fomentar y transmitir a las generaciones futuras sus historias, idiomas, tradiciones orales, filosofías, sistemas de escritura y literaturas (Artículo 13);

d) El derecho a mantener y fortalecer su propia relación espiritual con las tierras, los territorios, las aguas, los mares costeros y otros recursos que tradicionalmente han poseído u ocupado y utilizado (Artículo 25);

e) El derecho a mantener, controlar, proteger y desarrollar su patrimonio cultural, sus conocimientos tradicionales, sus expresiones culturales tradicionales y las manifestaciones de sus ciencias, tecnologías y culturas; y a mantener, controlar, proteger y desarrollar su propiedad intelectual de ese patrimonio, sus conocimientos tradicionales y sus expresiones culturales tradicionales (Artículo 31).

Actualmente, la mayoría de los Estados en la región cuentan con instrumentos legales y estructuras institucionales dedicadas a la educación de los Pueblos Indígenas, aunque se identifica que en algunos casos continúan promoviendo el uso de la lengua y códigos indígenas como peldaño para la adquisición del idioma y cultura oficial mayoritario, consideradas como herramientas necesarias para acceder a la "otra" cultura o incluso para acceder a una educación occidental y urbana. Hay otras experiencias, por el contrario, que buscan un trato igualitario de las distintas culturas y lenguas y ven la educación intercultural como una necesidad de toda la sociedad y no solo de los Pueblos Indígenas, para lo cual buscan adecuar toda la institucionalidad educacional de su respectivo país.

Por lo tanto, lo que se observa en la región es una gran diversidad de respuestas educativas interculturales. Hay una gran variedad de normas, concepciones teóricas y metodológicas con estructuras institucionales diversas. Las políticas educativas interculturales responden también a los contextos sociopolíticos de cada país, al nivel de formación docente y las formas en que se tratan los conocimientos, las prácticas pedagógicas y el papel de las y los sabios indígenas. En la mayoría de los casos, las políticas y los programas se orienten mayoritariamente a la educación primaria, con limitada presencia en la educación secundaria y técnica. Entre las principales estrategias utilizadas para incluir los conocimientos de los Pueblos Indígenas, se pueden identificar las siguientes:

I. programas de rescate y uso de las lenguas indígenas, tanto en la docencia como en la producción de materiales;
II. programas de formación de docentes profesionales culturalmente pertinentes. Hay cada vez mayor reconocimiento de que se requiere de maestras y maestros capacitados tanto para programas bilingües como interculturales;
III. programas dirigidos a formular adaptaciones curriculares en el marco de una perspectiva intercultural que incorporen los conocimientos indígenas y consideren la necesidad de alcanzar al conjunto de la sociedad con una perspectiva de interculturalidad. Las mejores experiencias han estructurado la organización curricular en torno a la vida cotidiana incorporando contenidos locales relativos a conocimientos y técnicas locales. Para ello ha sido importante la participación comunitaria mediante expertos comunitarios en conocimientos tradicionales y tecnologías apropiadas en campos como la artesanía, la botánica, las técnicas agrícolas, la historia oral, la medicina, la música, la astronomía, las prácticas religiosas y el arte, entre otros.
IV. Programas de educación superior. En 11 países de la región se cuenta con programas de formación superior con enfoque intercultural, ya sea mediante la creación de Universidades Indígenas e Interculturales, así como mediante la transversalización progresiva de la perspectiva intercultural en instituciones de educación superior convencionales. La incorporación de los conocimientos, la historia y la situación de los Pueblos Indígenas se ha realizado principalmente mediante las siguientes estrategias:[21]

a) Basan el diseño curricular, el modelo de gestión y el desarrollo de los programas en la cosmovisión y filosofía indígena y son elaborados con participación del liderazgo comunitario, sabios/as indígenas y en su ges-

[21] UNPFII. E/C.19/2013/17 Estudio sobre Estudio sobre la forma en que se incluyen en los planes de estudios de los sistemas educativos los conocimientos, la historia y las circunstancias sociales actuales de los pueblos indígenas. 20 de febrero del 2013. http://documents.un.org/doc/undoc/gen/n13/238/46/pdf/n1323846.pdf?token=EE5ahjqj4jjA

tión procuran incorporar a representantes de los Pueblos Indígenas en los consejos directivos y, en algunos casos, su conducción está bajo la responsabilidad de las organizaciones indígenas. Una experiencia en ese sentido es la Universidad Amawtay Wasi, creada por la Confederación de Nacionalidades Indígenas del Ecuador. Se plantea ser parte del tejido vivo que entreteje la interculturalidad cósmica y que contribuye a la formación de talentos humanos que prioricen una relación armónica entre la Pachamama y el Runa, sustentándose en "Sumak Kawsanamanta Yachay" (bien vivir comunitario), como base de la comunidad científica;

b) Han sido el resultado de procesos históricos que transforman las relaciones estructurales entre los Pueblos Indígenas y los Estados. Así es el caso de las universidades comunitarias en las Regiones Autónomas de Nicaragua, que surgen a raíz del reconocimiento del derecho de autonomía por parte del Estado nicaragüense para los Pueblos Indígenas y comunidades étnicas que viven en la antigua región de la Moskitia, hoy Regiones Autónomas.

c) Adoptan enfoques integrales, abarcando varios niveles y modalidades de educación. Por ejemplo, el decreto de creación en el año 2003 del Colegio Superior para la Educación Integral Intercultural de Oaxaca, establece que tiene facultades para ofrecer educación superior, media superior, para adultos, así como formación artística y para el trabajo;

d) Tienen estructuras descentralizadas. La oferta de los cursos se hace de forma desconcentrada, llegando a las comunidades, utilizando idiomas indígenas y apoyándose en facilitadores/as que son sabios indígenas locales;

e) Han asumido lecciones aprendidas de las experiencias de los programas de educación intercultural bilingüe; tales como los nidos de lengua, la reforma curricular en educación básica, las secundarias comunitarias indígenas y los bachilleratos integrales comunitarios;

f) Aplican medidas de acción afirmativa para promover la participación de las mujeres y de los miembros de las comunidades indígenas aislados y dispersos. En algunos casos cuentan con áreas de escuela y comunidad; en otros, el 50% de las actividades académicas se realizan en las comunidades;

g) Promueven espacios abiertos de discusión sobre temas relevantes comunitarios y el intercambio con las comunidades para generar enfoques que les den perspectivas de identidad;

h) Incorporan elementos de análisis para orientar la actividad educativa hacia la formación social de las personas sobre la historia, su origen, su cultura, cosmovisión, lengua y entorno, el criterio propio y juicios de valor éticos;
i) Buscan aplicar modelos pedagógicos interculturales innovadores tales como la construcción colectiva de los conocimientos, la deconstrucción y reconstrucción de conocimientos.

A manera de conclusiones

Para promover los sistemas de conocimientos de los Pueblos Indígenas se requieren algunas condiciones, como son:

a) Reconocimiento de los Pueblos Indígenas como titulares de derechos humanos individuales y colectivos;
b) Contar con mecanismos formales de diálogo y participación entre los Pueblos Indígenas y los Estados;
c) Establecimiento de marcos normativos, programas y mecanismos para el diálogo intercientífico, el diálogo entre sistemas de conocimientos;
d) Salud y educación están íntimamente vinculados con el territorio y los recursos de la naturaleza para que los conocimientos puedan ser utilizados y conservados;
e) Los programas globales de salud y educación deben incorporar las necesidades y perspectivas de los Pueblos Indígenas;
f) Es fundamental la participación de los Pueblos Indígenas en los procesos de toma de decisiones sobre salud y educación;
g) Debe contarse con información con desagregación de origen étnico para facilitar la adopción de políticas interculturales;
h) Hay necesidad de desarrollar y aplicar metodologías de investigación intercultural que permitan documentar y conocer sobre los conceptos de salud y educación de los Pueblos Indígenas.

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YOUTUBE PRESENTATION

Ti Szwatenem: What We Know: The Gift of Indigenous Knowledge for Life and Living and the Challenges of Exclusion

Lorna Wanosts'a7 Williams
Member First Nation, Professor Emerita, Lil'watul; University of Victoria, Canada

https://youtu.be/KPziAyXsiRQ?si=3S7lZ9KAiGxdXLVM

2.3. PERSPECTIVES FROM ASIA

India's Experiences on Traditional Knowledge and the Traditional Knowledge Digital Library (TKDL)

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Abstract

The workshop on "Indigenous Peoples' Knowledge and the Sciences" organised by the Pontifical Academy of Sciences (PAS) and the Pontifical Academy of Social Sciences (PASS) focused on bringing together indigenous knowledge and local communities and the science fraternity to arrive at common understanding, objectives and joint work to address climate change vulnerabilities affecting lives and livelihoods. The workshop witnessed participation from across the world, and India shared its experiences on handling and working with traditional knowledge (TK) and the Traditional Knowledge Digital Library (TKDL). The importance of national government policies was highlighted in the context of preserving, protecting and promoting TK for better socio-economic growth in the country, while also addressing India's interventions to improve the livelihoods of the indigenous and local communities. Further, the talk covered aspects of Intellectual Property Rights (IPR) and People's rights, while laying emphasis on ethical practices to be followed to respect the Moral Rights of the concerned knowledge holder(s).

1. Overview and Discussion

1.1 Traditional Knowledge – Preservation and Protection

Traditions and culture have always been integral to the identity of people and every nation's heritage. Despite the prevalence and practice of the traditions and cultural expressions globally, traditional knowledge (TK) still does not have an accepted definition internationally. The World Intellectual Property Organization (WIPO) states that TK embraces the content of knowledge resulting from intellectual activity in a traditional context, and includes know-how, practices, skills, and innovations and traditional cultural expressions.[1] Traditional cultural expressions (TCEs) or "expressions of folklore", according to WIPO, include "artistic or cultural expressions such as music, dance, art, designs, names, signs and symbols, performances, ceremonies, architectural forms, handicrafts and narratives, among others".[1] Further, TK can exist in both codified and oral forms, and may be disclosed or undisclosed in public domain.[1]

Owing to its very nature, TK has often been confined to specific regions and communities within a nation. While the ownership of TK often rests with nations, disclosed codified TK is public knowledge. However, in case of undisclosed TK, including oral, the custodians are primarily the knowledge holder(s) themselves and often sensitive sacred knowledge and beliefs are associated with this category.

While the TK is intergenerational and has traversed time, in conventional terms, intellectual property (IP) as defined by WIPO includes "creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce".[2] Though both TK and IP are creative works of the mind, IP rights (IPR), a modern era development, are to enable the right holder(s) to earn ownership, recognition or financial benefit from such IP creations through available legal provisions. TK does not enjoy such protection and thus becomes a subject matter of misuse, misappropriation and bio-piracy.

In general terms, TK includes two major categories of protection – defensive and positive.[3] While codification of TK is a way of preserving intergenerational knowledge, it also offers the TK content as prior-art information under conventional IP systems. Codified TK, when provided as prior-art information, stops and prevents third parties from claiming IP ownership rights on such knowledge and thus serves as a means of defensive protection. Lacking such provisions, the concerns of unethical use of oral and undisclosed TK remain. However, considering that the custodians of such knowledge are the concerned individuals or communities, it calls for positive protection where promotion of such knowledge to improve the livelihoods of the knowledge holder(s) bears prime importance. Countries thus look for enactment of sui generis legal frameworks to protect such knowledge and practices.

1.2 Biopiracy and Misappropriation of TK

The TK, both in its native form as well as minor variations thereof, have been the subject matter of patent grants across IP jurisdictions globally. This matter is of high concern to nations which are victims of TK misappropriation and biopiracy. Patents when granted can be opposed only through litigation, which is a complex task. Further, revocation of patent grants is not a feasible option for all patents on TK, as the efforts require keen intent, time and money. Further, the process of identifying such patent grants on TK is a laborious manual task and could be missed lacking the relevant correct search terms or knowledge thereof. Sometimes, one finds patent grants on TK accidently and from unexpected sources.

The classical examples of biopiracy and misappropriation of Indian TK include patent grants on the wound healing properties of turmeric, basmati rice and the fungicidal formulation from neem.[4]

a) Turmeric has been traditionally used in India as an ingredient in food, medicines, cosmetics and dyes, besides others. A patent (no. 5,401,504) on the use of turmeric in wound healing was granted to the University of Mississippi Medical Centre by the US Patent and Trademark Office (USPTO). India challenged the patent on the grounds of existing prior art from the classical texts relating to Indian systems of medicine and research publications in journals. The USPTO upheld the objections and cancelled the patent on the grounds of it lacking novelty. The turmeric patent revocation was a first of its kind success for a developing nation on its TK.

b) Rice Tec. Inc. from the USA filed for registering a trademark "Texmati" at the UK Intellectual Property Office. Agricultural and Processed Food Exports Development Authority (APEDA), India opposed it successfully. In this context, the company submitted a granted patent (no. 5,663,484 by USPTO) as evidence in support of the trademark registration. The patent claimed (particularly claims 15-17) a rice plant having characteristics similar to the traditional Indian Basmati Rice lines. Information from the Indian Agricultural Research Institute Bulletin and the germplasm collection of the Directorate of Rice Research, Hyderabad were presented as evidences to oppose the patent. Upon India's re-examination request, Rice Tec withdrew claims 4 and 15-17.

c) In India and several South Asian countries, neem extract has been used for its pesticidal properties in agriculture. The seed oil is known for its medicinal properties and when mixed in soap, it provides relief from malaria, skin diseases and even meningitis. The European Patent Office (EPO) granted a patent (no.436257) to W.R. Grace Company and the US Department of Agriculture for a method using hydrophobic extracted Neem oil for controlling fungal growth on plants. India, through a group of NGOs and representatives of Indian farmers, undertook a legal course of opposition against the patent. Evidences were submitted from

Indian TK on the subject matter which indicated that neem extracts were used traditionally in Indian agriculture to protect crops. EPO revoked the patent granted on the grounds of it lacking an inventive step.

The misappropriation and biopiracy of TK is not limited to India alone. Some examples from across the world include erroneous patent grants to third parties on Kava, an important cash crop in the Pacific, especially in Fiji and Vanuatu regions; on Ayahuasca from the Amazon basin; on Quinoa, a staple food crop of the Andes; on Hoodia from Africa, among others. Besides the wrongful patent grants on TK, the provisions of the Convention on Biological Diversity on access and benefit sharing were also not followed in several of the cases, which have been detrimental to the lives and rights of the knowledge holder communities.

2. Defensive Protection of TK – Traditional Knowledge Digital Library (TKDL) – A Case in Point

India took strong cognizance of the fact that even its codified TK was not serving as prior-art literature to patent offices, which continued to offer grants on patents related to its TK. India also recognized that its TK is primarily in its native languages such as Sanskrit, Hindi, Arabic, Urdu, Tamil etc., besides ancient dialects that are now not in use. Even the codified Indian TK literature is neither accessible nor understood by the examiners at patent offices. However, the significant efforts, time and money expended in patent litigations drew to attention a strong need for India to protect its TK from misappropriation and biopiracy. An effective intervention was required to bridge this gap, and ensure that India's TK is served as prior-art to patent offices for their pre-grant process of patent applications. India thus conceived a proactive mechanism for TK protection through a defensive framework. In 2001, India set up a pioneering initiative called the "Traditional Knowledge Digital Library" (TKDL) to protect Indian TK from misappropriation through patent grants by patent offices worldwide. The TKDL was initiated jointly as a collaborative activity of the Council of Scientific and Industrial Research (CSIR), India and the Department of Indian Systems of Medicine & Homeopathy (now Ministry of AYUSH), India. The CSIR through its constituent, the CSIR-TKDL Unit, handles and administers the work on TKDL. Globally, TKDL was a first of its kind tool for protecting and preserving TK.[5]

To begin with, the TKDL focused on the Indian systems of medicine (ISM) namely, Ayurveda, Siddha, Unani, Sowa Rigpa and Yoga. To address the challenge of language and access barriers, the TKDL was conceptualized as a bridge between local Indian languages and language and format understandable to patent examiners. The TK from the existing codified literature was transcribed into five languages covering English, German, Spanish, French and Japanese, in a digital format.

The TKDL is based on an innovative structured classification system, the "Traditional Knowledge Resource Classification" (TKRC) to provide a structured and systematic arrangement and dissemination of TK information so it can facilitate easy and focused search and retrieval by patent examiners. The TKDL is not a transliteration of TK information, thus meeting its objective of a value-added prior-art database of Indian TK. Traditional terminology is also linked to modern terminology. Concordance is drawn between the TKRC and the International Patent Classification (IPC) codes. The TKDL information structured under section, class, subclass, group and subgroup provides for convenience of use by patent examiners. The search features include both simple and advance searches with complex Boolean operators. Thus, the database is a knowledge-based conversion in a digital format, wherein information transcribed into several languages serves as prior-art in a recognizable format. Thus, the digital database of TK is an effective tool to prevent misappropriation and biopiracy of Indian TK. Today, the TKDL database comprises about 4.67 lakh formulations/practices that have been transcribed from the texts of Ayurveda, Siddha, Unani, Sowa Rigpa and Yoga.

To add to the efficacy of the framework put in place, the CSIR-TKDL Unit also files third party observations and pre-grant oppositions on patent applications that are related to Indian TK on ISMs and provides evidences from the TKDL database. Based on the TKDL evidences, so far 329 positive outcomes have been obtained so far – these include patent application refusals, rejections, amendment of claims and other aspects of the patent application, withdrawal and/or abandonment of the patent application by the concerned Parties.[6] Thus, the TKDL has been serving as an exemplary prior-art database on TK for both protection and preservation of the ancient knowledge and practices.

3. Importance of Government Policies – Preservation, Protection and Promotion of TK

The TKDL has been an important initiative from India to safeguard its TK from unauthorized use and wrongful claim of ownership of such knowledge. At a practical level, it is important to realise that TK, which is intergenerational, is not a static matter or a relic of the past. The continued use of TK as means of livelihood to several people and in the context of global competitiveness, the ineffectiveness of modern interventions to address all the unmet needs, indicates the continued relevance of TK to meet the current and future needs as well. Globally, TK is understood to be aligned with the ecology and environment of the time, and provides for a balanced human-planet well-being. In current times, the TK may be used in its native form, can be co-opted or integrated with contemporary modern practices or innovated further upon. However, worldwide, TK does not seem to receive its due recognition and promotion thereof, for utilization and application in every day life. In this content, the initiatives from India provide encouraging examples of how government policies on TK are important.

Herein, the author limits herself to discussing India's important policies on TK that cover the broad horizons of education to innovation. Right from inculcating the importance of TK in a child's mind through formal education process to furthering R&D and then innovation and trade, India has been placing continued focus on TK, IPR as well as people's rights. Some key aspects are mentioned below.

3.1 Education

The National Education Policy 2020 (NEP2020)[7] lays emphasis on including the TK from India as part of school and college academic curriculums. Some extracts from the Policy document include the following on Indian Knowledge Systems (IKS):

"4.27. 'Knowledge of India' will include knowledge from ancient India and its contributions to modern India and its successes and challenges, and a clear sense of India's future aspirations with regard to education, health, environment, etc.

These elements will be incorporated in an accurate and scientific manner throughout the school curriculum wherever relevant;

In particular, Indian Knowledge Systems, including tribal knowledge and indigenous and traditional ways of learning, will be covered and included in mathematics, astronomy, philosophy, yoga, architecture, medicine, agriculture, engineering, linguistics, literature, sports, games, as well as in governance, polity, conservation.

Specific courses in tribal ethno-medicinal practices, forest management, traditional (organic) crop cultivation, natural farming, etc. will also be made available...".

The NEP2020 stresses upon use of local languages to impart education with an inclusive approach. The NEP2020 also recommends the following:

"5.6. Schools/school complexes will be encouraged to hire local eminent persons or experts as 'master instructors' in various subjects, such as in traditional local arts, vocational crafts, entrepreneurship, agriculture, or any other subject where local expertise exists, to benefit students and help preserve and promote local knowledge and professions".

The motto of the Ministry of Education, India on IKS is "Value-education and Value-based Education for Value-based Living". The University Grants Commission (UGC), India has put in place "Guidelines for Incorporating Indian Knowledge in Higher Education Curricula".[8] Every student enrolled in an undergraduate (UG) or postgraduate (PG) programme is encouraged to take IKS courses to at least 5% of the total mandated credits. Further, the UGC Guidelines lay emphasis on highlighting the objectives, methodology and core concepts of IKS; the contemporary applications of IKS, where applicable, is to be indicated; the IKS courses are to be given in Indian languages, among others.

The All India Council for Technical Education (AICTE), India has provided guidance on a Minor Degree in Universal Human Values (UHV)[9] which would cater to students completing 18 credits in IKS courses and that the credits of the mandatory IKS are to be counted in total IKS course credits. Under this, there would be a mandatory 3-week Student Induction Program that would cover Indian culture and civilization along with its knowledge systems and traditions.

The Ministry of Education, India has also set up the IKS Division[10] under its ambit, whose Vision is "To promote interdisciplinary research on all aspects of 'Indian Knowledge Systems', preserve and disseminate 'Indian Knowledge Systems' for further research and societal applications". The Mission of the IKS Division is "Create a database of individuals and organizations who have contributed by way of Research, Teaching, Publication and Preservation of ancient and contemporary rich Indian knowledge systems ranging from art, music, dance, drama, to mathematics, astronomy, science, technology, life sciences, environment and natural sciences, health care, yoga, law, jurisprudence, economics, social sciences, psychology, philosophy, management, linguistics, oral traditions of India, knowledge hidden in Sanskrit, Prakrit, Tamil, Pali, etc.". The IKS Division provides support for (i) Internships to encourage and enthuse youth to take up deeper study in IKS; (ii) Research Proposals, wherein catalytic grants are given to young scientists and grants to established scientists to embark on new research directions or approaches in IKS; and (iii) IKS Centers covering research centers, teacher training centers and language centers to serve as a catalyst for initiating research, education, and outreach activities.

Materials for the educational courses across diverse areas are also being developed in the country to emphasise the importance of the national heritage and continued relevance through the times.

3.2 Innovation

In India, TK continues to be a means of livelihood for a sizeable population and the country is home to several diverse living traditions and culture. Two specific Ministries, namely, the Ministry of Culture and the Ministry of AYUSH, have been established with specific focus on the traditional cultural aspects of the country and traditional medicine, respectively. Considering the continued contributions of the traditional practices and interventions to socio-economic development and growth, India's Ministry of Commerce and Industry, specifically the constituent Department for Promotion of Industry & Internal Trade (DPIIT) ensures an inclusive approach towards TK. The DPIIT handles matters related to IPR, including its legal frameworks and policies, besides other matters of industry and trade.

The Vision statement of the National Intellectual Property Rights (IPR) Policy 2016 of India[11] is as follows: "An India where creativity and innovation are stimulated by Intellectual Property for the benefit of all; an India where intellectual property promotes advancement in science and technology, arts and culture, traditional knowledge and biodiversity resources; an India where knowledge is the main driver of development, and knowledge owned is transformed into knowledge shared". TK and biological/genetic resources (GR) have been given due importance in this innovation policy.

The Policy specifically includes the following on TK:

"2.30. Promote India's rich heritage of traditional knowledge with the effective involvement and participation of the holders of such knowledge. Traditional knowledge holders will be provided necessary support and incentives for furthering the knowledge systems that they have nurtured from the dawn of our civilization.

4.12. Introduce approaches and mechanisms so that benefits of the IP system reach all inventors including MSMEs, informal innovators and holders of traditional knowledge."

Further, the National IPR Policy 2016 provides the following recommendations on the TKDL:

- Scope be expanded to include other fields besides traditional medicine;
- Research institutions and private sector be allowed access to TKDL for furthering R&D, with necessary safeguards to prevent misappropriation;
- Document oral traditional knowledge, preserving integrity and that the life of communities involved is not compromised;
- Continue efforts to include TKDL as a part of PCT minimum documentation.

In the aforesaid context, the CSIR-TKDL Unit is working towards including TK information from other subject areas. Further, considering the immense potential that the value-added TK information in the TKDL can offer, the Government of India accorded approval to widen the user base of the TKDL database. The CSIR-TKDL Unit is working out the procedures and processes for the same. On the sensitive subject matter of oral TK, especially considering moral rights, the CSIR-TKDL Unit is putting together a guidance document on handling and working with the yet undisclosed TK, that includes oral knowledge. The guidance lays emphasis on ethical practices that need to be followed in order to respect the rights and livelihoods of the knowledge holders. The key principles recommended include (i) Free and prior informed consent that mainly targets understanding the interests and concerns of knowledge holder(s); defining the objectives; and specifying the roles of the concerned persons, among others. (ii) Attribution of TK to the concerned knowledge holders by way of acknowledging and recognizing the contributions of the knowledge holder(s) by way of authorship; inventorship; partnership, etc. (iii) Access and Benefit Sharing: arriving at the mutually acceptable terms and conditions of access, including benefit sharing; and also updating the knowledge holders on developments from time to time on the knowledge being used.

The CSIR has also put in place a unique national program entitled "SVASTIK", which is to communicate scientifically validated TK and practices to the public.[12] The objective of this program is "to conserve the practice of the right tradition, inculcate scientific temper of verifying tradition in a scientific manner and instill confidence in citizens regarding the scientific value of India's traditional knowledge/practices". The activity provides simplified creative content on the specific TK which is then disseminated through digital platforms, including social media platforms, in English, Hindi, and various other Indian languages.

In addition to the above, among other positive protection frameworks loosely related to TK, India's interventions for promoting registration of Geographical Indications (GI) deserves special mention. The GIs are IPR tools that provide protection to goods, "where a given quality, reputation or other characteristic of such goods is essentially attributable to its geographical origin".[13] The GIs cover three major categories of goods – Agricultural, Manufactured (including handicrafts (handloom & textiles), food stuff (wines & spirits) and manufactured industrial goods, and Natural. The GI registration provides for recognizing communities and their products towards better branding and income generation. So far, about 535 GIs have been registered in the country. India has also initiated "One District One Product" (ODOP) program[14] that aims at recognition of a local product with its unique characteristics and identity associated with that region. The establishment of ODOP and GI-specific stores across the country, including at railway stations and airports, fosters wider recognition and adoption of these traditional products among people.

Thus, India provides for a canvas of interventions that reiterate the significance of the valuable heritage and the continued need for preserving, protecting and promoting TK to address needs of the current times and the future.

4. Key International Initiatives – TK, IPR and People's Rights

In the context of IPR, India is a signatory to the World Trade Organization's Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement. As one of the member states of the WIPO, India is also an active participant in the proceedings of the Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC).[15] Though the IGC was established in 2000, no concrete decisions could be taken by the WIPO considering the complexity of issues associated with TK, TCEs and GR. In reference to TK, the IGC-WIPO has also suggested creation of databases/registers on TK information. Documentation of TK shall provide for preserving TK, including confidential TK/TCEs, protect TK from misappropriation by providing prior art, promote R&D & innovation, and thereby enable benefits through PIC and ABS, while facilitating and managing rights of TK holders. However, the key challenge of the IGC-WIPO is on arriving at a text that balances effective protection of TK/TCEs, and the interests of knowledge holders and other stakeholders. In this context, the WIPO has planned a Diplomatic Conference in May 2024 to conclude an international legal instrument on IP, GR and TK associated with GR.

Further, the matter of culture as a transformative driver of Sustainable Development Goals (SDGs) was also discussed at the G20 held in India. The G20 New Delhi Leaders' Declaration of 9-10 September 2023[16] states the following:

"31. ... We encourage the international community to protect the living cultural heritage, including the intellectual property, notably with regard to the impact of the over commercialization and misappropriation of such living heritage on the sustainability and on the livelihoods of practitioners and community bearers as well as Indigenous Peoples".

The high recognition being placed by nations worldwide on the nature, diversity and importance of TK, including IPR and people's rights, calls for concerted and immediate action for arriving at a legally binding instrument on the subject by all countries.

His Holiness Pope Francis, in his address to the participants in the Indigenous People's Forum, Consistory Hall, on 10 February 2023[17] stated that, "... We should listen to Indigenous Peoples more and learn from their way of life, so as to understand properly that we cannot continue to greedily devour natural resources ... The contribution of Indigenous Peoples is fundamental in the fight against climate change. And this has been scientifically proven ... I ask governments to recognize the Indigenous Peoples of the whole world, with their cultures, languages, traditions and spirituality, and to respect their dignity and their rights, in the knowledge that the richness of our great human family consists precisely in its diversity". His Holiness stressed the importance of government policies and the narrative from India mentioned herein connects with the sentiments and recommendations.

This workshop on "Indigenous Peoples' Knowledge and the Sciences",[18] organized by PAS and PASS, stands testimony to the interests and actions of Vatican City State to preserve and promote TK for the well-being of the people and planet. Besides the representatives of the indigenous communities and the scientific fraternity, the workshop witnessed the participation of world bodies such as the United Nations (UN) and associated entities for discussing the subject matter towards facilitating the rights of the knowledge holders while bringing together TK and modern practices to address unmet needs, including issues of climate change. The workshop deserves much appreciation considering that parties with divergent views on indigenous knowledge and modern (western) science were called upon to converge on integrated approaches for addressing the rising needs of climate change, primarily affecting lives and livelihoods of the indigenous and local communities.

5. Recommendations

The workshop provided India with an opportunity to share its experiences on handling and working with TK, while making efforts to address complex matters such as misappropriation, IPR and people's rights. In case of undisclosed and oral TK, there is a critical need to put ethical frameworks in place, though a sui generis legal framework specific to TK would be the preferred one. While world bodies such as WIPO, CBD and FAO, among others, are making strong efforts to recognize TK and put in legal instruments in place, there is a need to recognize that the diversity of TK across nations is not a matter for simplification and normalization. The distinctness and diversity of TK are to be recognized as elements that align with the regional ecological and environmental needs and therefore the acceptance of a broad definition of TK and recognition of the continued role of TK in socio-economic growth and development are critical. Developed nations therefore need to have a strong commitment towards enabling an inclusive approach on TK and the people and nations concerned. On this matter, organizations such as PAS and PASS can play a stronger role in ensuring and accelerating the pace of activities and positive decision making on matters of TK, IPR and People's rights.

6. Acknowledgement

The author expresses gratitude to the PAS and PASS for the opportunity and sponsorship, and the Council of Scientific and Industrial Research (CSIR), India for the financial and technical support to participate in the workshop held at PAS, Vatican City.

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Honey Bee Network in Africa Leveraging Local Knowledge, Creativity and Innovation-Based Entrepreneurial Opportunities

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Every society has young and old mavericks and extremely knowledgeable elders whose experimental ethic equips them with special skills for solving local problems. Many times, these solutions are not optimal. But every solution is an indicator of a) an unmet need, b) an unexploited opportunity and c) an unrecognised human potential. Honey Bee Network has been scouting, spreading, and spawning grassroots innovations and outstanding traditional knowledge that have solved local community problems through their geniuses without outside help. However, it later started recognising extremely affordable innovations *for* grassroots, since formal and informal knowledge systems may need to synergise in some cases. Support continued for innovations from the grassroots.

The key links in the knowledge and innovation chain are scouting & documentation, prior art search and segregating unique from common knowledge, and validating where needed through on-farm research or lab tests those practices/innovations in which relevant literature is not available or data about efficacy is weak. In many cases, the performance of a mechanical innovation at the hands of satisfied users also suffices. Value addition might be needed in cases where proof of concept is too crude, and the facilities with innovators are rudimentary. In health-related cases, more advanced trials may be required depending on the regulatory and ethical requirements in the country. Sharing information about these solutions in regions where similar challenges are faced is an important aspect of HBN activities. Innovators often have one piece of the solution in the case of mechanical innovation, or just a small quantity of seeds of an improved variety. Procurement of such seeds or herbal pesticides, growth promoters or other such solutions is facilitated as per the prior informed consent of the knowledge providers or innovators.

Dissemination of innovation often remains constrained because of a lack of on-farm trials or demonstrations by public agencies or NGOs. Blaming an innovator for developing a localised solution and holding a lack of scaling up against her is not a good policy. HBN shares the innovations in multiple ways: exhibitions during innovation walks in different rural regions of the country. HBN volunteers have walked more than 6,000 km throughout all the states of the country in the last three decades. In addition, local language newsletters, regional exhibitions, festival of innovations (in the past such festivals were organized at President of India's house also), and multi-language online databases besides lectures and workshops in schools and colleges. Social media is also used, but its reach in some interior regions is limited due to internet connection issues. Traditional Food and Nutrition Festival and an innovation exhibition are organised, attracting almost 50,000 people in four days.

Most innovators treat their innovations open source but patents are filed to prevent others from usurping their intellectual property rights and in some cases to facilitate licensing of their innovations to entrepreneurs. Almost all the licensing has been so far to small entrepreneurs on non-exclusive basis.

Micro Venture Innovation Fund (MVIF) has also been set up to provide a low rate of interest risk capital to the innovators who wish to scale their innovations. Banks are often hesitant to lend to innovators who are yet to succeed in the marketplace. Awards at national and regional level have been organized all these years to motivate the innovators and create greater visibility for their creativity in media and among the masses.

Policy changes for encouraging grassroots innovations are extremely important. Creating national foundation or agency can be helpful. One can create grassroots innovation clubs in schools and colleges to *search, spread*, inclusive/frugal innovations, *celebrate* them by inviting innovators to classrooms and *sense* the unmet needs of the community to trigger creativity and innovation to address those needs. HBN had influenced the 13th Finance Commission (it sets the parameters for allocation of central funds to state in a specific formula) to set up two major initiatives: a district innovation fund of Rs 2 crore and b) a centre of innovation in public systems. Neither grew much later, but at least a beginning was made.

Similarly, national innovation clubs were set up in all the central universities and institutions which would share their achievements at the Festival of Innovations.

Way forward:

– HBN has found numerous innovations and outstanding Traditional knowledge from Africa and published them and through HBNCRIIA_

GLOBAL awards; GIAN even honoured a few of them. A similar campaign can be started to map such innovations from grassroots, and also for grassroots annually or biennially. GIAN and GBN did work with UNDP ACC lab network.

- Mandate some technical universities to help the Grassroots Innovation Network in Africa (GRIN-Africa) validate, value-add, and redesign grassroots ideas.
- Seek scientist volunteers in biotechnological and pharma labs to help validate the community knowledge in a time-bound manner, making knowledge providers co-authors in papers and protecting their IPRs, and helping develop products for bio entrepreneurship. Bioeconomy has the potential to strengthen the grassroots knowledge and innovation ecosystem.

The incorporation of inspiring examples of grassroots innovations from Africa and for Africa from other southern countries in textbooks of schools and colleges might make youth impatient with inertia and reinforce their experimental and innovative spirit.

3. INDIGENOUS PEOPLES' KNOWLEDGE SYSTEMS FOR HEALTH AND PHARMACEUTICAL PRODUCTS AND THE SCIENCES – INNOVATION OPPORTUNITIES, RIGHTS, POLICIES

Bridging Indigenous Knowledge and the Sciences: The Role of Indigenous Peoples in Health and Pharmaceutical Products Development

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1. Indigenous Knowledge

1.1 Indigenous peoples' knowledge, language and culture in health promotion

Knowledge is a form of theoretical or practical understanding of a subject matter or situation. Knowledge, whether indigenous or modern, has the capability to transform a person or community. In other words, knowledge is an intellectual capital for development which, in the informal sectors, is intertwined in culture and beliefs. So-called Indigenous Knowledge (IK) is deeply and richly implanted in the peoples' language they speak, food they eat, song or dance they enjoy, materials they use, etc. One such culture is Bantu, which comprises about 400 distinctive local ethnics groups covering most of the Central and Southeast part of Africa (Patin et al., 2017). Tanzania is among the countries which are dominated by Bantu people who embrace the Swahili language. Kiswahili is native to Tanzania, but it is now expanding to cover about 200 million speakers (UNESCO, 2021). Language promotes harmonious communication, unity in diversity and international understanding. No wonder Kiswahili was used in uniting people during independence and is now proclaimed by the UN as the first African language, which is celebrated on 7th July of each year (UNESCO, 2021). This language is a media for indigenous and modern knowledge exchange.

Swahili language is one of the successful innovations in health because Kiswahili by itself has no ethnicity, due to being widespread across tribes. People in coastal East Africa and even in the diaspora see themselves united by the same culture and language, which embrace brotherhood, love and peace, hence providing a massive safe, healthy environment for people to live. Peace and harmony is the number one medication for a human being. That is why both Indigenous and science knowledge now agree that a sick person is not necessarily diseased; rather, he or she can be affected due to associated surroundings. Some such ill health conditions can as well be treated/managed by/or through faith, humility and understanding, e.g. Wellness of displaced communities such as refugees requires affirmation that there shall be restoration of peace and harmony.

Harmony with one's surroundings is an important aspect because human beings share space with animals, plants and other species in the environment, which in turn are resourceful agents in advancing wellbeing. Indigenous Knowledge (IK) provides understanding and interpretation in interacting and responding to societal events. For example, simple knowledge like the movement of winds can be an indicator to predict an event such as an outbreak of certain pandemic or contagious diseases. Also, certain patterns of behavior of insects and birds are used in the prediction of weather conditions which are relevant to responding to climate change, whether by mitigation, resilience, or coping. Gender roles in the communities, such as women, elderly community leaders and traditional healers, continue to serve as major preservation and reserve of Indigenous Knowledge in the informal sectors.

1.2 Contribution of Indigenous Knowledge to the science of health

One form of IK is traditional medicine. In the context of Africa, the WHO/AFRO Region (World Health Organization, 1978) defines African Traditional Medicine as the sum total of the knowledge, skills and practices based on the theories, beliefs and experiences indigenous to African cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness. Interestingly, the term "explicable" is used to refer to both knowledge already understood that can be justified in the context of existing science and knowledge which is still in the IK domain. Myths, beliefs, societal norms and moral values are some forms of the indigenous healing/health systems impregnated to sustain the communities, but in science some do lack method and concepts that can be accounted for or explained. Thus, when addressing IK and science in the African context, one can, for instance, mirror it with what Bantu believe and its relation to health and wellbeing. Bantu believe in a holistic approach to treatment, which is the use of *materia medica* and some practices that are not necessarily tangible entities; some come from the cosmos. Bantu culture believes in the human body as an organic whole, which is integrated with the external environment. Thus, a human is regarded not as a purely physical entity but also taking into consideration sociological aspects (family or other), whether living or dead (ancestors) and "intangible forces" (God, gods,) of the universe.

This scenario, in the global arena, reiterates the contribution of IK to science of some practices that use non-material (non-medicines) treatments, including use of music and dances (e.g. Afro-soul music) in management of psychotic distress, e.g. stress, depression and other mental health disorders, etc.

1.3 Contribution of IK to pharmaceutical products

Nevertheless, IK on use of *materia medica*, especially medicinal plants, has been resourceful and effective in drugs discovery, e.g. vincristine and vinblastine from the Madagascan periwinkle *Catharanthus roseus* as cancer drugs (Karasov, 2001). The methods of drug discovery from biodiversity often follow a bio-prospecting approach, which is a complicated process. Bio-prospecting involves identification of bioactive ingredients from a medicinal plant, understanding the mechanisms of action and possibly its synthetic route. Thus, often the original natural products isolated from the plant are not used in industrial production. For example, despite the widespread (Figure 1) traditional use of *Securidaca longipendunculata* in Africa in relief of headache and inflammation (Mongalo et al., 2015), its uses remain indigenous. One of the active ingredients in this plant is methyl salicylate,

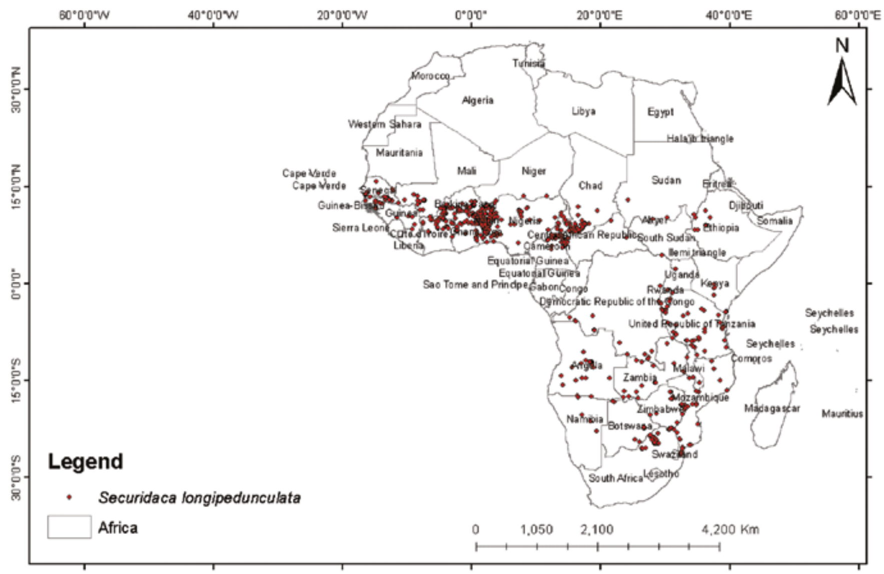

Figure 1. Map showing the distribution of *Securidaca longipendunculata* in Africa (coordinates for mapping the distribution by ArcGIS version 10.8).

but it is labile (Jayasekara et al., 2002). The plant is a tree, but since it is life sustaining, communities have learned how to harvest the medicines from the roots in a sustainable manner (Figure 2).

However, in order to have a useful drug agent for clinical use, several layers of knowledge have to be created to improve methyl salicylate in order to arrive at the pharmaceutical production of Aspirin (Figure 2). Thus, the original active ingredient from the plant only serves as a mirror to reflect on, during laboratory experimentation, to inform an understanding of the actual alternative chemical structures that can be used in pharmaceutical synthesis (Figure 2). Through bio-prospecting, there are several useful hospital medicines, such as quinine, ephedrine, amodiaquine, primaquine, chloroquine, mefloquine, atropine, reserpine, digoxin, metformin, scopolamine, taxol, calanolide A, etc., which are synthetically made from a structure of an initial, naturally isolated compound from medicinal plants (Innocent, 2016).

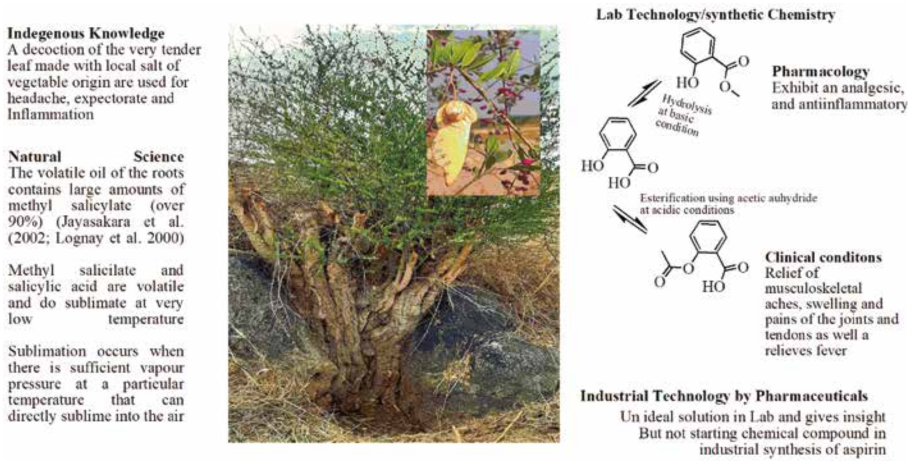

Figure 2. A model depicting the bio-prospecting process and the contribution of Indigenous Knowledge to scientific knowledge in the discovery and clinical uses of drugs.

2. Perspective of Intellectual Property Compensations

2.1 The borderline between Bio-prospecting and Bio-piracy

Bio-prospecting principles go hand in hand with intellectual property (IP) and access and benefit sharing (ABS) in a fair and equitable manner when potential commercial value is realized by partners (CBD, 2017; Ramos, 2021; WTO, 1994). However, some areas in the bio-prospecting approach which need careful considerations include IK documentation as a prior art. There should be:

a) A clear way to ascertain originality of IK and who really owns the knowledge during filing for IP, because IK has developed over time; it is exchanged and ever-changing. Therefore, IK being a living knowledge can cut across related cultures in the communities.
b) Progressive upgrade and compensation of IK as it grows. Otherwise, relying on documented prior art limits innovativeness at communal levels.
c) Flexibility of translation of IK along the transformation through research and development of other related future advancements, e.g. *Hoodia gordonii* being known for thirst and hunger by the San people, with the end product in bio-prospecting being a slimming product in IP systems (Wynberg et al., 2009).

Basically, any knowledge is transformative to the intent, and research is just one of the couriers/carriers of transformation. When such transformation is done through research in a fair and equitable term it results in bio-prospecting.

In some circumstances, during transformation there is a great intent of misappropriation, misinterpretation and misrepresentation of IK holders, resulting in the so-called bio-piracy. The pertinent loopholes to bio-piracy are in the memorandum of understanding (MoU), material transfer agreements (MTA) and specific clauses under non-disclosure, IP, and obligations of parties in the memorandum of agreements (MoA).

2.2 Some Mechanisms to Resolve IP Issues, Including Linking Synthetic Pharmaceutical Products and IK

Therefore, exploration of pharmaceutical products from biodiversity through a bio-prospecting approach requires a balance of cultural rights of IK holders, intellectual property rights, and global justice to access of medicines. Traditional medicinal (TM) plants within the ecosystem of the communities continue to be relied on for survival. However, in large-scale production, modification of knowledge through research and development resulting in synthetic pharmaceutical products remains a sustainable way. Nevertheless,

i. Strengthening mechanisms of fair and equitable benefit-sharing may increase market status of TM associated with IK for global access and products development, as well as curbing bio-piracy. This may further reduce secrecy by IK holders as a preferred IP protection over other forms of IP that are transferable for product development and promotion of global health.

ii. Mechanisms that recognize originality of initial information and material sources should be strengthened through IP systems. Accessing parties should be obliged to specify **the origin of the genetic material and all the associated traditional knowledge that gave a clue to the discoveries.**

iii. Strengthening IP institutions and those which deal with access and benefit sharing (ABS) could eventually help promote disclosure of use of medicinal plants and practices that would enable the valuation of the services and proper documentation of prior arts to serve as a reservoir for referencing, but not as signatures of the *status quo*.

3. IK Holders' Participation in a Sustainable Value Chain

IK holders have fear of losing ownership of knowledge because they are not informed of the incentives that would impact their socio-economy. This is why a lot more traditional medicinal plants used by different communities in Tanzania and Afro-region have not yet penetrated the markets, despite the fact that they still serve about 60-80% of the population, in one way contributing to primary health care and to universal health coverage. African countries continue developing education curricula for training TM experts as a way of disseminating traditional medical knowledge and practices embedded in African culture (Innocent, 2016; Innocent et al., 2022). In particular, countries such as Ghana, South Africa, Tanzania, etc. that have developed education curricula also have traditional medicines registered and sold over the counter (Innocent, 2016). The Covid-19 pandemic in Tanzania left a remarkable emphasis on the use of evidence-based traditional medicine, also being a landmark in formalization of the integration of traditional medicine in the Tanzania referral hospital (Tarimo et al., 2023).

Otherwise, IK holders continue sharing practices and *materia medica* associated with certain knowledge in trade systems. For example, the growth of the global market for herbal products is at the rate of 7%, with a forecast expectation of $5 trillion by 2050 (Fao, 2005; Jadhav et al., 2020). Most worldwide traded medicinal plants include spices as medicines or raw materials for pharmaceutical developments. In Tanzania, exports of spices are dominated by cloves which in 2021 made it the 3rd largest exporter of cloves

(*Syzygium aromaticum*, HS Code 090710), in the world with an export value of 93.2 million (Nderitu, 2021). Eugenol extracted from cloves bears huge industrial applications, particularly in pharmaceutics. In dentistry, *eugenol is the main ingredient in dental preparations with zinc oxide for root* canal sealing and pain control. Also, eugenol is used as a flavouring of foods, perfumes, and cosmeceutics. Other significant exports from Tanzania are cardamom, pepper (of the genus Piper) and ginger, neither crushed nor ground, both having classified health benefits of global concern (Nderitu, 2021). The use of spices as medicines by the Swahili people of the coast of East Africa is a common practice. The spices are impregnated in food preparation depending on a desirable carrier, method of administration and the disorder or condition to be treated. For example, for digestive and respiratory disorders they can be prepared as spiced teas, sauces, soup, etc. Spices are thus significant in the local market as well as contributing to the export earnings.

4. Conclusion

The contribution of IK in advancing science that addresses local and global health challenges is significantly acknowledged. Bio-prospecting should recognize and remunerate indigenous people for ethno-ecological knowledge and biodiversity conservation. Transformation of IK through research, development, innovations and trade systems is inevitable. Thus, fair and equitable sharing of benefits creates a motivation to biodiversity protection/conservation to curb climate change, as well as continuing to offer mankind medicines and leads in pharmaceutical production.

Acknowledgments

The Author is grateful to the Vatican Pontifical Academy of Sciences (PAS) for sponsorship to the conference *on Indigenous Peoples' Knowledge and the Sciences – Combining Traditional knowledge and science on innovations for resilience to address climate change, biodiversity loss, food security and health*, held on 14-15 March 2024 and to Muhimbili University of Health and Allied Sciences for granting permission to participate.

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Scientific Validation of Traditional Medicines: Perspectives of ICMR-National Institute of Traditional Medicine, Belagavi, India

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Abstract

Background: Traditional medicines (TMs), deeply rooted in indigenous knowledge and culture, are widely used globally. Despite their growing popularity, they lack sufficient scientific validation in the context of modern science, raising concerns about their safety and efficacy.

Objective: This review discusses the role of the ICMR-National Institute of Traditional Medicine (ICMR-NITM) in validating TMs, particularly herbal medicines commonly practiced in India, using modern scientific tools.

Methods: ICMR-NITM employs a reverse pharmacology approach, with a focus on documenting traditional practices, pharmacognostic analysis, phytochemistry, toxicology, preclinical and mechanistic studies and finally, clinical evaluation. Emphasis is placed on community-based validation cycles.

Results: Various medicinal plants were scientifically validated for safety and efficacy. Significant advancements have been made in pharmacognostic studies, chemical profiling, and toxicity assessments.

Conclusion: Validation of TMs through modern science is crucial for their integration into healthcare. ICMR-NITM's efforts provide a framework for future research and the sustainable use of traditional knowledge in modern medicine.

Keywords: Traditional Knowledge, Traditional Medicine, Herbal Medicine, Validation, Ethnomedicine, Integrative Medicine, Integrative Health.

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Traditional Medicines

Traditional Medicine (TM) refers to the health practices, approaches, knowledge, and beliefs developed over generations within various cultures (WHO, 2013). It is often used to prevent, diagnose, and treat illnesses. Unlike modern medicine, TM is rooted in cultural traditions and may include a holistic view of health. Though TMs are not the mainstay for treating major diseases, they are invaluable in preventing and managing chronic ailments and addressing the health demands of ageing populations. According to some estimates, over 80% of the world's population uses TM products in some form, and the tendency is growing (Thakkar et al., 2020). The increasing usage of TM products is attributed to a preference for 'natural or holistic' approaches, a desire for a high degree of autonomy in self-management, and a perception of ultimate safety (Hirschkorn et al., 2006; Hassan et al., 2009).

Traditional Medicines as rich legacy of Traditional Knowledge across the world

Traditional medicines have long been a rich source of indigenous knowledge across the world, playing an essential role in the health and well-being of numerous communities. Indigenous systems of medicine are often deeply rooted in cultural, spiritual, and ecological knowledge, passed down through generations, often in oral forms. These practices and remedies are typically based on local flora, fauna, and natural elements, tailored to suit local environmental conditions and/or diseases.

Traditional medicine is often connected to rituals, customs, and spiritual beliefs, providing not only physical healing but also cultural continuity and identity for indigenous groups. Indigenous communities have a deep understanding of the medicinal properties of local plants, animals, and minerals. This knowledge is highly specific to local ecosystems, guiding the sustainable use of biodiversity. Indigenous medicine often views health holistically, focusing on the balance between mind, body, spirit, and community, rather than merely treating symptoms. The balance of energies and prevention are central.

Some of the global examples are:

- India (Ayurveda and Unani): Ayurvedic practices use herbs like turmeric, ginger, and ashwagandha for healing, integrating principles of balance and energy.

- China (Traditional Chinese Medicine): Herbal medicine, acupuncture, and qigong are key components of Traditional Chinese Medicine, drawing on ancient texts like the Huangdi Neijing.
- Africa: Various African countries have rich traditions of using herbal remedies and spiritual healing practices. For example, in South Africa, sangomas (healers) use herbs like buchu for treating ailments.
- South America: Indigenous groups in the Amazon use a vast array of plants, many of which have not been fully studied by modern science. Ayahuasca, a brew with psychoactive properties, is used in spiritual ceremonies.
- North America: Native American tribes, like the Navajo or Lakota, have herbalists and spiritual healers who utilize plants such as sage, echinacea, and bearberry for various health conditions.

Many pharmaceutical drugs used today have origins in traditional medicines. Indigenous knowledge has contributed to the discovery of compounds in plants like quinine (used for malaria), aspirin (from willow bark), and many others. Traditional medicine often emphasizes the sustainable use of natural resources and many indigenous practices involve the conservation of plants and careful harvesting to maintain ecosystems.

Present day challenges include the erosion of knowledge due to globalization, industrialization, and the loss of natural habitats that threaten indigenous knowledge systems. Younger generations are often found to be less exposed to traditional medicine practices. There are also issues with biopiracy and commercialization of indigenous knowledge without proper compensation or recognition of the original source become remain contentious. Pharmaceutical companies are often accused of patenting medicinal ingredients used by indigenous communities for centuries.

There is increasing recognition of the value of traditional medicine in complementing modern healthcare, leading to integrative approaches in many countries. However, tensions remain between traditional practitioners and modern medical systems across the globe.

Preserving traditional medicine involves safeguarding not just the plants and ingredients used but also the cultural practices, languages, and ecological knowledge that underpin these systems.

Codified and Non-Codified systems within Traditional Medicine practices

TMs are often classified into codified and non-codified systems based on the availability of the written scripts on TMs. The codified traditional medicine systems refer to systems of medicine that have been formally documented, standardized, and often recognised by governmental or regulatory bodies. These systems typically have written texts, guidelines, and established practices that define their use.

The non-codified system are, on the other hand, practices that are often not available in authentic written scripts, mostly comprises of knowledge handed over from generation to generation by oral and ritual means.

Most folklore and health practices of indigenous tribes and communities fall under this category. Non-codified systems form a large part of the wealth of indigenous knowledge systems that require preservation.

Traditional Medicine practices in India

In India, Ayurveda, Yoga and Naturopathy, Unani, Siddha, Sowa-Rigpa, and Homeopathy (collectively known as AYUSH) are the codified systems of TM in practice. On the other hand, the non-codified TMs consist of practices that are primarily based on oral traditions, local customs, and community knowledge. These systems lack formal documentation and standardization, making them more varied and individualized. Folk medicines and indigenous healing practices are included among such systems.

In India, over 80% of the rural population use medicinal herbs or traditional medicines, especially for their primary healthcare (Mukherjee & Wahile, 2006). It includes both codified systems and non-codified practices. TM practices are deeply embedded in Indian culture and continue to play a vital role in healthcare, wellness, and spirituality nationwide.

A reason behind India's strong wealth of knowledge in traditional medicines is its mega-diversity that harbours 7-8% of all recorded species; 45,000 different plant species (in addition to 91,000 animals) distributed in 15 agro-climatic zones, India boasts of the presence of 17,000 to 18,000 species of flowering plants out of which 6,000 to 7,000 are designated to have medicinal value (National Biodiversity Authority, India, 2014, NMPB http://www.nmpb.nic.in).

Surge in TM use

The past decade has witnessed a tremendous surge in acceptance and public interest in natural therapies both in developing and developed countries. Herbal remedies are available not only in drug stores but now also in food stores, supermarkets and on e-commerce platforms (Ekor, 2013). A major reason why the industry is falling back on nature is the difficulty in identifying new lead structures, the high cost of classical drug discovery, and the huge burden of drug failures in recent history. Bandaranayake (2006) has listed out some other possible reasons for the new interest in herbals, many of which are criticised largely because of a lack of data on safety and proven efficacy (Ekor, 2013).

Need for validation of TMs

Despite centuries of use, one of the major drawbacks of TMs is the scarcity of scientific literature that demonstrates and documents the safety and efficacy of these medicines. In an informed world, evidence is a prerequisite for advocacy. With the development of sophisticated tools and modern technologies, it has become imperative that TMs are tested for their use and relevance in the modern-day environment. Therefore, there is a requirement for validation (often called re-validation) of traditional medicines to establish their utility. Furthermore, because of their natural origin, there are often issues with their contents, depleting plant/natural resources, problems with misidentification/substitution/adulteration of crude drugs, microbial contamination and shelf life, undermining of safety and toxicity, there is a need to establish certain standards. There is also an urgent need for regulations to ensure the safety and efficacy of traditional medicines, which in turn require scientific evidence based on the data. Therefore, these TM practices need to be scientifically validated to provide evidence of their safety and efficacy, to ensure better patient care and reliability and for their wider acceptance.

Validation of TM at ICMR-National Institute of Traditional Medicine (ICMR-NITM), Belagavi, India

The ICMR-National Institute of Traditional Medicine (https://icmr-nitm.res.in/), located at Belagavi in Karnataka State, India, is one of the Institutes of Indian Council of Medical Research under the Department of Health Research, Ministry of Health and Family Welfare, Government of India. It is a premier institution dedicated to the research, education, and promotion of traditional medicine systems in India. Established to support integrating traditional healing practices with modern scientific methodologies, ICMR-NITM plays a vital role in advancing the understanding and application of various traditional medicine systems.

ICMR-NITM works mainly in two research domains; the first one is to generate knowledge in the area of conventional medicine, including modern technologies for diseases of importance, while the second domain is to conduct research on knowledge systems of Indian TMs, including both codified and non-codified systems. The overall objective is to generate evidence on the safety and efficacy of TMs, so that those could be integrated into the health care system for better health outcomes (Fig. 1). It is also aimed to generate the required evidences on various TM systems to enable the Government to frame suitable policies and frameworks to regulate the TM systems in India.

This article is limited to the aspects of ICMR-NITM's validation of herbal medicines, the mainstay of various forms of traditional medicines practised in India.

Herbal Medicines

Herbal medicines are medicinal products consisting of a substance produced by subjecting a plant or plants to drying, crushing or any other processes or of a mixture whose sole ingredients are two or more substances so produced. It is a mixture of herbs/plants for therapeutic value.

About 30% of the worldwide sales of drugs are based on natural products originating from traditional medicines. Even modern drugs like morphine, quinine, cocaine, tubocurarine, pilocarpine, reserpine, etc., were derived from traditional medicinal forms. Traditional medicines have also provided new lead structures, templates and scaffolds for modern drug discovery. It has been reported that 39% of 520 new approved drugs are derived from natural products. Natural products also contribute to 60-80% of antibacterial & anticancer drugs (Newman & Cragg, 2012). It has been reported that about 80% of 122 plant-derived drugs were related to their original ethnopharmacological use. Current drug discovery from plants based upon bioactivity-guided fractionation has led to the isolation of many important anticancer drugs such as paclitaxel, camptothecin, etc. The first therapeutic commercial pure natural product discovered this way was morphine (1826), while the first semi-synthetic pure drug, aspirin by Bayer, was based on salicin, isolated from the plant *Salix alba*. Isolation of other drugs, e.g. cocaine, codeine, digitoxin, quinine and pilocarpine, followed. Some are still in use, and others have undergone development from plant-derived compounds (Fabricant & Farnsworth, 2001).

Although animal products, minerals, etc., are also often used in various forms of traditional medicine, this paper is restricted to the validation of herbal medicines.

For the validation, ICMR-NITM follows the 'Reverse Pharmacology' approach. This approach of TM research is defined as the science of integrating documented clinical experiences and experimental observations into leads by transdisciplinary exploratory studies and further developing these into drug candidates through robust preclinical and clinical research (Patwardhan et al. 2008). The Reverse Pharmacology approach aims to reduce the major bottlenecks of cost, time and toxicity in TM research. The application starts with proper documentation of TM practice, including clinical observations; followed by the exploratory studies in relevant *in vitro* and *in vivo* models; and the third phase is validation through experimental studies, both laboratory and clinical setups. In this approach, the lead travels a reverse path from 'clinics to laboratory' rather than classical 'laboratory to clinics'.

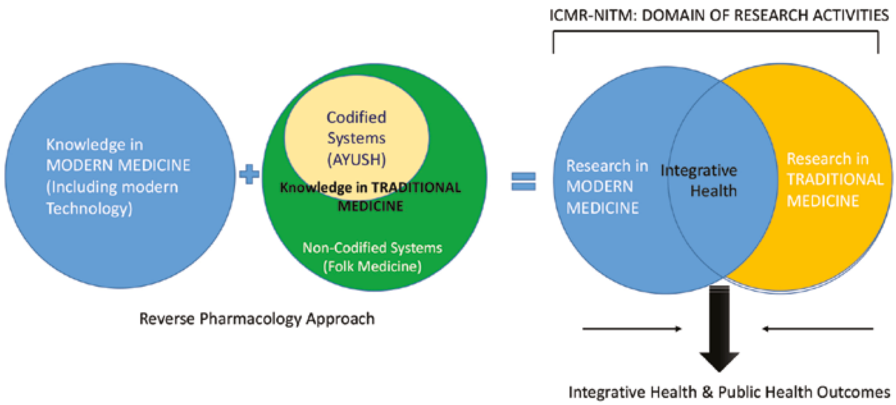

Figure 1. Research domains of ICMR-NITM for validation of TMs.

Validation cycle for TM at ICMR-NITM

The validation cycle, which is being followed at ICMR-NITM, starts in the community settings, traverses through various laboratory procedures and ends again in the community or clinical settings (Fig. 2). This validation cycle aims to provide the community either with a validated practice, which is safe to use and efficacious in treatment or to develop a validated product by value addition to the existing practice, which is found to be safe and effective. The first approach empowers the community directly while ensuring the safety and efficacy of the locally used TM practice, whereas the second approach adds value to the validated practice enabling further development into products for their wider utility (Fig. 3).

The details on each of the steps with the examples and the outcome so far are discussed below.

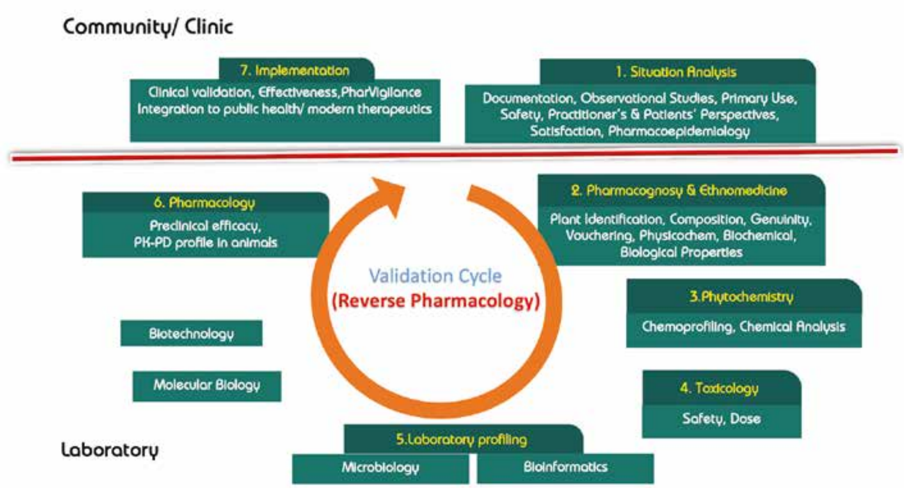

Figure 2. Validation cycle for TMs at ICMR-NITM.

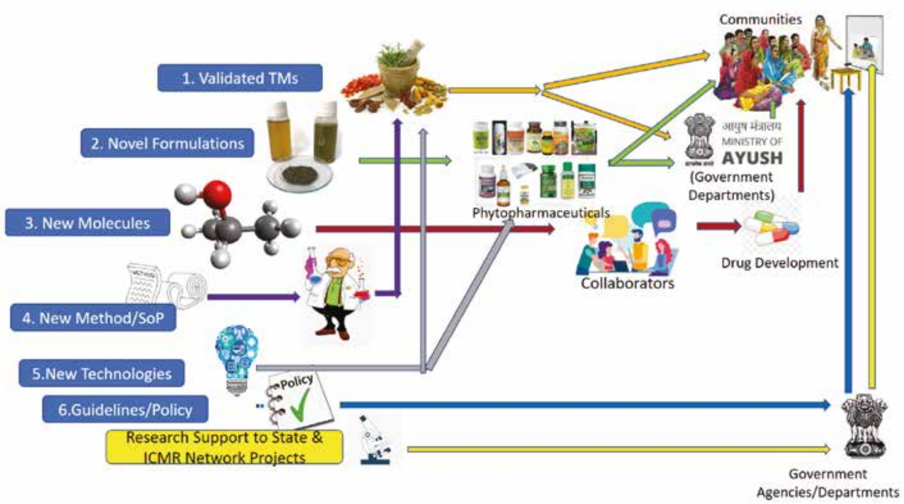

Figure 3. Outcome delivery of ICMR-NITM's research.

1. Documentation of TM practices

The first step in the research on TMs is correct documentation of TM practices, especially for those from non-codified systems. The use of medicinal plants, animal or mineral sources are properly documented through visits to the TM practitioners and through observational studies. The documentation is done through discussions and semi-structured interviews with the identified TM practitioners. The data is collected in the validated data capturing format and the corresponding herbarium specimens are preserved at the herbaria of the Institute. The perspectives from the patients attending to the practice are also documented to generate preliminary information about the clinical safety and efficacy of the practice from the patient's point of view.

ICMR-NITM is involved in such documentation since its inception in 2006 and it coordinated the documentation of the medicinal plants employed in the TM practices of the Western Ghats in India, which has been compiled into a 'Database on ethnomedicinal plants of Western Ghats' (Upadhya et al., 2009a). This database has free access from the website of the Institute (https://nitmmedplantsdb.in/) (Fig. 4). Various TM practices from the Belagavi region in Karnataka (Upadhya et al., 2009b) and their present scenario (Upadhya et al. 2014a) have been studied in detail. The details of TM practices for reproductive health (Hegde et al., 2007) and bone fractures (Upadhya et al., 2012) from the region were also recorded by the Institute.

The documentation of traditional medicinal practices is vital for preserving cultural heritage and also to set the platform for their validation process. As it is not possible to validate all the documented TM practices due to the limitations of time and resources, and therefore, only a few of the practices are prioritised. The selection of TM practices for validation is a multifaceted process that requires careful consideration of the history of their use, availability of evidence base, and economic viability, in addition to empirical and practical factors. The availability of the resources and their sustenance is also a factor for selection. For example, the plants that are endangered, the plant parts leading to destructive harvesting of plants such as roots and bark, seasonal plants, etc., are normally considered not suitable for the validation process. Employing such criteria, the TM remedies that hold the most significant promise for safety and efficacy are selected for further validation.

In the process of documentation of ethnomedicinal use of plants, ICMR-NITM could also locate and report a few rare and a few new plant species from the region (Mesta et al., 2009; Mesta et al., 2011; Pai et al., 2011) contributing to set conservation priorities for medicinal plants in the region.

During the documentation process, ICMR-NITM also created a Directory of Traditional (Folk Healers in Non-codified TM practice) in the Western Ghats region with details such as their names, telephone numbers, types of conditions they treat, how they have learnt the treatment, etc. (Fig. 3). This Directory is not in the public domain as it contains the personal information of the folk healers. However, this Directory not only helps find the set of healers for a particular disease during specific research needs but also helps the Institute conduct Traditional Healers' Meet from time to time to share knowledge between healers and scientists and understand the needs from both perspectives.

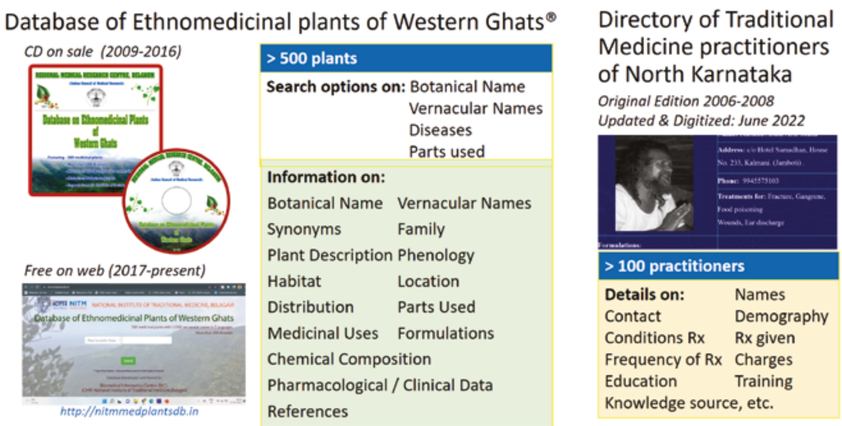

Figure 4. ICMR-NITM database on ethnomedicinal plants and directory of TM practitioners.

2. Pharmacognosy and Ethnomedicine

Pharmacognosy is an invaluable tool for ensuring the quality of medicinal plants. By employing a range of scientific techniques for identification, standardization and quality testing, pharmacognosy supports the reliable use of herbal medicines in healthcare.

As examples, we take the cases of the two important medicinal plants *viz. Achyranthes aspera* L. and *Piper nigrum* L. The root of the former is used for the treatment of various fevers and poisonous bites, while the fruits of the latter are extensively used as spice and also in treating cold and cough, and inflammations. ICMR-NITM noted the instances of the adulterations of these plant drugs with other allied species of plants from the same genus. The detailed pharmacognostic evaluations of allied species in the genera *Achyranthes* (*A. aspera* L. and *A. coynei* Sant.) (Upadhya et al., 2014b; Upadhya et al., 2015) and Piper (*P. nigrum* L. and *P. trichostachyon* (Miq.) C.DC.) (Upadhya et al., 2016; Balekundri et al., 2024) enabled their differentiation, so that the authenticity of the raw drugs are ensured.

Saraca asoca (Roxb.) Willd., commonly known as 'Sita ashok' in India, is now an endangered species but is extensively used as a tonic for many gynaecological disorders. It is often found contaminated, substituted or even adulterated with materials from other plants like *Polyalthia longifolia* (Sonn.) Thw., *Mesua ferrea* L., etc. ICMR-NITM's studies on phytochemical and genetic profiling of *Saraca asoca* (Roxb.) Willd. addressed the identification and differentiation issues and led to ways that help differentiate *S. asoca* from its adulterants even in commercial market samples (Hegde et al., 2017). The studies on seasonal variations in the chemical constituents in the bark of *S. asoca* revealed marked seasonal variations and helped in standardizing the right season for its collection (Ketkar et al., 2015a; Ketkar et al., 2015b).

Shikimic acid is the precursor to oseltamivir, one of the most important anti-viral drugs, mostly used for treatment of influenza, particularly suspected swine flu. Shikimic acid is conventionally isolated from medicinal plants like *Illicium verum* Hook.f. (Star anise). However, this particular plant rarely grows in India. ICMR-NITM screened fifty eight tree species from the Western Ghats of India for their shikimic acid content, and identified the potential plants species for downstream applications to enhance their shikimic acid content (Kshirsagar et al., 2018).

Further, studies have also been carried out to validate certain principles and practices of *Ayurveda*, one of the oldest TM systems in the world practised widely in India. In *Ayurveda*, certain toxic plants are used for their beneficial effects, after their detoxification. The study on the method of traditional detoxification (*Shodhana*) of two such toxic plants, *Plumbago zeylanica* L. and *Aconitum chasmanthum* Holmes, showed that the levels of toxicity have been drastically reduced following the traditional detoxification procedures (Ankad et al., 2024; ICMR-NITM Unpublished data). The classical Ayurveda preparations *Panchagavya* (made of five ingredients from cow-based products) and *Kunapa jala* (a product based on Ayurveda literature for enhanced plant growth) were found to enhance plant growth on their application to plants and also enhanced the important bioactive components in the experimental plants viz. *Withania somnifera* L. and *Andrographis paniculata* Nees (Ankad et al., 2017; Ankad et al., 2018; Ankad et al., 2020).

As interest in natural remedies continues to grow, the role of pharmacognosy will be increasingly vital in ensuring the use of correct plant drugs so that the safety and effectiveness of medicinal plants used are beneficial to both patients and practitioners alike.

3. Phytochemistry

Phytochemical investigations help to know the chemicals and bio-actives present in the plants that are utilized in TM practices. This chemo profiling and chemical analysis is performed using various chromatographic and analytical methods and instrumentations, which include column chromatography, High Performance Liquid Chromatography (HPLC), Ultra Flow Liquid Chromatography (UFLC), High-Performance Thin Layer Chromatography (HPTLC), Gas Chromatography (GC), Mass Spectrometry (MS), Fourier Transform-Infrared Spectroscopy (FTIR) and Nuclear Magnetic Resonance (NMR) spectroscopy.

The chemical composition of traditional medicinal plants is critical to understanding their therapeutic properties and potential applications in healthcare. These plants contain a diverse array of bioactive compounds that contribute to their medicinal effects.

While modern techniques and methods have helped identify bioactive compounds from some medicinal plants, identification of active principles has remained elusive for most medicinal plants even today. It has often been found that multiple molecules play an important role in the activities of medicinal plants in vivo, and therefore, these molecules in isolation often fail to elicit the response that the crude drugs or their extracts/fractions elicit. Nonetheless, there are continuous efforts to identify active molecules and understand the modes of action of these medicinal plants.

As essential oils play a significant role in the biological activity of plants, several medicinal plants have been screened for the chemical compositions of their essential oils. The essential oils of various parts are from well-known plants in Indian TM practices such as *Feronia elephantum* Correa (Joshi et al., 2011), *Tridax procumbens* L. (Joshi et al., 2012), *Chromolaena odorata* (L.) RM King & H. Rob (Joshi et al., 2013a), *Ocimum gratissimum* L. and *O. sanctum* L. (Joshi et al., 2013b), *Cyathocline purpurea* (Buch.-Ham. ex D. Don) Kuntze (Joshi, 2013c), *Chloroxylon swietenia* DC (Ankad et al., 2014), and *Saraca asoca* (Roxb.) Wilde (Joshi, 2015) have been subjected to chemical profiling, along with evaluating their antimicrobial activities. The chemical profiling of extracts and quantification of known bio-active compounds were carried out for other traditionally used plants such as *Achyranthes coynei* Sant. (Upadhya et al., 2013), four allied species of *Ocimum* (Pai & Joshi, 2016) and four species of Terminalia (Bidikar et al., 2023).

The chemistry of the plants was also used to differentiate the chemotypes of *Mentha spicata* L. (Joshi, 2013d) and profile the aroma pattern of *Mentha arvensis* L. (Joshi, 2014) in the Belagavi region in India.

The development of new methods for identification, quantification and analysis of known phytocompounds from medicinal plants helps in either speeding up the process or enhancing the efficiency. Compound-specific extraction methods were developed for Camptothecin from *Nothapodytes nimmoniana* (Grah.) Mabb and Piperine from *Piper nigrum* L. (Upadhya et al., 2014), while methods for analysis were developed for betulinic and oleanolic acids from *Achyranthes aspera* L. (Pai et al., 2014), Nitrosamines in tobacco (Sharma et al., 2015) and piperene from *Piper trichostachyon* (Miq.) C.DC. (Hurkadale et al., 2021). The elite population for the production of bio-active compounds like camptothecin in *Nothapodytes nimmoniana* (Grah.) Mabb. (Ankad et al., 2015), mangiferin from *Swertia sps*. (Kshirsagar et al., 2016), and oleanolic and ursolic acids from *Achyranthes aspera* L. (Pai et al., 2016) were identified through the content range analysis of the desired compounds.

The chemical composition of traditional medicinal plants is complex and varied, encompassing a wide range of bioactive compounds. Understanding these constituents is crucial for validating traditional uses, ensuring safety, and discovering new therapeutic applications. Ongoing research into the chemical profiles of these plants not only enhances our knowledge of their health benefits but also supports their use in the TM systems.

4. Toxicology and safety studies

Toxicology and safety studies of TM are crucial for ensuring their safety at the first level. This will also help establish safe dosage ranges to prevent any adverse effects of the TMs. The toxicity studies of the TMs are carried out at ICMR-NITM first in *in vitro* system (in cell lines), and then evaluated in suitable *in vivo* models (in animal models). *In vivo* studies are carried out in zebrafish models initially and then in rodent models, wherever required, following standard protocols and Institutional Animal Ethics Committee recommendations. The TMs are evaluated for their acute toxicity (effects of a single dose over a short period), chronic toxicity (long-term exposure and its effects), genotoxicity (potential to damage genetic information), and reproductive and developmental toxicity (effects on fertility and foetal development). Generally, the safety studies are conducted along with the efficacy studies to save time and resources, except for a few (Kumar et al., 2015), and therefore, they are discussed in sections 5 & 6 along with laboratory studies (for *in vitro* models) and pharmacology and pre-clinical studies (for *in vivo* models) respectively.

The safety and toxicological data are crucial in developing modern scientific evidence for TM to ensure their safety before the efficacy. This will also help to monitor the unsolicited adverse events of the TM practices, especially with the dose adjustments.

5. Laboratory studies

Laboratory studies of the TMs generally involve scientific investigations to understand the mechanisms of action of the TM as a whole or its ingredients and contents. These involve *in silico* studies using bioinformatics tools, microbiology and molecular biological studies, and biotechnological applications.

5.1 In silico studies (Bioinformatics)

In silico studies refer to computational methods used to analyse biological data and simulate biological processes, particularly in the context of drug actions. Applying *in silico* techniques to medicinal plants has gained significant traction, providing valuable insights into their chemical properties, potential therapeutic effects, and mechanisms of action.

While working on *in silico* studies of medicinal plants involved in TM, ICMR-NITM developed a new concept and niche area of 'Herbal Informatics' in 2013 (Fig. 5). Herbal informatics is a multidisciplinary approach that links traditional knowledge to modern medicine using information technology and big data biology. It starts with information on the plants used to treat various disease conditions from the TM knowledge base (e.g., the Database of Ethnomedicinal Plants of Western Ghats, developed by ICMR-NITM). This is correlated with the modern description and definition of the identified disease condition, and information available in the medical literature (e.g. PubMed) on the disease metabolites. Then data science takes the lead with the identification of the phytocompounds in the plants and the targets for the identified disease conditions by applying various bioinformatics tools (Fig. 5). This leads to identifying the active phytocompounds from the plants, which bind to the disease-specific targets, and thus helps in predicting the action of the phytocompounds present in the plants. The plants or the phytocompounds thus selected are further subjected to their we-lab evaluations. Thus, the herbal informatics approach acts as a sieve to shortlist the plants from TM for their further evaluations, saving time, material resources and effort.

ICMR-NITM was amongst the first to use this approach of 'Herbal Informatics' on Reverse Pharmacology validation of TMs. Using Herbal Informatics, ICMR-NITM decoded the plant metabolite-disease target linkages in many traditionally used medicinal plants. The roles of gymnemagenin from *Gymnema sylvestre* (Retz.,) R.Br. in diabetes (Rathore et al., 2016); flavonoids and diterpenoids from *Andrographis paniculata* Nees and *Thespesia populnea* (L.) Sol ex Correa in hepatocellular carcinoma induced by hepatitis B (Patil et al., 2022); and efficacy of *Theobroma cacao* L. against doxorubicin-induced organ toxicity were predicted based on the bioinformatics studies (Patil et al., 2023a). Further, the molecular mechanism of actions of *Withania somnifera* (L.) Dunal against cancer (Deshpande et al., 2023a), *Garcinia indica* Choisy (Beerwala et al., 2024) and *Bidens pilosa* L. (Galagali et al., 2024) against alpha-amylase inhibitory activity, and selected phytocompounds from medicinal plants against diabetes mellitus (Patil et al., 2020), rheumatoid arthritis (Deshpande et al., 2023b), hepatitis B (Patil et al., 2023b) were deciphered employing such computational studies.

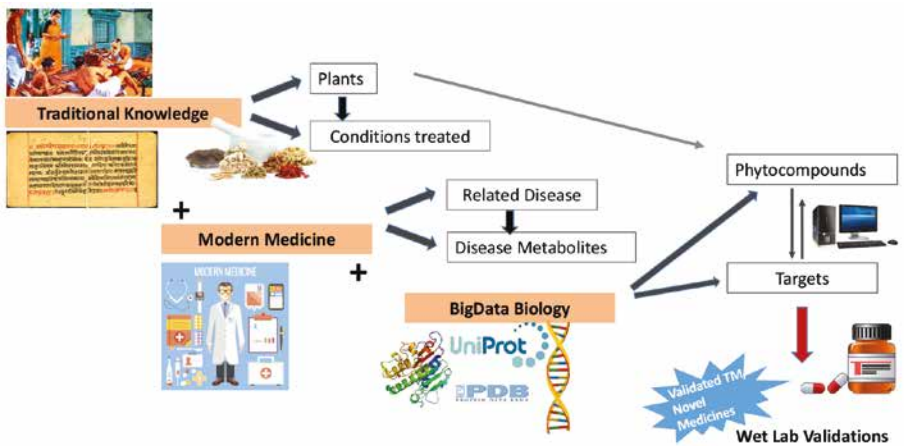

Figure 5. ICMR-NITM concept of Herbal Informatics.

The *in silico* approach was also found useful in predicting the phytochemical moieties from Indian TM for targeting dual hotspots on SARS-CoV-2 spike protein (Umashankar et al., 2021), and profiling a natural product, diosgenin, against breast cancer (Khanal et al., 2023).

In silico studies are transforming the field of medicinal plant research by providing powerful tools for understanding the chemical properties, biological activities, and therapeutic potentials of plant-derived compounds. The availability of tools to draw network maps in biochemical actions have helped in studying interactions between targets and potential drugs at the systems level. The use of Artificial Intelligence and Machine Learning in these areas are expected to further strengthen this field. This aspect of science is playing a crucial role in bridging the gap between traditional knowledge and modern science. It helps to validate the efficacy of herbal medicines, supports the development of evidence-based practices, and ultimately enhances our understanding of traditional medicinal practices and their applications in modern healthcare.

5.2 Microbiology and Molecular Biology

Microbiology and molecular biology are crucial fields for research in traditional medicine, as they help elucidate the mechanisms behind the efficacy of various natural remedies.

Microbiological studies help determine the efficacy and safety of traditional medicines against various pathogens and research the antimicrobial properties of traditional remedies, which can provide alternatives to synthetic antibiotics and help combat resistance. Antimicrobial activities of *Craniotome furcata* (Link) Kuntze (Joshi et al., 2010) and *Achyranthes coynei* Sant. (Ankad et al., 2013) provided promising leads for natural antimicrobials. The investigation on anti-cholera toxin activity of selected polyphenols from *Careya arborea* Roxb., *Punica granatum* L., and *Psidium guajava* L. provided the important leads for further animal experimentations (Charla et al., 2023).

Molecular biology tools, like gene expression analysis, can reveal how the bioactive compounds interact at the cellular level, including their effects on specific biological pathways. ICMR-NITM also utilized the molecular biology techniques for quality assurance of the medicinal plants, by differentiating the adulterants from the genuine plant drugs based on their genetic profiles. Molecular identification of *Saraca asoca* (Roxb.) Willd. in combination with RP-HPLC analysis effectively differentiated the genuine samples from its adulterant (Hegde et al., 2017; Hegde et al., 2018). Further, the same tools were utilized to assess the genetic diversity of *Saraca asoca* (Roxb.) De Wilde (Saini et al., 2018), and for understanding their population variability to develop conservation strategies (Hegde et al., 2018).

TM research benefits greatly from the integration of microbiology and molecular biology tools and techniques. This multidisciplinary approach not only helps to validate and enhance traditional practices but also opens avenues for developing new therapeutic strategies grounded in ancient knowledge.

5.3 Biotechnology

Plant tissue culture is one of the biotechnological tools which is being employed at ICMR-NITM for rapid multiplication of medicinal plants and for enhancing the production of identified secondary metabolites. The protocols were developed for the enhanced production of phenolic antioxidants from *Jasminum malabaricum* Wight (Gadkar et al., 2015), and triterpinoids from *Achyranthes aspera* Linn. (Pai et al., 2018). Protocol was also developed for rapid multiplication of vulnerable plant *Curcuma pseudomontana* J. Graham (Vaze et al., 2024). The antibacterial activity was found to be enhanced in leaf-callus extracts of *Alophyllus cobbe* L., when compared to that of the leaves (Hegde et al., 2010).

Plant tissue culture is providing a rapid way for multiplication for the plants, especially those with conservation concerns. In addition, the developed protocols for enhancing the production of bioactive compounds *in vitro* will reduce the dependency on natural resources, thereby enhances sustainability.

6. Pharmacology & pre-clinical studies

Pharmacology and preclinical studies in TM are essential for understanding how the medicine works, their safety, and their potential therapeutic effects. This involves studying their effects on biological systems and comparing them with conventional treatments. Animal models are used to evaluate the safety and efficacy of TMs, that forms a living model. This phase helps in understanding how the body responds to the treatment and allows for the observation of side effects. Preclinical studies support the development of a regulatory framework for TM, before their clinical trials in humans.

The first level of pre-clinical studies are *in vitro* evaluations, wherein various biological models other than animals are used. This may include bacteria, fungus, proteins, cell lines and models mimicking the actions of the biological system. Along with identifying the chemical composition of the plants used in TM, many of the plants are screened for their preliminary biological activities, such as antimicrobial and antioxidant activities. In one such study, a thermo-reversible gel of cranberry juice concentrate was formulated and evaluated for its biocompatibility and its antimicrobial activity against periodontal pathogens (Rajeshwari et al., 2017). Various plant extracts have been tested for their antiviral activity against dengue and chikungunya viruses *in vitro* (Alagarasu et al., 2022), which provided potential leads for evaluation of their antiviral activities. The leaf extracts of *Anacardium occidentale* L. showed promising antimalarial activity against *Plasmodium falciparum* Transketolase (Kaushik et al., 2023). Medicinal plants traditionally used against diarrhoeas were evaluated against toxin-induced cyto- and entero-toxicities in cholera (Charla et al., 2022) and selected polyphenols from *Careya arborea* Roxb., *Punica granatum* L., and *Psidium guajava* L. have shown Anti-Cholera toxin activities, which are promising (Charla et al., 2023). This has implications in use during outbreaks, thereby reducing unnecessary use of antibiotics and serving to reduce emergence of Anti-Microbial Resistance (AMR) which is a global concern. Glaucarubinone, a natural product, was found to sensitise KB cells to paclitaxel by inhibiting ABC transporters via ROS-dependent and p53-mediated activation of apoptotic signaling pathways (Karthikeyan et al., 2016), while Piperlongumine was found to induce ROS mediated cell death. It showed synergistic activity along with paclitaxel in human intestinal cancer cells (Rawat et al., 2020). It is also found that Gymnemogenin, one of the major compound from *Gymnema sylvestre* R.Br., reduces the risk factor by promoting lipid metabolism in type 2 diabetes (DasNandy et al., 2022).

In *in vivo* studies, animal models, such as zebra fish, mice, rats, etc. are used for evaluating the TM and their components. In a particular study, selected traditional formulations as a whole were evaluated for their spasmolytic effect in guinea pig ileum (Kumar et al., 2015) and for allergic asthma in Wistar rats (Patil et al., 2018). In another study it was demonstrated that the essential oils from *Mentha arvensis* L. and *Angelica glauca* Edgew. supress airway changes induced by histamine and ovalbumin in experimental animals (Sharma et al., 2017a; Sharma et al., 2017b). When orally administered, the partially purified protease inhibitors from Soyabean showed anti-cancer activity in animal models (Mayasa et al., 2016). The traditionally used medicinal plants, *Sida rhombifolia* L. and *Cynodon dactylon* (L.) Pers. were found to ameliorate scopolamine-induced cognitive dysfunction in rats (Pattanashetti et al., 2021a; Pattanashetti et al., 2021b). The phenol-enriched fraction and ethyl galate from *Caesalpinia mimosoides* Lam. were found to promote cutaneous wound healing in rat models (Bhat et al., 2022; Bhat et al., 2023).

Integrating pharmacological research and preclinical studies into the evaluation of traditional medicine will help to bridge the gap between traditional and modern medical practices, leading to the development of safe, effective, and standardized herbal treatments.

7. Clinical and Implementation Research

ICMR-NITM is conducting clinical/community-level trials of many of the TM practices, both from codified and non-codified systems. A couple of TM practices for anaemia, one each for non-alcoholic fatty liver disease (NAFLD), diabetic foot ulcers and osteoarthritis, are undergoing clinical trials. Many such TM practices are at various validation stages, which will be taken up to the clinical trials stage in due course of time.

Implementation research in traditional medicine focuses on understanding how to effectively integrate traditional practices into healthcare systems, ensuring they are safe, effective, and accessible. This research is critical for optimising health outcomes, particularly in communities that rely on traditional healing practices. However, the implementation research in TM is still evolving in India, and there is a need to address the proper framework, regulations for TM and rules for their integration with the conventional healthcare system. ICMR-NITM is trying to address a few of these issues. To identify the reported adverse drug reactions related to TM, ICMR-NITM compiled and analysed the data for the Asia region from the United Nations WHO VigiBase on Suspected cutaneous adverse drug reactions (Barvaliya et al., 2023). A similar case of suspected cutaneous allergic reactions with Ayurveda medicine *Punaranava Mandura* was observed at the integrative clinic of ICMR-NITM and was reported (Roseleena et al., 2024). Recognising the importance of vigilance on potential herb-drug interactions during concomitant use of conventional medicine and TM, ICMR-NITM carried out a study of reported adverse and synergistic interactions between commonly used conventional medicines and commonly used OTC drugs from TM for diabetes, arthritis and gastrointestinal disorders (unpublished). It developed a web-based resource that would not only help patients and practitioners to understand reactions between herbs and drugs that have been reported but also understand the potential reactions that are likely to happen by the concomitant use of certain herbs and drugs in these common conditions. This has been made possible by leveraging modelling predictions using bioinformatic tools. ICMR-NITM The gaps in implementing clinical trials for TM practices, such as clinical trial insurance, were also flagged by the Institute (Roy et al., 2022).

However, there is a long way to go to reach the point of successful integration of TM into the conventional healthcare system.

Thus, the implementation research links the studies back to the community, completing the cycle. Implementation research in TM is vital as it bridges the gap between traditional and modern healthcare practices. By focusing on effective integration, addressing barriers, and engaging stakeholders, this research can lead to improved health outcomes and a more holistic approach to healthcare.

Future prospects for TM research

The future of traditional medicine research holds great promise as the field continues to evolve, driven by technological advancements, growing interest in holistic health, and an increasing acceptance of integrative approaches in healthcare. The interdisciplinary approaches combining traditional knowledge with modern pharmacology, molecular biology, and biotechnology to validate and understand traditional remedies and thrust for evidence-based practices drive the research to provide credibility to TM practices and their mainstreaming in healthcare systems.

Using computational methods, such as molecular docking, big data biology, and machine learning, facilitates rapid screening and analysis of phyto-compounds, thereby enhancing the efficiency of drug discovery from TM. The establishment of comprehensive databases documenting TM practices, compounds, and their effects is facilitating research in TM. Advances in biotechnology, including genetic engineering and metabolic profiling, are facilitating the extraction and optimization of active compounds, enhancing their therapeutic efficacy and also providing sustenance to the production of bioactive compounds. However, there is a need for more focussed effort on sustainability and conservation of resources, policy and regulatory frameworks, ethical issues related to IPR, clinical trials and integration with conventional health systems, and to increase the quality and level of evidence base for public acceptance.

The future of traditional medicine research is poised for significant advancements, driven by technological innovations, interdisciplinary collaboration, and a global shift towards integrative and holistic health practices. Therefore, the scientific validation of TMs provides much-required insights into holistic health solutions, bridging the gap between ancient wisdom and modern medicine. As TM gains recognition and respect, it will play an increasingly vital role in addressing contemporary health challenges, promoting well-being, and enriching global healthcare.

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Beyond Sacred Ecology: Indigenous Peoples' Observations to Advance the Understanding of Earth's Systems

Yolanda López-Maldonado
Indigenous Science

Abstract

We live on a dynamic planet that is constantly changing. It is in our mutual interest to observe and understand these changes and the behaviour of the planet's systems. Indigenous groups around the world have, since time immemorial, provided sophisticated, accurate and precise observation of changes in various earth systems. They have their own world knowledge systems for observing, collecting, classifying, using, recording, disseminating and reviewing information and concepts that explain how the world works. This includes the use of their own protocols, methods and approaches to data collection and monitoring. Examples include the navigational techniques of Indigenous Peoples of the Pacific islands, and the knowledge of the cryosphere and snow processes by Indigenous groups in the Arctic, to name a few. Despite these precise and accurate observations of change, particularly of the hydrological cycle, Indigenous observations and knowledge are often undervalued and not sufficiently included in global monitoring efforts. But the problems affecting the planet cannot be solved by a single discipline or a single knowledge system. It is therefore important to allow Indigenous Peoples to contribute their observations and knowledge. By continuously observing and developing a deep understanding of the Earth, its evolving behavior and characterizing the processes that shape the planet in which we live, Indigenous Peoples have been able to further develop the foundations on which all our societal benefits are built.

1. Like Gods

Thanks to Western science, humans are now almost like Gods. We have the power to create or destroy life on earth and to alter in seconds important ecological processes that took millions of years to reach an equilibrium. For example, our nature, on which we all depend, has been profoundly shaped by our human activities (Díaz et al., 2019). The magnitude of our negative impacts over ecosystems and the dangerous decline of biodiversity is unparalleled, and negative trends in nature are expected to worsen in the coming decades, leaving humanity insufficient time for action. This escalating environmental crisis has highlighted our vulnerabilities and has also shown that we are often unaware of how we are affected, and how it will continue to affect us, including deepest changes in our interconnectedness with nature. In front of three crises (climate change, pollution and loss of biodiversity), we continue to push planetary boundaries, and it seems that only Western science can help us meet these challenges (UN Environment Program (UNEP), 2020). Since we live on a dynamic planet that is constantly changing due to natural and human processes, it is in our mutual interest to observe and understand these changes and the behaviour of the planet's systems, to be able to develop solutions. But the problems affecting the planet cannot be solved by a single discipline or a single knowledge system. It is therefore important to allow Indigenous Peoples to contribute their observations and knowledge.

As many sustainability efforts have fallen short (Díaz et al., 2020), research has begun to recognize that the Indigenous People's knowledge constitutes an essential and key reservoir of ecological information in our efforts to confront and better understand the ecological crisis we face today (Nakashima et al., 2012). This is because, through intergenerational experience and precise observations, Indigenous Peoples were among the first to understand complex processes on Earth, notice changes in natural phenomena (López-Maldonado et al., 2024), and gain critical knowledge to adapt to environmental (Turner et al., 2022) and climate changes (Reyes-García, García-del-Amo, Álvarez-Fernández, et al., 2024; Reyes-García, García-Del-Amo, Porcuna-Ferrer, et al., 2024).

Research has shown, for example, that nature generally declines less rapidly on the lands owned, managed, and occupied by Indigenous Peoples (Garnett et al., 2018). To a large extent, the physical form and habits of the earth's biodiversity have been preserved through Indigenous People's knowledges and practices. Indigenous Peoples' knowledge has been considered essential and relevant when integrated with Western science in our efforts to understand current environmental changes. Indeed, Indigenous Peoples have become central actors in nature protection, as their knowledge contributes to conservation of important ecosystems and biodiversity around the world (e.g., assessing forest, wildlife, etc.) (Hill et al., 2020; McElwee et al., 2020). Similarly, methods, tools and approaches have been developed that attempt to engage with Indigenous knowledge-holders and to reveal such practices (Tengö et al., 2014). Indigenous Peoples and the detailed information on Earth's features and processes, for example, might contribute to support efforts of new global technologies for monitoring Earth processes and can contribute to further enhance transformations towards sustainability (López-Maldonado et al., 2024).

However, despite all the advances, Indigenous peoples' knowledge is still overlooked and its independence and validity remain undervalued. Why do we continue to rely on a single source of information to solve such complex environmental problems? Why does humanity continue to take such risks? Why does Western science continue to fail in the search for solutions to the most pressing environmental challenges? Is there any other science to rely on? Is there an Indigenous scientific thought? Some of these questions will be answered in this contribution chapter. This will be done by exploring three overarching questions:

1) What do we know about Indigenous Peoples and their knowledge? Here I will situate the most common knowledge and conceptions, misconceptions and myths we have about Indigenous Peoples.
2) What do we probably not know about Indigenous Peoples and their knowledge? Here I will present facts about Indigenous Peoples and talk about the sophisticated thinking of Indigenous groups. I will describe the foundations of this thinking and I will do so from an indigenous perspective.
3) What do we need to know about Indigenous Peoples and their knowledge? I will discuss the importance of Indigenous knowledge and scientific thought in terms of its accuracy as well as the urgent need to decolonise Earth observations for the benefit of humanity.

This manuscript is not in any way intended to suggest that Western science is bad, good, flawed, etc. I argue instead that various misconceptions and myths still abound around Indigenous knowledge and that there is a need to properly distinguish what is and what is not Indigenous knowledge, and to show its precision and accuracy.

1.1 How do we know what we know about Indigenous Peoples?

We know about Indigenous Peoples from pictorial documents (codices), European accounts, and from cultural, archaeological and historical evidence. The few codices that have survived are an important source of information. However, most of the codices that are preserved today are in a highly deteriorated state, making them difficult to read. Similarly, those sources of information are difficult to interpret since they were written using Indigenous languages that do not exist today or that have been suffering a profound erosion. Other sources are the European accounts of Indigenous People's traditions collected during colonial times, although these sources were not very accurate, as they exaggerated the life of indigenous peoples, often presenting them as barbaric, while creating a false image of indigenous cultures. Nowadays, these sources are viewed more critically. The cultural pre-colonial and contemporary continuity between Indigenous Peoples is important to understand their cultures and archaeological remains. Archaeological evidence, however, is so fragmented that it is difficult to build a past without uncertainties. Along with past and contemporary records, scientists understand only a portion of our Indigenous knowledge and the Indigenous scientific thought that has been preserved. Consequently, Western science continues to play a substantial role in the analysis, definition and use of indigenous knowledge and has repeatedly triggered divergent perspectives.

Several myths and frequent misconceptions exist due to the failure to fully understand the magnitude and foundations of Indigenous thought. For example, one of the most common myths is that Indigenous knowledge of the past is not the same as that of today. However, all Indigenous groups have in-depth knowledge of their natural and cultural environments that is place-based, specific and associated with human usage, stretching back over many generations. They have been successfully managing landscapes for centuries and continue to do so (Garnett et al., 2018). Knowledge was transmitted orally, main characteristics remain but, as societies, they have also developed and evolved.

Another common myth is that Indigenous knowledge is unprecise and difficult to understand. The truth is that Indigenous knowledge provides information, methods and practices for the conservation and sustainable use of ecosystems & biodiversity. It can enrich our understanding of environmental change (e.g., through ecological assessments and monitoring) (López-Maldonado et al., 2024).

Among the most frequent misconceptions is that we tend to believe that if Indigenous knowledge is lost, nothing will happen because we have Western science. However, as our humanity struggles to deal with current environmental challenges, supporting Indigenous peoples to preserve their knowledge is relevant since more erosion – even small – of it, represents an existential threat to humanity (López-Maldonado et al., 2024). Listening directly to contemporary Indigenous voices is therefore the only primary source we have for educating people about who are Indigenous Peoples, and constitutes the most direct view of our knowledge, cultures and practices.

1.2 What do we know about Indigenous Peoples and their knowledge?

Spread across more than 90 countries on several continents, Indigenous Peoples are today seen as the actors that will enable a transformative change towards sustainability (Turnhout et al., 2012). Their knowledge has been crucial in nature conservation efforts and the way they sustain thriving habitats and biodiversity has been well documented. Indigenous People's groups account for nearly a quarter of the planet's land surface and protect about 80% of the world's most biodiverse areas, despite the fact that they comprise less than 6% of the world's population (Garnett et al., 2018).

Indigenous Peoples often express deep spiritual connection to nature, reflected in millennia of stewardship, and maintain the healthiest ecosystems of the planet, essential to produce food, freshwater supply and climate stability (Berkes, 2012; McGregor et al., 2020). There are many lessons for the modern world to learn from the ways in which they have understood and coexisted with the environment, especially to explore lessons and principles for living in harmony with nature. Hence, the scientific and policy spheres have been open to examining such non-conventional sources of knowledge and have welcomed dialogue with Indigenous Peoples to co-produce knowledge in different disciplines and thematic areas (Tengö et al., 2017).

In this context, both spheres have undoubtedly recognized Indigenous knowledge and presented it in a way that scientific and policy spheres can understand and connect it to their work. Unfortunately, such processes attempting to emphasise Indigenous dimensions are not made based on Indigenous understandings, conceptions and frameworks and, paradoxically, neglect Indigenous ways of thinking. This method and similar approaches often claim to be inclusive, with guidelines, principles, articulating methods, protocols and approaches to enhance dialogues with Indigenous knowledge-holders (Hill et al., 2020). Despite the long-standing recognition of Indigenous Peoples' ability to understand and adapt to environmental changes (Latulippe & Klenk, 2020; Reyes-García, García-del-Amo, Álvarez-Fernández, et al., 2024; Reyes-García, García-Del-Amo, Porcuna-Ferrer, et al., 2024), Indigenous knowledge is undergoing rapid change and erosion due to the well-intentioned, but inadequate, attempts of scientific spheres to define and to attempt to integrate Indigenous knowledge with western science (Tallis & Lubchenco, 2014).

A common myth in this regard is, for example, that scientists often believe that Indigenous knowledge is intangible and it is not possible to include it in global monitoring efforts. However, Indigenous knowledge and observations comprises several interrelated levels of analysis ranging from the local level (e.g., precise knowledge of species), to the understanding of complex ecological and earth processes on a global scale (e.g., accurate knowledge of the hydrological cycle). The local and global representation of this information is a valuable resource to validate large scale observations and modeling tools that support scientific research. For example, because the Earth's dynamics are connected to broader environmental and biological processes, Indigenous knowledge and local observations may include one or more important connections and events of other processes and changes that might go unnoticed on a global scale (Deemer et al., 2017).

Indigenous knowledge has also been described as an information library for dealing with complex systems (Berkes, 2009) that can help connect the present with the past and restore resilience (Gunderson & Holling, 2002). Indigenous knowledge is based on observations over a restricted and detailed geography (Gadgil et al., 1993). But Indigenous knowledge not only involves accurate locally-based information, but also global processes (Finney, 1998). For example, Indigenous groups have been able to accurately make measurements, observations and predictions of natural phenomena (many of them have not even occurred today) such as equinoxes, solstices, etc., and they did so without the technology we have today. In practice, however, despite such precise and accurate observations, Indigenous observations and knowledge are often undervalued and not sufficiently included in global monitoring efforts as their precision and accuracy are always discarded.

This is perhaps because policy and scientific spheres have not been able to understand the different components of Indigenous knowledge.

1.3 What is it we probably don't know about Indigenous Peoples and their knowledge?

Indigenous Peoples have their own systems of knowing the world for observing, collecting, categorizing, using, recording, disseminating and revising information and concepts that explain how the world works (Johnson et al., 2014). They have their own protocols, methods and approaches for data collection and monitoring (Chilisa, 2012; Deloria, 1999; Kovach, 2009; Lambert, 2014; Smith, 2012; Wilson, 2008). All this is a key characteristic of a particular scientific thought and it has been described as a bound up with a sense of community (Cajete, 2000; Johnson et al., 2014). In practice, it embraces the spiritual and moral relationship side of human-nature

Characteristic	Indigenous	Western	References
INFORMATION			
Type of information/data	Qualitative Depends on local-social mechanisms Involves environmental ethics and spirituality No vocabulary to describe terms Different starting points, assumptions and rules Large spatial scales Precise quantification Holistic Moral	Quantitative Theoretical constructs and discipline specific jargon Does not involve spirituality nor environmental ethics in the form of values and beliefs Large spatial scales Precise quantification Reductionist Value-free	Ellis, E. C. et al. 2021, Turnhout, E., Bloomfield, B., Hulme, M., Vogel, J. & Wynne, B. 2012
How information/data is collected and shared	Based on observation and accumulation of facts by trial and error Accumulates incrementally Gathered over generations by observation Transmitted orally or shared by practical experiences Drags from intuition or sense of body and heart (e.g. feeling the winds, listening to the tick of ice, etc.) Grounded in experimentation Acquired over long time series but over smaller and specific localities	Based on experimentation and deliberate accumulation of facts Gathered by experiments and observation Transmitted in written form Own accepted truths about our behaviour Grounded in experimentation	Ellis, E. C. et al. 2021, Agrawal, A. 1995
Use of information	Life of observers depended directly on this information and its use Knowledge accumulated to respond to environmental feedbacks such as changes in the catch per unit of effort to help monitor the status of the resource	Life of observers do not depend directly on this information and its use Removes incentives for building ecological knowledge base	Gadgil, M., Berkes, F. & Folke, C. 1993
How the world is perceived	Physical world, abstract Encoded in rituals and cultural practices of everyday Intuitive	Physical world, concrete Purely rational	Tengö, M., Brondizio, E. S., Elmqvist, T., Malmer, P. & Spierenburg, M. 2014
NATURE AND HUMAN			
Threatening nature	Holistic Adaptive, able to adjust Nature cannot be controlled nor predicted Mother earth, nature gifts Ecosystem change indicate direction Flexible use of resources (rotation, species switching, etc.) Conservation of nature is doing things right, taking care of nature	Atomistic Non-adaptive, rigid Value nature in economic terms Nature, ecosystems Services, benefits Yield target indicates direction Emphasis on steady states and maintenance of predictable yields Conservation of nature is defined according to policy and social processes	Gadgil, M., Berkes, F. & Folke, C . 1993
Threatening humans	Humans part of an interacting set of living things Based on participation with the natural world (people do not separate from the Earth's processes) Management characterised by the use of rules locally crafted and socially reinforced by the users	Humans separated from nature Not based on participation with the natural world (people separated from the Earth's processes) Ecological stability characterised by rules, regulations enforced by agents which are not resource users	Ellis, E. C., 2021

Table 1. Main differences of Western and Indigenous sciences in valuing and perceiving nature.

interactions. Fundamentally, Indigenous Peoples were among the first observers of the arrival of Europeans, but these native endeavours were soon dominated by Western paradigms (Kean, 2019; López-Maldonado et al., 2024; Makgoba, 2020).

For example, Indigenous Peoples and other native groups studies included not only listing and categorizing flora, fauna, etc. but also precise and accurate knowledge of medicinal properties, system dynamics, behavioural changes of species, the sky, the planets, etc. (Gon & Winter, 2019). In other words, most of the supposedly early European discoveries and studies had already been carried out by Indigenous and native peoples using their own methods of scientific inquiry. They have been able to accurately, and continue to do so, make measurements, observations and predictions of natural phenomena (many of them have not even occurred today) such as equinoxes, solstices, etc., and they did so without the technology we have today (López-Maldonado et al., 2024). It is clear that, with some differences, the practice of Indigenous science thus has implications for research and methods and different approaches to nature (see Table 1).

Millennia of experimentation and empirical observations of Indigenous Peoples has led them to a sophisticated understanding of the natural environment, the cosmos and use of technologies (e.g. fire) (Kimmerer & Lake, 2001; Usher, 2000). This information can provide valuable insights for better understanding complex Earth processes (e.g. precise knowledge of snow cover, ice properties, weather changes, etc), and could help support global efforts for monitoring earth changes (López-Maldonado et al., 2024).

For example, specific observations have been compiled by Indigenous Peoples from the Mayan region of Yucatán, Mexico. To survive in a place where water was scarce or difficult to obtain, the Maya had to organize themselves to design and to manage their water resources, including water bodies and natural and human-made reservoirs (Lopez-Maldonado, 2019; Lopez-Maldonado & Berkes, 2017). They developed a complex system of water management dependent on water collection and storage. The hydraulic system was tailored to the biophysical conditions and adaptively engineered to the evolving needs of a growing population(Lopez-Maldonado, 2021). Similar to modern water management practices, the Mayas directed, stored and transported water with canals, dams, sluices and berms. To filter water, they used several natural resources, starting with quartz sand and zeolite sand — both of which were only available in distant areas (Lucero, 2023). Thousands of years ago, when most of the Spanish arrived in Yucatán, the Maya people possessed specific and precise knowledge and skills to study they components of the hydrological cycle and natural phenomena with precision. However, much of this and similar information remains undervalued in current global water monitoring. allowing for better decisions to be made at local to global scales (López-Maldonado et al., 2024).

There is thus ample evidence of sophisticated earth observations by Indigenous groups around the world dating back to time immemorial. Further examples include the navigation techniques of Indigenous Peoples in the Pacific islands (Mulalap et al., 2020), and knowledge of the cryosphere and snow processes by Arctic Indigenous groups (Deemer et al., 2017), among many others (Table 2).

However, another common falsehood that prevails in scientific and policy spheres is that Indigenous knowledge must be combined with Western science. But this commonly-accepted idea can be false and lead to serious 'erosion of knowledge', particularly in groups that have lost important amounts of knowledge and language.

This is because combining different knowledge systems to solve environmental problems towards sustainability is rooted in "inclusive" partici-

System	Problem	Western science	Indigenous science
Groundwater	A clean and abundant water supply is a necessity for both human consumption and agriculture, so it is essential to understand the sources and pathways of water pollutants	Scientists can track the movement and origin of contaminants in water systems, which identifies sources and pathways of contamination and helps implement effective mitigation strategies to maintain water quality. Because groundwater movement can be very slow, these tracers have limited utility	Indigenous observations can play a crucial role in the understanding and monitoring groundwater systems particularly in helping us to understand natural flow systems movements and dynamics in complex groundwater basins
Cryosphere	Understanding changes in the Arctic is crucial to understanding other components of the hydrologic cycle. The dynamic nature of sea ice complicates the collection of information across the ice, ocean and atmosphere. Accurate, in situ, long-term data are needed	Modern technologies such as satellites, bio-optics, drifting platforms and acoustic instruments are available for data collection in arctic and large-scale environments	The polar regions are home to indigenous peoples. They have developed precise knowledge, techniques and observations to monitor and understand cryosphere processes, such as changes in sea ice and snow cover. This knowledge can help characterize and merge spatial and temporal scales (e.g., to measure and understand the mass balance of land ice and its implications for sea level rise, as well as its relationships with other parts of the climate system, ice mass balances, etc.)
Ocean	Oceans are changing rapidly and urgent action is needed protect marine biodiversity and to restore degraded ecosystems	Satellite data collection, remote sensing, sophisticated modeling techniques are a new field of exploration and have improved our ability to predict global events. Before satellites, the only information came from infrequent measurements collected from ships, trawlers, etc. Much of what we know today, and still do not know, about the ocean comes from indigenous knowledge and navigation techniques	Indigenous peoples have a deep understanding of the ocean, including species connectivity, marine processes, currents, winds, tides, etc., as well as knowledge of other phenomena such as the sky and the movement of celestial bodies and precise navigation techniques. Indigenous knowledge analyses and transmits large amounts of information that can support other studies that fail to capture complete information on larger time scales
Lakes	Lakes are important inland water transportation systems and the best source of freshwater on the planet	Remote sensing data, computer models and extensive scientific reach have helped us to understand the dynamic conditions and cycles of lakes	For thousands of years, lakes have been governed through indigenous international regional and local relations. Baseline, in situ data are critical to better understand these systems. Indigenous peoples might support the generation of know knowledge and the creation of future scenarios by providing accurate physical, chemical and biological water property dynamics

Table 2. Examples of the contributions of indigenous people's earth observations of changes in the hydrological cycle.

pation. This 'perhaps' does not lead to construct new knowledge at its maximum potential since the instruments and tools come from methodologies and approaches that do not respect Indigenous thinking. Yet, "romanticization" of Indigenous knowledge and its manipulation to fit external agendas can create bigger problems and, hence, important environmental knowledge can be lost.

1.4 What do we need to know?

In general, and for too long, Indigenous People's knowledge has been and continues to be absent from scientific and political debates on how best to make decisions to protect nature. Indigenous knowledge continues to suffer from historical erosion and this may have consequences that undermine the vitality of important ecosystems, while compromising society's ability to meet global sustainability goals. Certainly, most scientific and political approaches fall short when attempting to understand and respect the integrity of Indigenous knowledge and its epistemological and ontological foundations. It is therefore important to take into account the following aspects:

1. Indigenous science is very old and exists long before, compared to Western science. If we look at the complex processes of the systems on the planet that Indigenous Peoples were able to understand, we can say that Western science is still at a very early stage. However, Western science, in a process of domination, reconfigured other ways of knowing under different guises, in order to obscure them or make them inferior, including Indigenous knowledge.
2. Indigenous peoples observed and analysed nature phenomena, used proper methods, tools, frameworks for research enquiry and, on the basis of this, formulated universal laws. Such tools and approaches are rooted on a different paradigm. This paradigm is not opposed to the epistemics of Western science and is not an anti-scientific stance. Rather, we argue here, as previously stated by Santos (2016), "*it is a call to modern science to look at other ways of knowing for solving current environmental challenges, specifically to the science of Indigenous Peoples*".
3. Indigenous knowledge involves four different levels to understand life cycles, structure, function and evolutionary processes within nature. All those levels are important and interconnected. However, Indigenous Peoples gave particular attention to worldviews and values for their relation with nature (Acosta, 2013; Gudynas, 2011; Gudynas & Acosta,

2011). It is precisely this component that modern science does not make sense of. This being a key component of the expansion of capitalism due to the lack of an environmental ethic and a society devoid of values.

4. Despite having their own Non-Western scientific methods for research inquiry, Indigenous Peoples also place an essential value on worldviews. However, their worldview remains misunderstood and misrepresented. Thus, often the way Indigenous Peoples report their observations is not empirically useful for policy and scientific spheres since they ascribe meaning to spirituality and supernatural stories. This has led to Indigenous knowledge being vaguely addressed.
5. Indigenous science is equally rigorous and as precise as Western science, but Indigenous science originates in completely different contexts than Western and non-indigenous spheres are used to (Gewin, 2021). Western societies are characterised by a mechanistic way of perceiving nature and by approaches that ignore or disregard other forms of knowledge because they are perceived as myths, legends or implausible. For example, Western science often tends to ignore rich oral traditions in many Indigenous cultures which contain ecological information embedded in songs, origin stories, and ancestral sayings, which are crucial to understand nature.
6. Western science works in a completely different time scale because natural processes, humans, organisms, ecosystems work on cycles and a lot of time is needed to understand them. Understanding and adapt to changes requires time.
7. Earth's dynamics are connected to broader environmental and biological processes. Indigenous knowledge and observations may include one or more important connections and events of other processes and changes that might go unnoticed on a global scale (Deemer et al., 2017).
8. Scholarly and policy circles must include Indigenous knowledge, observations and understandings of the environment into their measuring and monitoring processes.

As illustrated by these points, the recognition of Indigenous science requires an understanding of non-Western approaches and ways of knowing and conceptions from Western and non-Western ways of thinking. This means that the growing interest of scientists in focusing on colonialism and decolonisation without engaging in a critique of capitalism and patriarchy distracts from the problem. Allowing Indigenous knowledge to play a key role will improve tremendously our understanding and overall representation of earth processes into global models. Instead of maintaining Western science as the only source of knowledge, we should move closer to those knowledge systems that have been on earth for much longer and whose understanding of natural processes is more holistic.

Acknowledgments

I would like to express my gratitude to all Indigenous Peoples who, with their knowledge and observations of planetary processes, have succeeded in preserving important ecosystems that sustain life on earth. My gratitude to Dr. Nigel Crawhall for his valuable guidance.

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Phytotherapy for the Health of All

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I am sharing my experience as a healer and some of the pathologies I have successfully treated using medicinal plants. In particular, I will discuss the therapeutic protocol I developed to combat the Coronavirus epidemic caused by the emerging SARS-COV-2 virus, which has challenged modern therapies and resulted in numerous casualties worldwide.

My journey into phytotherapy began with the study of African pharmacopoeia. Historically, this traditional medicine was largely abandoned in favor of modern medicine during the colonial era, as the latter offered free and comprehensive patient care. Consequently, people opted for these new health services.

However, African pharmacopoeia did not vanish; it continued to thrive as people sought out healers and wise individuals within their communities for health issues. Thus, both therapeutic approaches coexisted, providing a broader spectrum of healthcare options. If one approach did not yield satisfactory results, individuals would turn to the other.

It is important to highlight that many Africans and other populations worldwide still lack access to necessary healthcare due to financial constraints and disorganized health systems. This situation leaves many to fend for themselves, raising a critical question: How many lives are lost daily due to inadequate healthcare?

Access to healthcare for African populations presents significant challenges. Medicines produced in developed countries, where the standard of living is high, often become prohibitively expensive for African individuals who rely on agriculture for their livelihoods. Upon reaching Africa, these medicines incur various taxes, resulting in prices that may double or triple. Families must then dip into their meager savings, which are already stretched thin by basic living expenses. How can we solve this problem?

In 1988, I encountered this dire lack of healthcare firsthand when I became head of a small seminary housing approximately one hundred youths without sufficient funds for their medical needs. Confronted with this reality in 1990, I opted to adopt the approach used by their families: employing medicinal plants for treatment. Alongside another priest, we began exploring traditional healing methods from local village healers and nomadic practitioners frequenting markets with their botanical remedies.

The initial obstacle was gaining trust from these healers to share their plant-based healing knowledge with us, since our status as priests initially barred us from fully engaging with them. I recall sitting beside a healer at a market amidst judgmental stares; an internal conflict arose within me that was challenging both to articulate and surmount. This same conflict likely deters our medically trained doctors from seeking wisdom from these uneducated healers – whom they wrongly assume have nothing valuable to offer – thus widening the gap between conventional medicine and invaluable plant-based healing practices.

Through my research, I gathered various medicinal recipes from phytotherapists who generously shared their knowledge with me. To identify the plants, each phytotherapist guided me into the bush, showing me the ingredients for different recipes and providing the names of the plants in their language. Using African phytotherapy books I had acquired, I undertook the challenging task of identifying each plant – a process requiring considerable patience. This allowed me to study the plants, determine their toxicity, and establish the correct dosages for those seeking my help.

There is an art to be learned from healers. A healer is not merely someone who offers a plant-based remedy; they also care for the person suffering before them. The patient will describe their pain and often explain why they believe they fell ill, attributing their condition to an imbalance between themselves and their environment. The healer's role is to restore this harmony, addressing not just the physical ailment but the whole person. This may involve helping the patient make peace with those around them or even offering a sacrifice if they practice traditional religion. The goal is to help the person heal and find peace, which is the ultimate aim of everyone.

This holistic approach to healing is also evident in the teachings of St Hildegard, as presented by Daniel Maurin.[1] For the German saint, healing involves caring for the entire person. This approach aligns with the World Health Organization's definition of health: 'Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity (...) The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being'.[2]

[1] Daniel Maurin, *Sainte Hildegarde, La santé entre ciel et terre*, Edit. Trois Fontaines, 1991.
[2] Preamble to the WHO Constitution, 1946, quoted by Paul Maurin, in *Sainte Hilde-*

My research extended beyond African plants. In 1995, I was sent to Rome to pursue ecclesiastical studies, which provided an excellent opportunity to explore European medicinal plants. I was able to obtain medical books focused on phytotherapy and meet with phytotherapists in Italy and other European countries. These practitioners shared their expertise with me, teaching me about different preparation techniques, the role of phytotherapy in modern healthcare, and the interest Europeans have in this field.

I would like to highlight a remarkable phytotherapist of German origin who resides in the Puy-En-Velay region. He has embraced rural life and is passionate about preparing products using the spagyric method. He generously allowed me to consult some ancient books from his collection. Without this encounter, I would never have discovered this plant preparation technique, which is cherished by true plant enthusiasts.

In my quest to learn more about medicinal plants, I discovered essential oils, which are the most potent extracts of plants. Today, we are rediscovering their incredible powers. Dr. Jean Valnet, M.D., a renowned French phytotherapist, wrote: 'Apart from their widely recognized antiseptic and antimicrobial properties, essential oils have antitoxic effects, antiviral actions, powerful energetic influences, and undeniable healing powers. They are poised to play an increasingly important role in the future'.[3] Plant essences are becoming more prominent in therapeutics today due to numerous studies and publications, offering new hope to many patients with severe conditions.

Jean Mességué, another esteemed French phytotherapist, expressed a similar sentiment: 'I am certain that there is a plant to cure every disease on earth; yet my knowledge of plants remains limited'.[4] The resurgence of interest in phytotherapy supports his view. It is worth trusting in phytotherapy, from which modern medicine originated; all medical practitioners should reconsider its value.

My keen interest in phytotherapy is justified by the effectiveness of plants in treating severe pathologies where modern medicine falls short. The more I explored the world of plants, the more I discovered their efficacy. Medicine began with them, and humanity has always used them for health. The

garde, la santé entre ciel et terre, Edit. Trois fontaines, 1991, p. 13; https://www.who.int/about/governance/constitution

[3] Jean Valnet, *Aromathérapie, Traitement des maladies par les essences des plantes*, édit. Maloine, Paris 1990, p. 24.

[4] Maurice Mességué, *Mon herbier de santé*, édit. Laffont, Paris, 1975.

world stands to gain much by utilizing plants for healthcare. As Dr. Jean Valnet aptly noted: 'We often return to simple medicine when faced with severe conditions that respond poorly to various modern therapies. It seems that starting with these simple remedies would have been more advantageous, saving time and effort'.[5]

When the Coronavirus pandemic broke out, I wondered if I could find a cure using the plant recipes I had collected. With limited information about the new virus – primarily that it attacked the lungs and caused death by suffocation – I relied on the known antiseptic, antiviral, and bactericidal properties of plants. It was a challenge, but I felt it was necessary to respond to the epidemic as our ancestors might have.

Recognizing that plants often work synergistically, I adapted my existing recipes used for other ailments, adjusting dosages to address the virulence of Covid-19. I developed two formulations: Adsak Covid and Elixir Covid.

Adsak Covid is based on seven essential oils: *Melaleuca leucadendron* (Cajuput), *Ocimum basilicum* (Basil), *Juniperus communis* (Juniper), *Melaleuca alternifolia* (Tea Tree), *Pinus sylvestris* (Scots Pine), *Rosmarinus officinalis* (Rosemary), and *Cupressus sempervirens* (Cypress).

Elixir Covid consists of eight plants: *Allium sativum* (Garlic), *Aloe vera*, *Citrus limonium* (Lemon), *Cymbopogon citratus* (Lemongrass), *Eugenia caryophyllata* (Clove), *Myristica fragans* (Nutmeg), *Xylopia aethiopica* (Ethiopian Pepper), and *Zingiber officinale* (Ginger). These plants are known for their medicinal properties and as condiments, and are safe when used in the correct dosages.

The two formulations underwent three scientific analyses with the following results:

1. The University of Yaoundé I concluded: 'The phytomedicines Elixir Covid and Adsak Covid possess antiviral, antibacterial, antioxidant, anti-inflammatory, and analgesic activities. Given the results obtained, Elixir Covid and Adsak Covid showed no toxicity to the body'.

2. The Institute of Medicinal Plant Research and Studies of the Ministry of Scientific Research and Innovation conducted a subacute analysis, which found: 1. Food and water consumption: Normal; 2. Percentage body weight: Normal; 3. Organ (liver, kidney, heart): Normal; 5. Kidney function test (Creatinine, Urea): Normal; lipids (Triglyceride,

[5] *Aromathérapie*, p. 17.

Cholesterol) and blood glucose: Normal; 7. Haematology (WBC, RBC, HCT, indices): Normal.

3. The J.S. Hamilton laboratory in Poland confirmed that Adsak Covid and Elixir Covid do not present toxicity, stating: 'Sample description without any visible damages'.

The therapeutic properties of each plant are remarkable: they are bactericidal, antiviral, anticancer, anti-inflammatory, antioxidant, analgesic, and antispasmodic. These two medicines serve as powerful antiseptics for the pulmonary, urinary, and intestinal systems. Additionally, they act as general immune stimulants, cytophylactic agents promoting healthy cell growth, and anticoagulants preventing blood clots.

When the Covid-19 epidemic broke out in Cameroon, I administered these two medicines to the first infected individuals, and the results were very promising: all those who took this treatment recovered. Within 48 hours, the patients experienced significant improvement, breathing normally, regaining their sense of smell, and asking for food. These medicines proved effective against Covid-19 and also served as a preventive measure: individuals who took this treatment did not get infected and did not transmit the virus. In Cameroon and abroad, many people have been treated with these two associated medicines, resulting in few Covid-19 casualties and a swift containment of the epidemic.

It is important to highlight the synergistic effect of combining phytotherapy and aromatherapy. These two medicines clear the lungs of harmful substances, allowing the infected and fatigued person to recover quickly due to the diverse properties of each plant. For instance, essential oils generally help infected cells regenerate – a cytophylactic property – similar to certain plants like *Aloe vera*, which plays the same role: "It is a real mucilage with a pH of 4-5, suitable for cleaning mucous membranes while soothing and repairing damaged tissues'.[6]

For resistant diseases, modern phytotherapists suggest combining essential oils with antibiotics, paving the way for new therapeutic approaches. This integration revives the hope of curing various diseases.

Considering the analyses of the two medicines and their effectiveness, the Ministry of Public Health of Cameroon has granted Marketing Author-

[6] Ernesto Riva, *L'Universo delle piante medicinali, Trattato storico, botanico e farmacologico di 400 piante di tutto il mondo*, Ghedina e Tassotti Editori, 1995, p. 299.

ization (MA) for them. Today, this therapeutic protocol is well known and appreciated by many. It is noteworthy that these two plant-based medicines are the first to receive Marketing Authorization in Cameroon and are now available in the country's pharmacies.

Currently, these medicines are also used to treat other conditions, including pulmonary diseases (such as angina, asthma, bronchitis, flu, cold, whooping cough, and tuberculosis), urinary infections (such as gonorrhoea, cystitis, and leucorrhoea), general infections, various forms of cancer, and shingles. They have shown promising results, particularly in cancer treatment.

Phytotherapy offers a reliable means to combat incurable diseases; in the hands of skilled practitioners, plants become powerful healing tools. Throughout history, humanity has relied on plants to overcome successive epidemics. Dr. Jean Valnet highlights the effectiveness of plants against major epidemics, noting: 'Without delving too far into the history of epidemics, we know that the great plague of the 14th century, known as the Black Death, killed 80 million people in Europe within a few years. Humanity triumphed over this plague. One might have feared that such massacres were the prelude to the annihilation of the human race, yet none of the populations thus decimated have disappeared. We will see that the frequent use of aromatics, that is to say their essences, played a role in this'.[7]

Humanity ha overcome the most serious epidemics with plants. It is unfortunate that today we often overlook this effective remedy that has been given to us and which we must protect. As stated in the book of Genesis: 'Yahweh God took the man and put him in the garden to cultivate and keep it' (Genesis 2:15). Everything man needs – food and medicine – can be found in the garden.

For the most serious diseases, healers rely on the extraordinary power of plants. By following their example, we can address various pathologies with effective treatments. For instance, the viruses of hepatitis B and C are destroyed by the plant *Enantia chlorantha* combined with *Desmodium adscendens*; the bark of *Pigeum africanum* (African plum tree) treats prostatitis; the most resistant intestinal worms are eradicated by *Trichilia emetica*; several plants, particularly *Artemisia annua* or *afra*, are used against malaria; *Guiera senegalensis* regulates blood pressure without side effects; and various forms of cancer are treated with aloe.

[7] *Aromathérapie*, p. 32.

Additionally, some well-known recipes from around the world include the Swedish elixir, prepared with several plants, which remains a true panacea and is still used today.[8] The ancient balm of the Saint Saviour Pharmacy of Jerusalem, known in Italian as Antico Balsamo di Gerusalemme, was composed in the 18th century with 40 ingredients, mainly plants. The Franciscan brothers used it to treat the inhabitants of Jerusalem. This is how humanity has utilized plants to treat diseases throughout history.

Many diseases are treated with African medicinal plants; it is just a matter of knowing how to use them. They represent the future of medicine, as Dr. Jean Valnet wrote: 'Phytotherapy and aromatherapy have the rare privilege of being both the oldest and the most current of therapies'.[9]

We are at a pivotal moment where true collaboration between phytotherapy and modern medicine is essential. These two therapies do not need to exclude each other; on the contrary, they should be integrated to serve human health. Some civilizations, like Chinese culture, have successfully developed their traditional medicine alongside conventional medicine. Those who study plants readily acknowledge the necessity of this collaboration. The two therapies complement each other, each offering what the other lacks. Philippe Mailhebiau noted: 'It seems necessary to emphasize that chemotherapeutic principles, the basis of symptomatic intervention medicine useful in emergencies, and the principles of terrain on which natural medicines are based, more inclined to foundational treatments, can be seen as complementary; provided that their original motivations are maintained, namely the restoration and maintenance of individual and collective health'.[10]

Adding to Mailhebiau's perspective, phytotherapy is comprehensive in its approach to care. Medical history shows that humanity has survived by treating itself with plants, overcoming the most serious epidemics with their help. What is lacking today is sufficient attention to phytotherapy. A WHO official from my city of Douala recently mentioned that the department of phytotherapy had been closed. However, after Covid-19, the leaders of the Organization recognized the need to focus more on phytotherapy. This is the path we must follow today: to give phytotherapy the attention it deserves.

[8] Maria Treben, *La Santé à la Pharmacie du Bon Dieu*, Ennsthaler, Steyr, 2004.

[9] *Aromathérapie*, p. 33.

[10] Philippe Mailhebiau, *La Nouvelle Aromathérapie, caractérologie des essences et tempéraments humains*, 2e édit. Jakin, 1994, p. 18.

In conclusion, it is impossible for humanity to distance itself from nature and plants. Let us consult a book that details the properties of the vegetables, fruits, and cereals we consume daily. We will be surprised to see that, for example, garlic, cabbage, onion, *Hibiscus sabdariffa*, celery and thyme all offer significant health benefits. By eating, we are healing ourselves. This is what we need to maintain good health. For the healthcare of African populations, a new health policy should be established to leverage phytotherapy, making it accessible to all. This would involve introducing the study of medicinal plants in medical schools so that African doctors can learn the secrets of African pharmacopoeia and giving greater attention to healers so they are willing to share their healing arts. A shift in mindset and a spirit of conversion are necessary. More effective healthcare is needed in developing countries, and this is the path we must follow today.

YOUTUBE PRESENTATION

Promoting and Protecting Indigenous Knowledge and Contributions to Health

Pauliina Nykänen-Rettaroli
Indigenous Peoples' Focal Point in the World Health Organisation

https://youtu.be/2H9Wp-u1rMA?si=ncj_1ywMijCXUIBF

4. THE IMPORTANCE OF INDIGENOUS PEOPLES FOR CLIMATE, BIODIVERSITY, FOOD AND NUTRITION AGENDAS

4.1. BIODIVERSITY AND NATURE PROTECTION

Biodiversity and Social-Ecological Research for People and Nature

Katrin Böhning-Gaese
Senckenberg Biodiversity and Climate Research Centre and Goethe University Frankfurt

Loss of biodiversity

The biodiversity on our planet is declining dramatically. In the first global report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), published in 2019, the scientific consensus was reached that of the approximately 8 million species currently found on Earth, 1 million species are at risk of extinction (IPBES 2019). There is a particularly high risk in cycads, i.e. palm-like gymnosperm trees, with over 60% threatened species, in amphibians, i.e. frogs, toads and salamanders, with 40% threatened species, and in corals, with almost 40% threatened species (IPBES 2019). In addition, the populations of many species are declining severely. An index that reflects species abundances, the Living Planet Index, shows a decline in species abundance of more than 60% over a 50-year period (WWF 2022). In Germany and Europe, we primarily find steep declines of species diversity and abundances of species in agricultural landscapes, i.e. in fields, meadows and pastures. Abundances of farmland birds in Europe have declined by almost 60% in agricultural landscape over a period of 37 years (Rigal et al. 2023).

In addition to species, natural ecosystems are also disappearing. They are converted into ecosystems used by humans or are increasingly degraded. Half of all ecosystems have already been massively changed. In the last 30 years, the extent of natural forests has declined by an area that corresponds to a total of twelve times the area of the Federal Republic of Germany (FAO 2020). In Germany, only 4% of the previously extensive moors are nature conservation areas (Greifswald Moor Centrum 2022).

Consequences for nature's contributions to people

The changes in biodiversity have consequences for the contributions that nature makes for us humans (nature's contributions to people). Biodiversity is the basis of human existence: almost everything that we humans use is provided for by biodiversity. The material contributions of nature include air to breathe, clean drinking water, food, building materials, energy, fibers or medicines, while the regulatory contributions include pollination, seed dispersal and the natural regeneration of forests, the regulation of the climate or the formation of fertile soils. Finally, biodiversity provides a wide range of non-material contributions: beauty, recreation and mental health, spirituality, home and identity. The loss of biodiversity has consequences for nature's contributions to people. According to scientific consensus (IPBES 2019), of the 27 sub-categories, all but three of nature's contributions are declining; the only contributions that increase are areas cultivated for food and animal feed, for energy crops (e.g. oil palm) and for materials (e.g. cotton). Ecosystems are obviously managed with a view to some short-term material benefits for humans at the expense of all regulatory and non-material contributions, and even at the cost of other material contributions, e.g. forested land.

Drivers of biodiversity loss

What are the causes of biodiversity loss? There are five important direct causes, the so-called "Big Five," of biodiversity loss (IPBES 2019). Number one is land use, which is essentially agriculture. The agricultural area is currently massively expanding, especially in tropical countries. Natural ecosystems like forests, savannahs, grassland ecosystems or wetlands are lost and degraded. In Germany and Europe, the reason for the decline in species in the agricultural landscape is very intensive agricultural use, with high application of fertilizers and pesticides, large-scale monocultures, with the disappearance of hedges, trees, little wetlands and fallow areas. Second comes the exploitation of species. Here, marine areas are particularly affected; over 35% of commercially exploited fish stocks are currently overfished (Blue Action Fund 2022). Climate change, pollution and the immigration of so-called "exotic" species are also important. However, behind these direct proximate factors lie indirect or ultimate factors, which cause, e.g. land use change and species exploitation. These include demographic and socio-cultural changes, such as increasing global population, increasing per capita consumption of natural resources and an increasingly meat-based diet. Other factors include economic and technological changes, changes in institutions and governance, conflicts and epidemics. These include, for example, increasing prosperity or the institutional and technical possibilities for global supply chains.

What can be done to bend the curve of biodiversity loss?

From a scientific perspective, it is clear that the loss of biodiversity and its contributions to us humans is already affecting the health, prosperity and well-being of many people. If biodiversity and its contributions to people continue to decline, an ever-increasing number of people will be at risk. But what can we do to bend the curve of biodiversity loss, and to stop further decline in biodiversity and promote biodiversity?

Convention on Biological Diversity

Among the measures of highest importance are international agreements, such as the Convention on Biological Diversity, which was drawn up at the Earth Summit in Rio de Janeiro in 1992 and which 196 nations have signed since. At the 15th Conference of the Parties at the end of 2022 in Montreal, new goals were declared, the Kunming-Montreal Global Biodiversity Framework. These include, among others, the goal of effectively protecting 30% of the land and the sea by 2030, restoring 30% of degraded land and sea by 2030, and promoting sustainable agriculture, forestry and fishing. The great strength of these agreements is that they are international agreements that almost all countries in the world have signed. Hence, these countries have now a moral obligation to implement these goals.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

In addition, international science-policy interfaces play a central role in protecting biodiversity. The corresponding international interface between science and politics for biodiversity is the aforementioned IPBES, the World Biodiversity Council. It is the equivalent of the Intergovernmental Panel on Climate Change (IPCC), which was established for protecting the climate many years earlier. The World Biodiversity Council compiles the state of knowledge and options for action both for individual regions of the world and globally. A key finding of the reports so far is that the protection and promotion of biodiversity can no longer be achieved through individual measures. This means that setting up protected areas or reducing the use of pesticides are good and necessary measures, but on their own will not be enough to conserve biodiversity. Instead, a social-ecological transformation is called for, defined as a fundamental, system-wide transformation of the entire society, i.e. politics, law, business, science and civil society (IPBES 2019).

Future biodiversity scenarios

Further, political and societal decisions can be based on thousands of scientific publications that have examined the influence of humans on biodiversity and the consequences for ecosystems and people. A particularly important role for decision making have publications that use biodiversity models. These models function like the better-known climate models: They are parameterized and validated with existing data and proven relationships; then alternative future scenarios are created. These open up alternative futures that, depending on the measures taken, predict a positive development of biodiversity, a stabilization or a further decline. A particularly comprehensive and ambitious study by Leclère and co-authors (Leclère et al. 2020) reached the conclusion that with a bundle of three types of measures, we can stop the decline in biodiversity by 2030 and increase biodiversity again by 2050. The types of measures are: 1. Large, well-managed protected areas, plus restoration of ecosystems, 2. productive but sustainable agriculture and forestry and more trade, and 3. changes in our consumption and diet towards less food waste and, for countries like Germany, towards a more plant-based diet.

Establishment of protected areas

Hence, the goal of protecting 30% of the land and sea by 2030 is also from a scientific perspective an effective and important goal. However, where and how should protected areas be established and managed? In theory, protected areas should be established in sites with high or unique biodiversity. Nature conservation is important everywhere. However, given that biodiversity is in general much higher in the tropics than at high latitudes, establishing protected areas in tropical regions of South-East Asia, Africa and South and Central America is particularly important. Here, we give recommendations based on a new publication, that supports decision making on-site selection for the Legacy Landscape fund, a public-private initiative that is setting up funds for ideally indefinite funding of large protected areas in low-income countries in the Global South (Voskamp et al. 2023). The decision support tool is drawing on macroecological information on the species richness, endemicity and phylogenetic uniqueness of birds, mammals, reptiles and amphibians, on ecosystem integrity and carbon stocks, as well as on resistance and resilience to climate and land-use change. Most importantly, the tool allows to weight these different criteria, according to individual priorities. Depending whether the priority is, e.g. high biodiversity *or* high ecosystem integrity, different sites are prioritized. When establishing protected areas in practice, it is of uttermost importance to address each step in a collaborative way, recognizing and respecting the rights of indigenous peoples and local communities over their traditional territories (CBD 2022).

Transformation of agricultural and food systems

In addition, agriculture, at least in Europe, needs to change in a way that allows for more sustainability. As mentioned above, biodiversity is declining severely in agricultural landscapes in almost all European countries (Rigal et al. 2023). Based on a systematic analysis of the situation, including the embeddedness of the agricultural system in the wider political, juristical, economic and societal system, the German National Academy of Sciences, Leopoldina, developed recommendations on how to promote biodiversity in agricultural landscapes (Leopoldina 2020). The most important result was that the decline of biodiversity in agricultural systems can only be stopped with an integrative, systemic approach, considering not only agriculture, but society at large. Agriculture needs to promote productive, but biodiversity-rich, land-use systems. Measures to be taken are a wider distribution of organic agriculture, but also a more biodiversity-friendly conventional agriculture. Important concrete measures are, e.g., growing a wider variety of crops, using less pesticides and less fertilizer, and promoting hedges, trees, fallows, and other structural components. However, these changes need to be supported by the European Common Agricultural Policy (CAP). In the future, the immense number of subsidies needs to be distributed not according to the size of the farm, but according to the common goods the farm provides also for the protection of biodiversity, climate and water. Further changes are the promotion of joint panels for landscape planning, the development of new technologies, e.g. making use of digitization or breeding new crop species, that are more resistant to pests. However, a major problem is that many of these measures will reduce the productivity of the agricultural system. Together with a larger proportion of protected areas, this raises the question, how to provide food for an increasing number of people?

The Leopoldina systems' analyses demonstrated that a change of the agricultural system is not sufficient to support biodiversity. In the end, the food system needs to be transformed as well. Concretely, there is the need to promote less food waste and, for countries like Germany, a considerably more plant-based diet (Leopoldina 2020). In addition, in trade and retail, biodiversity-friendly products need to be promoted. Labels should provide easy to understand, trustworthy information on the biodiversity footprint of the product.

Reflecting different world views

In addition to transformative change within nations, e.g. Germany, the reflection, recognition and harnessing of different world views, knowledge systems and values are key to foster biodiversity. This became very apparent when developing the framework on which IPBES is basing its understanding of people-nature relationships (Figure 1, Díaz et al. 2015). In the process of developing the framework, it became visible that different people have very different concepts of nature, of nature's contribution of people and of a good quality of life. While in science, the terms usually utilized are "biodiversity and ecosystems", "ecosystems goods and services", and "human well-being", in other knowledge systems the terms "Mother Earth", "Nature's gifts" or "Living in harmony with nature" might be much more

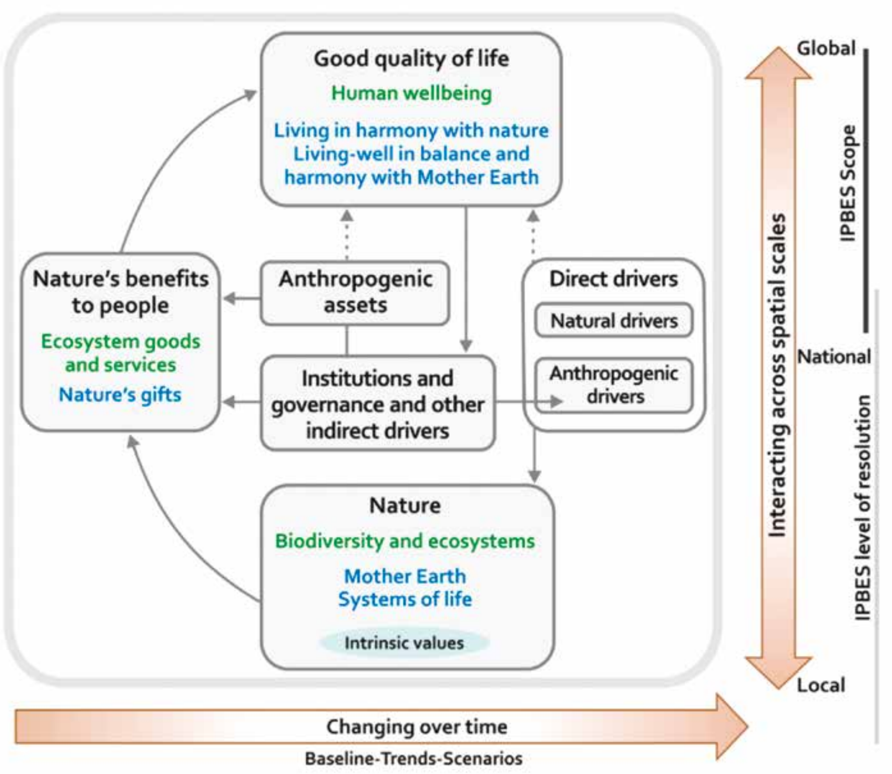

Figure 1. The IPBES Conceptual Framework. "… In each of the boxes, the headlines in black are inclusive categories, that should be intelligible and relevant to all stakeholders involved in IPBES and embrace the categories of western science (in green) and equivalent or similar categories according to other knowledge systems (in blue)…" (Díaz et al. 2015).

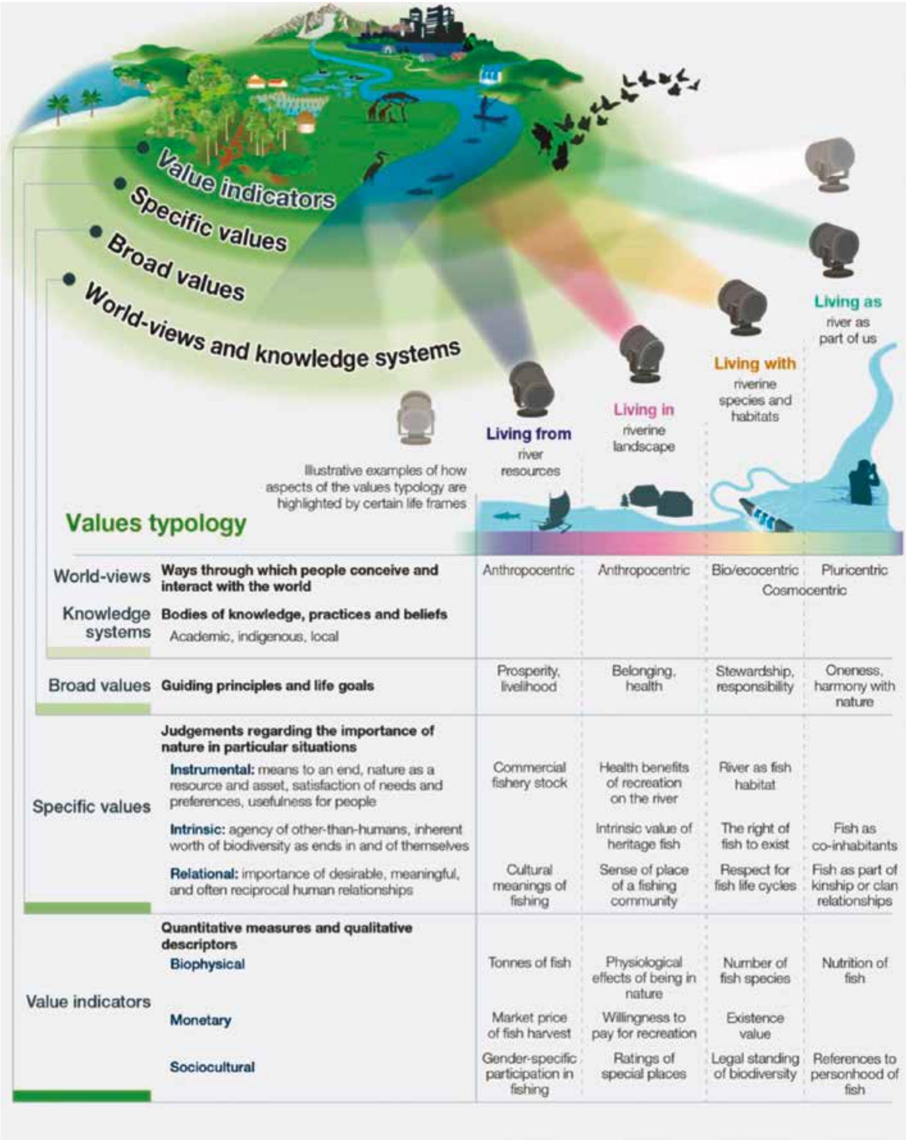

Figure 2. "The values assessment typology highlights key concepts and their interrelationships to understand the diverse values of nature. The figure centers on potential foci of value (e.g. agroecosystems, biodiversity, cities, rivers) and concentric circles illustrate different value types and dimensions (world views, broad and specific values, nature's contributions to people and value indicators). Life frames are not mutually exclusive; individuals or groups can hold multiple frames. Metaphorically, they are light beams that cut across value categories" (IPBES 2022).

adequate. The framework explicitly embraces different disciplines and value systems, including indigenous and local knowledge, when addressing biodiversity and nature's contributions to people. The framework can be thought of as a kind of "Rosetta Stone" that highlights commonalities between diverse world views, knowledge systems and value sets and seeks to facilitate crossdisciplinary and crosscultural understanding (Díaz et al. 2015).

Recognizing and harnessing different world views

In the next step, different values and valuations of nature were explicitly addressed in a new IPBES assessment, the methodological assessment report on the diverse values and valuations of nature (IPBES 2022). The Values Assessment explores how people across many different regions and social contexts have conceptualised human-nature relationships (Figure 2). Important results of the assessment are: "Key Message (KM)1: The causes of the global biodiversity crises and the opportunities to address them are tightly linked to the ways in which nature is valued in political and economic decisions…". "KM2: …most policymaking approaches have prioritized a narrow set of values at the expense of both nature and society as well as of future generations, and have often ignored values associated with indigenous peoples' and local communities' world views". "KM7: Achieving sustainable and just futures requires institutions that enable a recognition and integration of the diverse values of nature and nature' contributions to people". And, finally, "KM8: Transformative change needed to address the global biodiversity crisis relies on shifting away from predominant values that currently over-emphasize short term and individual material gains, to nurturing sustainability-aligned values across society".

Shallow and deep leverage points

When approaching transformative change and action, it is helpful to distinguish between shallow and deep leverage points (Meadows 1999). Shallow lever points take hold, among other things, on parameters, for example the toxicity of pesticides. In contrast, deep leverage points address, among other things, world views, knowledge systems and paradigms on which a societal and political system is based. To date, measures taken to protect biodiversity have tended to be based on shallow leverage points, for example the establishment of protected areas or the reduction of pesticides. In contrast, measures that target deep leverage points are very rarely used. Admittedly, these deep leverage points are very difficult to access. Nevertheless, approaches to deep leverage points, to world views, knowledge systems and paradigms, have huge potential to bring about truly deep and sustainable, long-term changes towards better human-nature relationships.

These analyses offer huge promise in transforming not only people-nature systems globally, but especially in cultures that are currently dominated by short-term and individual material gains. They provide visions of a life in harmony with nature, a vision that 196 nations have declared to follow in Montreal 2022, and that consequently each nation, community and individual should aspire to.

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Ărramăt Model – Global Indigenous-Led Research for Biodiversity Conservation and Indigenous Health and Well-being

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Abstract

Biodiversity loss is a global crisis which adversely impacts the health and well-being of Indigenous Peoples, who contribute minimally to the problem and have much to offer by way of solutions. While the potential role of Indigenous Peoples has been acknowledged in various global forums (e.g., the Global Biodiversity Framework), there are, to date, no working models that ensure Indigenous self-determination and respect of equity, diversity and inclusion in the documentation and mobilization of knowledge. The Ărramăt Model discussed in this chapter provides an example of how Indigenous Knowledge can be meaningfully documented and shared; this project supports work in more than 80 Indigenous languages through over 146 Indigenous-led place-based projects in more than 276 ecoregions. The

model, grounded in three design principles, demonstrates how Indigenous leadership can advance biodiversity conservation and health and well-being, while also fostering innovative approaches to equitable access to financial resources for Indigenous-led initiatives and projects.

Keywords

Indigenous Knowledge, Indigenous governance in biodiversity conservation, Equity in conservation funding, Ethical space, Biodiversity loss, Health and well-being.

1. Introduction

Biodiversity loss in Canada and globally is now recognized as a crisis.[1–3] Indigenous Peoples, particularly in the global south, who have contributed little to the present biodiversity crisis, are among those most impacted. For example, 'land grabbing' (in the name of conservation) and criminalization of Indigenous practices[4–9] have resulted in food insecurity and related illnesses (e.g., malnutrition, Type II diabetes),[10–16] economic exclusion (i.e. poverty),[17–20] cultural discontinuity,[21,22] conflict,[23–26] and hopelessness.[27–30] The exploitation of Indigenous territories has led to the contamination of food resources,[31] water insecurity,[32] and the extirpation of many valued wild species (e.g. boreal caribou).[33] Unhealthy relationships between people and nature have also created scenarios where wildlife-related diseases (e.g., COVID-19) have had devastating global impacts.[34]

Indigenous leadership is recognized as critical to addressing these losses in biodiversity and their impacts on human health and well-being. While the potential role of Indigenous Peoples has been acknowledged in various global forums (e.g., Global Biodiversity Framework), there are, to date, no working models that ensure Indigenous self-determination and respect of equity, diversity and inclusion in the documentation and mobilization of Indigenous Knowledges, including those target agreements in the landmark Global Biodiversity Framework adopted during the 15th Conference of the Parties of the Convention of Biodiversity.[35] Epistemological biases in what constitutes "evidence", barriers to representation within global institutions, as well as racism against Indigenous Peoples in many countries, remain challenges for meaningful collaboration between governments, Indigenous Peoples and other parties (e.g., environmental organizations). Strengthening capacity and resources for Indigenous-led research may help address these gaps and create new opportunities and solutions to the combined stresses on biodiversity, health, and well-being. To identify solutions to these challenges, this chapter shares lessons learned from developing the Ărramăt Model, including details about the journey to ensure Indigenous self-determination, respect, equity, diversity and inclusion.

The Ărramăt Project will supports more than 146 Indigenous-led research place-based projects in 28 countries, across 276 ecoregions, with funding from the Canadian Social Sciences and Humanities Research Council of Canada. In 2024, Ărramăt Project leaders were invited to participate in the Conference on "Indigenous Peoples' Knowledge and the Sciences" – Indigenous Knowledge science on innovations for resilience to climate change, biodiversity loss, food security, and health. The conference underscored the importance of bridging Indigenous Knowledge with scientific research to co-create effective biodiversity conservation strategies that prioritize the health and well-being of Indigenous communities. This dialogue presents an opportunity to empower Indigenous Peoples to lead research efforts that address global environmental challenges and promote social equity and respect for their cultural values, which is at the core of the Ărramăt Project.

2. Context and Opportunity

The number of opportunities for Indigenous engagement in biodiversity conservation has grown exponentially in recent years.[36–39] For example, the Kunming-Montreal Framework of the *Convention on Biological Diversity* explicitly recognizes Indigenous Peoples as "custodians of biodiversity and partners in its conservation, restoration and sustainable use." (Article 7 A). These calls to action of the Convention on Biological Diversity have created new spaces for dialogue and innovation.

However, communities without the resources for meaningful participation continue to be disenfranchised from these spheres of global environmental governance. Lack of equity within and between Indigenous communities, organizations, and governments seeking to engage in biodiversity conservation efforts is becoming a growing concern as is transparency about access to funding and representation. For example, evidence about endangered species in CITES is still heavily (if not exclusively) influenced by Western actors and animal rights organizations.[40–44] While some governments try to include or bring forward the perspectives and values of Indigenous Peoples, they continue to face racism within their own countries and territories, with women, youth and those of diverse gender identities being notably excluded.[45,46]

On the whole, Indigenous Peoples are still vastly marginalized from environmental decision-making processes or assigned roles in governance that are less than meaningful and fail to create outcomes that reflect traditional, cultural, or spiritual values.[37] Many of these patterns of exclusion are created and compounded by gaps in the availability of Indigenous Knowledge, resources, and support for Indigenous-led research on issues of biodiversity, climate change, and Indigenous health and well-being. To address this bias, the Ărramăt Model is shared to challenge the status quo on what constitutes knowledge and leadership on questions of biodiversity conservation and its impacts on health and well-being.

3. Overview of the Ărramăt Model

The Ărramăt Project, funded from 2021-2027, has been built around three core objectives: strengthening capacity (Obj. 1); building evidence about the interconnections between biodiversity and Indigenous well-being through Indigenous-led place-based research (PBR) (Obj. 2); and synthesizing-scaling research results through working groups aimed at policy transformation (Obj. 3). It is grounded in respect for the physical and spiritual relationships between Indigenous Peoples and Mother Earth around the globe. Our engagement of Indigenous Knowledge is also guided by the principles of "Ethical Space"[36,47] which guides us in working together to support Indigenous Peoples seeking to produce their solutions to addressing biodiversity loss. The Ărramăt Model also aligns with the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP).[48] The broadening scholarship has also inspired us in Indigenous research methodologies.[49–51]

The project is Indigenous-led. We are governed by a team of Co-Principal Investigators, an Advisory Circle of Indigenous Elders, leaders and senior academics, and 27 thematic leads (Global Transformation Pathway Co-Leads). The work is centered around Indigenous-Led and Place-Based Research Projects, which follow a term of reference co-designed through 300+ hours of online meetings with diverse Indigenous organizations, government representatives, and other team members. By 2027, we will have funded more than 150 place-based projects in more than 28 countries, with knowledge about more than 200 ecoregions being documented (Figure 1). The regions where the work has been carried out to date are culturally and ecologically significant – covering 276 ecoregions.[33,52,53] Some may be defined as "refugia" (little disturbed);[54,55] others are in "hot spots" with at-risk wildlife (e.g., polar bear, white sturgeon, mountain gorilla),[56,57] habi-

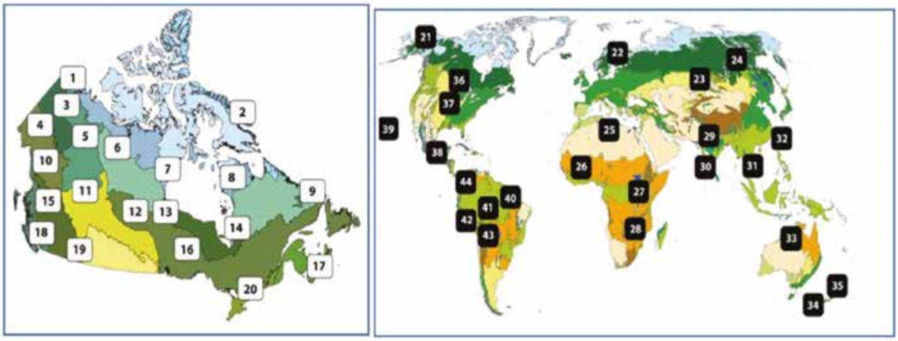

Figure 1. Global Map indicating where the Ărramăt Project is funding Indigenous-Led Place-Based Research Projects.

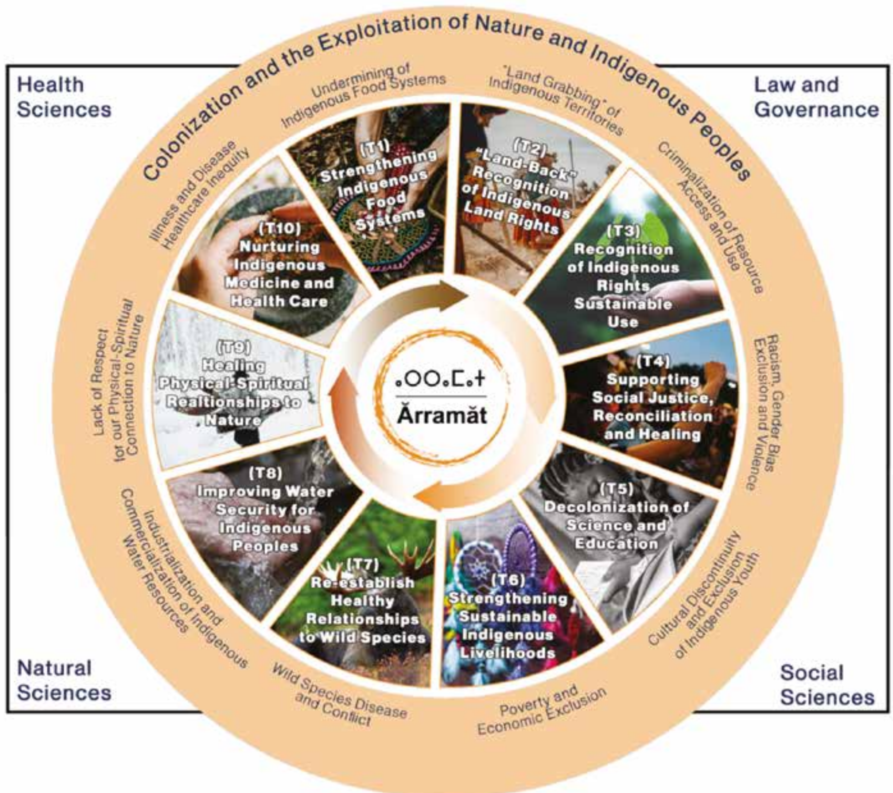

Figure 2. Working Group Themes of the Ărramăt Project (Global Transformation Pathways).

tats (e.g., sea ice, tropical forests, grasslands), and where Indigenous Peoples (IPs) are also under stress.

The anticipated contribution of new knowledge on biodiversity-human health and well-being revolves around ten interdisciplinary and transdisciplinary themes. (Figure 2). Indigenous organizations leading place-based projects have self-selected where or with which themes their research is most aligned.

Outputs from our work will include: i) culturally appropriate frameworks for defining and describing interconnections between biodiversity and well-being; ii) indicators and methods for tracking and interpreting patterns, trends and tipping points; and iii) modelling innovations and solutions for biodiversity conservation and care of people in hot-spots (e.g., areas/peoples under critical stress); and iv) actionable 'design principles' for strengthening holistic governance of biodiversity and health-wellbeing. Guided by theory on social and institutional learning,[58–62] we are working towards achieving the "transformative change" called for by global leaders.[63] This will be accomplished by: 1) filling gaps in our global understanding of biodiversity and well-being with IK identified as necessary by many institutions (e.g., IPBES);[33] 2) supporting institutional learning (i.e., changing beliefs about care for people and nature); and 3) catalyzing institutional innovation (e.g., new bridging organizations).

4. Learning from the Ărramăt Model

4.1 Foundational Principles

The Ărramăt Model (Figure 3) has many dimensions, including three core or foundational principles that were fundamental during the design of the Ărramăt Project proposal (2020-21) and that have continued to guide the implementation of the project.

4.1.1 Indigenous Leadership and Ethical Governance

A foundational principle of the Ărramăt Model is Indigenous leadership; we are Indigenous-led in all aspects of the structure and process of the research planning, implementation and reporting. This is unique from conventional kinds of research where Indigenous Peoples are commonly framed as vulnerable and powerless.[64] We confront this colonial stereotype using a strengths-based (rather than deficit-oriented) research approach. This leadership is not a simple process; it is a responsibility that has required significant time and effort to ensure day-to-day operations, resolve conflict, problem-solve and ensure meaningful engagement of all members of the Ărramăt Project team.

4.1.2 Elevating Indigenous Knowledge Systems (Transdisciplinarity)

Our purpose has been to elevate Indigenous Knowledge systems and address the bias towards Western science in biodiversity and health-related research. Indigenous Knowledge has many definitions that reflect the cultural, linguistic and epistemological diversity of Team members and projects. We define Indigenous Knowledge systems as a "way of life", including knowledge, practices, beliefs, and laws that reflect many generations living and being in place.[65–68] The knowledge system is holistic and transdisciplinary – synergistic with many forms of disciplinary inquiry (e.g., health sciences, biology, law, economics) commonly associated with academic research and policy circles.

4.1.3 Equitable Access to Research Funding

Indigenous Peoples and their organizations have limited access to research funding from academic institutions in Canada and elsewhere. Such exclusion from the enterprise of science and education has been attributed to patterns and tools of cultural assimilation, such as Canada's residential school system and the missionary schools led by the Catholic Church.[69,70] Much research on Indigenous Peoples, biodiversity, and health has involved objectification or "othering" of Indigenous Knowledge. We/Indigenous Peoples are too often considered only subjects or participants in research rather than having expertise and capacity for leadership, particularly at global scales. These inequities are embedded in the institutions of research funding. These organizations reinforce hierarchies of knowledge where science and those with academic credentials trump Indigenous Knowledge holders who do not necessarily have doctorates or university affiliations.[71] Previous research suggests that similar hierarchies of exclusion exist in the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES).[72–74] Partnerships between the Indigenous government and organizations with Canadian universities have been one opportunity for Indigenous Peoples to access research funding. Through a funding arrangement created through the Canadian Tri-Council, funding for Indigenous-led research proposed by the Ărramăt Project became plausible. Specifically, a unique call for proposals privileged Indigenous leadership and community engagement in "large-

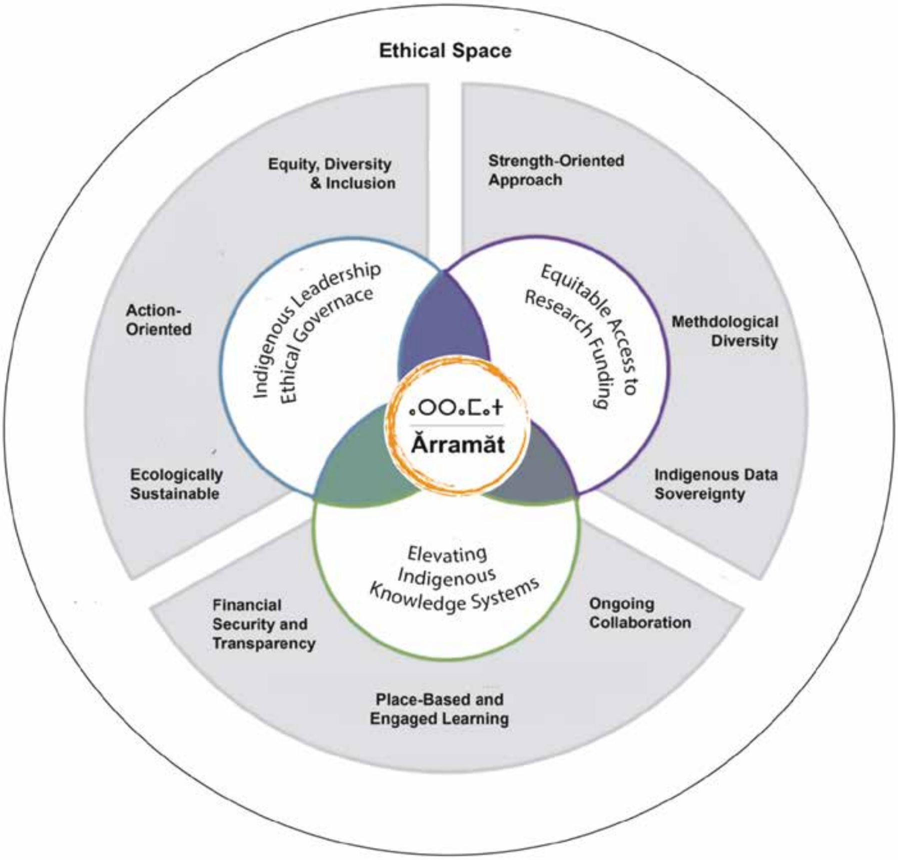

Figure 3. Design Principles.

scale interdisciplinary research projects that address major challenges with the potential to realize real and lasting change."[75] However, inequities persist even in nation-states considered advanced in the recognition and implementation of the rights of Indigenous Peoples; one must only review statistics on the research dollars allocated to Indigenous versus non-Indigenous Peoples for biodiversity-related research. The Ărramăt Model, built around the ideas of "Ethical Space" [1,2] and based around principles of Indigenous leadership, recognition of Indigenous Knowledges and equitable access to research funding, offers a way to address these gaps and biases.

4.2 Principles of Implementation

The Ărramăt Model was developed by the co-authors, was part of a proposal to the New Frontiers in Research Fund Transformation stream of the Canadian Social Sciences and Humanities Research Council (SSHRC) and was funded for six years (2021-2027). Among the starting points was the development of a clear and transparent governance framework. The "Ărramăt Project Principles of Working Together" (Figure 4) were the starting point for our governance framework.

Ărramăt Project Principles of Working Together

- By transforming the approaches and the way we think about biodiversity and well-being, elevating Indigenous knowledges, the project seeks to work towards a higher state of health and wellbeing for the benefit of all Peoples and Mother Earth.
- Engage as a broader team through Indigenous-led principles of good relations, facilitated through Indigenous and non-Indigenous methodologies and frameworks, informed by our partners and leaders, co-applicants, collaborators and supported by the academies of social, natural and health sciences, transdisciplinary and interdisciplinary voices with a shared vision for Indigenous wellbeing in the context of biodiversity conservation, being guided by principles of inclusivity, respect, kindness, honesty and reciprocity.
- Ensure an environment that recognizes intersectionality and gender diversity.
- Facilitate self-determination of Indigenous Peoples in the context of research, as well as elevate Indigenous systems, epistemologies, cosmologies, science, knowledge, language, and spirituality with a view to building capacities, ensuring continuity of Indigenous knowledge and its intergenerational transmission, and transforming relationality between and amongst peoples and the natural world.
- Promote respect for and full application of the provisions of the United Nations Declaration on the Rights of Indigenous Peoples in the context of the Project and all partners.

Figure 4. Ărramăt Project Principles of Working Together.

4.2.1 Equity Diversity and Inclusion

Principles of equity, diversity, and inclusion (EDI) guided the development of the project structure and are also a component of research themes (e.g., social justice). Equity, diversity, and inclusion (EDI) is "a conceptual framework that promotes the fair treatment and full participation of all people, especially populations that have historically been underrepresented or subject to discrimination because of their background, identity, and disability."[76] There are many definitions. However, equity generally refers to the intention of providing resources according to need; diversity refers to the representation of the total composition of social groups or organizations; and inclusion focuses on affirmations, celebrations and appreciation of the diverse experiences, knowledge, skill-sets and approaches to the engagement of diverse team members.[76] These efforts of our Team were positively reinforced through the funding agency, which recognized that "achieving a more equitable, diverse and inclusive Canadian research enterprise is essential to creating the excellent, innovative and impactful research necessary to advance knowledge and understanding, and to respond to local, national and global challenges."[77] We addressed equity, diversity, and inclusion through the structure of our project team, which is Indigenous-led (see above) and includes peoples of diverse gender identities, physical abilities, languages, and ethnicities. Over 60% of the project team comprises women and those of diverse gender identities, and many are primary caregivers for children, aging parents, and their communities. For example, we have accommodated the schedules of our leadership team with particular attention to mothers of young children. This is crucial to building a welcoming working environment and retaining Indigenous women in research who are often far from their family support network. This inclusive approach ensures that traditionally marginalized voices are prominently represented and led within the project. Our project also directly focuses on research about equity, diversity and inclusion. For example, an Indigenous trans-person (Muxhe) is leading a research project on the ancestral Indigenous gender identities of three different social groups in Mexico, Yucatan and Guerrero; she also co-leads the Ărramăt Project working group on "social justice, reconciliation and healing."

4.2.2 Strengths-Oriented Approach

In the Ărramăt Project, we are also working towards strengthening capacity to ensure that Indigenous Peoples who do not have well-developed skills or experience are supported in their efforts to lead their own projects. Capacity-building is an area of research praxis that has many definitions and dimensions. Definitions are highly context-dependent – "the ability to carry out stated objectives." It is often referred to as a process over time with domains or fields ranging from technical skill development to institutional development and civil action.[78–80] Building on ethical space and capacity-building frameworks developed in Native American health research, we define capacity-building around four principles[81] (Figure 5).

Capacity-Building Principles
Adapted from Gathering of Native Americans (GONA)

Building relationships (1st principle) facilitates open communication and the identification of common ground and common goals. **Building skills** (2nd principle) recognizes the importance of "mastery" and creating and nurturing opportunities for individuals and groups to make practical and unique contributions based on their own place. The third principle – working together – honours the importance of community or the "interdependence" within social groups and the environment (place). These interdependencies are not focused only on the present but also consider past, present and future connections. **Promoting commitment (4th principle)** – honours the importance of "generosity" and reciprocity between communities, within communities (e.g. elders and youth) and between people, their environment and the spiritual world.

Chino, M.; DeBruyn, L. Building True Capacity: Indigenous Models for Indigenous Communities. *American Journal of Public Health* 2006, 96, 596–599.

Figure 5. Capacity-Building Principles.

We take a strengths-based (not deficit-oriented) approach to working together to achieve the research objectives. This strengths-based approach guided our efforts to structure our team and support place-based work as well as knowledge mobilization in our ten working groups (i.e., Global Transformation Pathway Teams). Providing time and flexibility enabled Indigenous organizations to learn at their own pace and follow the best research practices relevant to their cultures and organizations. Capacity-building was also facilitated through a webinar series where Team members could learn from one another. These webinars were hosted to create dialogue about individual team members' key strengths (assets) and expertise that could be shared with others in the group. In addition to webinars, our Team members have contributed to the Project's methodological toolboxes (online resources) designed specifically to support Indigenous groups and leaders in planning and implementing their place-based research.

4.2.3 Methodological Diversity

The research approach and methods emerging through the Ărramăt Project build on or synergize with scholarship on Indigenous Research Methodologies.[50] While the broad research questions and themes are shared across the project, the specific focal points and research methods are not standardized; they reflect a diversity of cultures (e.g., worldviews, languages) and best practices of organizations involved in the work across 28 countries.

Examples include participatory mapping, filmmaking, and storytelling and collective remembering. Others designed and nurtured by Indigenous organizations and government have developed within the project's place and context. Essentially, people learn by doing and innovating new approaches that answer questions that are important to them.

4.2.4 Indigenous Data Sovereignty

Principles of Indigenous Data Sovereignty (IDS) also guide the implementation of the project work and the collaborative processes of knowledge mobilization. Some diverse definitions and elements have been developed by Indigenous scholars elsewhere. Among these are the FAIR and CARE principles, which focus on findability, accessibility, interoperability and reusability of information (FIND)[82] and CARE (collective benefit, authority to control, responsibility, and ethics).[83] These principles synergize with broader efforts to protect Indigenous rights and ensure free, prior and informed consent (i.e., UNDRIP).[84] At its heart, the focus is on protecting the rights and knowledge of Indigenous communities in collection, ownership, and use.[85] This framework acknowledges that the knowledge gathered through place-based projects is essential to Indigenous organizations and governments to meet local needs but is also part of a significant and collective effort of Ărramăt team members to bring knowledge together in solidarity to address issues of common concern.

4.2.5 Ongoing Collaboration

The Ărramăt Model is also based around principles of collaboration. Different collaboration modalities have been the project's core since its design's early days. Some of the tools we have developed have been around cross-cultural learning and dialogues. Many dialogues have been informal and self-organized; others have been more formal. These dialogues enabled us to identify epistemological synergies and differences, supporting collaboration across cultural and disciplinary contexts. These dialogues were challenging due to language differences and often required translation into three or more languages, as well as recognition and effort to practice and respect the many Indigenous languages (200+) important in global work. Specific collaborations have also been featured with the work of the Indigenous-led place-based projects and through the decisions of Indigenous organizations to engage (or not) in knowledge mobilization activities (i.e., through the Global Transformation Pathway Teams).

4.2.6 Place-Based and Engaged Learning

Another core principle guiding the implementation of the Ărramăt Project is place-based engaged learning. "Place-based research develops around locally relevant issues, which vary among social-ecological contexts… global sustainability issues are those that are common across multiple places and contexts, or those that are made visible by more influential or interconnected stakeholders, or by global bodies".[86] Places are sometimes described as sites of intimate relations between people, and between people and the environment, creating opportunities for the "production of knowledge and the reworking of human-nature boundaries. Place and intimate relations to place are also political spaces (i.e., where aspects of power are played out) and embodied places (i.e., indistinguishable from self and identity).[71,87,88] Previous research has focused on the opportunities of place-based research for documenting social and ecological change and stewardship of biodiversity. Place can sometimes be considered synonymous with "small-scale". However, like other multi-scale global projects (e.g., those on climate change), the Ărramăt Project is concerned with scaling insights developed through place-based research to influence global decision-making. In the Ărramăt Project, place generally has three dimensions; geographic location, locale (biophysical and spiritual definition), and social-cultural meaning (e.g., political, emotional). They are the sites and spaces where we collaboratively explore the interconnections between biodiversity and health. Between 2023-2024 we have funded more than 70 Indigenous-led place-based projects and will fund an additional 80+ projects in 2025-2027.

4.2.7 Financial Security and Transparency

Funding to support Indigenous-led place-based research is being allocated through an administrative process housed at the University of Alberta, Canada and guided by the terms of the funding agency (Social Science Humanities Research Council). Allocations of budgets for projects were created during the proposal development phase to honor the contributions of those governments and organizations who contributed intellectually to the development of the proposal and its success. Two kinds of funding are administered. In addition to the direct research costs, administrative overhead is shared with those leading research. This includes Indigenous governments, environmental organizations, not-for-profits, academic institutions, religious orders/groups and several small businesses. Sharing funding outside of Canada and to organizations other than Canadian universities has necessitated administrative creativity and attentiveness to different principles of the project (e.g., equity, diversity and inclusion). While easier to share funding with organizations with significant administrative experience, we intended to challenge the status quo and ensure that those most vulnerable (e.g., due to education levels, socio-economic, ecological stress, and political conflict) have equitable access to funding and are not burdened by top-down and western-academic financial policies and procedures.

Mutual respect for the principles of financial accountability and transparency (i.e. for public funds) throughout the process has ensured that the *Ărramăt Project* and its host institutions have been able to uphold principles of "research excellence" as defined by the *Tri-Council of Canada*. There are also challenges related to the capacities of academic institutions and other funding agencies; academic financial administration systems in Canada were not set up to support local organizations or communities, but rather universities and extractive (at best participatory) approaches to engaging with Indigenous Peoples. Our project and staff at the University of Alberta have developed strong working relationships in an "ethical space" to make room for Indigenous Peoples and organizations to be included as "eligible" to receive funding. This has come with a lot of work and effort from communities and administration to solve problems. However, more work is needed to align the administration systems with funding agencies and universities in Canada and elsewhere.

4.2.8 Ecologically Sustainable

Conventional research models depend on graduate students and researchers from urban centers (e.g., universities in the global north). It has been estimated that the carbon footprint of academics involved in research on climate change is high and growing. By funding researchers in-place, the work and outcomes are not only more culturally meaningful and outcomes more robust (i.e., knowledge holders have long-term and precise observations of place), but transaction costs (e.g., airfare travel) are significantly lower, as is the carbon footprint or greenhouse gas (GHG) emissions of researcher transportation and activities. The work also responds to the challenges of the global pandemic and the risks of increasing zoonotic diseases and viruses. By privileging local-scale and digital (rather than travel-related) communications and research activities, we are ensuring that the research process for the Ărramăt Project is sustainable from a human health perspective.

4.2.9 Action-Oriented

The project is a research project, but the outcomes are not standard academic outcomes. Many materials, reports, video documentaries, and book projects are being produced for educational, management, and policy-change purposes. The Ărramăt Project intends to support Indigenous governments and organizations to make their own "evidence" about issues of importance to them and meet their needs. There are opportunities to work together to achieve actionable solutions to global-scale biodiversity conservation and Indigenous health and well-being. By 2027, we anticipate place-specific data/knowledge being documented related to our ten themes of transformation (Pathways) with outputs speaking to i) culturally appropriate frameworks for defining and describing the interconnections between biodiversity and well-being, ii) indicators and methods for tracking and interpreting patterns, trends and tipping points in biodiversity and health-wellbeing; iii) model innovations and solutions for biodiversity conservation and care of people in hot-spot regions; and iv) actionable 'design principles' for strengthening holistic governance of biodiversity and health-wellbeing relevant at local-global scales.

5. Conclusions

Indigenous Peoples are among those most impacted by the present biodiversity crisis.[1–3] Despite growing opportunities for recognizing Indigenous Peoples and Knowledges, few models center Indigenous leadership in producing evidence and actionable solutions. Epistemological biases in what constitutes "evidence," barriers to representation within global institutions, as well as racism in many countries, remain challenges for meaningful collaboration between environmental organizations, governments, and Indigenous Peoples. In this context, this chapter offers the Ărramăt Model as an example of how funding for Indigenous-led research can be equitably and meaningfully supported. We designed this model in response to a Canadian Social Science and Humanities Research Council funding opportunity. The model, grounded in an 'ethical space', is based on three core principles: Indigenous leadership and ethical governance, elevating Indigenous Knowledge systems and equitable access to research funding. The funding award for 2021-2027 enabled us to operationalize these principles and offer additional lessons learned related to implementation.

Acknowledgements

We are grateful for the support, time and efforts of all members of the Ărramăt Project Team. We acknowledge the Indigenous territories of all our team members where we are working together to support our project. We give thanks to our connections to Mother Earth and all beings on Mother Earth who support our health and well-being. We acknowledge the funding of the Canadian Social Science and Humanities and Research (SSHRC) – New Transformation in Research Fund – Transformation (NFRFT-2020-00188). Ethical guidelines for research were developed and followed through the project based on the input of our team members, consistent with local Indigenous protocols and with the Canadian Tri-Council Guidelines on Ethical Research (University of Alberta #Pro00113756).

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Sustainable Wildlife Management: Why Indigenous People Matter

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Abstract

Indigenous Peoples are central to global efforts in biodiversity conservation and sustainable wildlife management, stewarding approximately 28% of the Earth's land surface, much of which overlaps with biodiversity hotspots and ecologically intact regions. Their traditional ecological knowledge (TEK) and sustainable practices, developed over generations, provide critical insights into the management of species and ecosystems. These practices, such as rotational agriculture, sacred groves, and sustainable hunting, are complemented by modern conservation strategies, resulting in reduced deforestation, enhanced biodiversity, and improved climate regulation. Indigenous territories are indispensable for maintaining ecological integrity, supporting climate change mitigation, and sustaining vital ecosystem services.

However, Indigenous communities face escalating threats, including land encroachment, deforestation, climate change, and poorly planned development projects, all of which undermine their ability to manage and conserve these landscapes. Social and political marginalization, inadequate legal protections, and the erosion of TEK further exacerbate these challenges. This chapter explores the transformative role of Indigenous Peoples in conservation, showcasing case studies from around the world while addressing the barriers they face. It concludes with actionable strategies, including strengthening land rights, promoting inclusive governance, supporting TEK, and raising awareness of their contributions. Empowering Indigenous Peoples is essential for achieving global biodiversity goals, advancing social justice, and fostering a sustainable and equitable future.

1. Introduction

Sound management of wildlife species is fundamental to sustaining their populations and habitats over time, particularly when considering the socioeconomic needs of human populations, as underscored in Decision 14/7 of the Conference of the Parties to the Convention on Biological Diversity. The sustainable use of wildlife is not only a conservation priority but also a socioeconomic necessity, with billions of people worldwide depending on wild species for food, medicine, energy, income, and cultural practices. As highlighted int the recent thematic assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2022), sustainable use is critical for maintaining the balance between human well-being and ecosystem health. It is integral to reversing the global decline in biodiversity and preserving the benefits that ecosystems provide to humanity.

Sustainable wildlife management involves practices that align the needs of wildlife populations with the requirements of human communities, ensuring that the use of species and ecosystems remains within ecologically sustainable limits. These practices are essential not only for maintaining biodiversity but also for supporting the livelihoods of millions, particularly in rural and forest-dependent communities. However, achieving this balance is becoming increasingly challenging due to threats such as overexploitation, habitat loss, and climate change.

Indigenous peoples play a pivotal role in addressing these challenges and advancing sustainable wildlife management. Their unique and longstanding relationship with nature is underpinned by extensive traditional knowledge systems, cultural practices, and a holistic understanding of ecosystems. Indigenous communities often view wildlife and natural resources as interconnected with their identity, well-being, and survival. This perspective fosters a stewardship ethic that promotes the sustainable use of resources while respecting ecological thresholds.

Moreover, Indigenous territories are among the most biodiverse landscapes on Earth, encompassing vital habitats for wildlife and ecosystems. Recent studies emphasize that biodiversity is often highest in areas managed by Indigenous Peoples, further demonstrating their effectiveness as custodians of nature. Yet, their contributions to wildlife management are frequently undervalued, and they face numerous challenges, including land insecurity, marginalization, and the impacts of global environmental changes.

This chapter explores the critical importance of Indigenous Peoples in sustainable wildlife management, shedding light on their contributions to conservation, the unique challenges they face, and the opportunities to enhance their involvement. By integrating Indigenous Knowledge and practices with modern conservation strategies, it is possible to create more inclusive and effective approaches to biodiversity conservation. Indigenous Peoples are not merely stakeholders in conservation efforts; they are indispensable partners whose active engagement is essential for sustaining wildlife populations, preserving habitats, and ensuring the well-being of human communities.

In recognising and supporting the role of Indigenous Peoples, this chapter aims to underline the need for equitable partnerships, respect for traditional knowledge, and the empowerment of local communities. Sustainable wildlife management is not just a conservation goal; it is a shared responsibility that requires bridging diverse worldviews, fostering collaboration, and promoting justice for those who have safeguarded the natural world for generations.

2. Indigenous Peoples: numbers and distribution

Indigenous Peoples (Box 1) are communities that have historical ties to specific regions and maintain distinct cultural practices and traditions. They are often characterised by their unique languages, social structures, and spiritual beliefs that are closely linked to their natural environments. Around the world, there are between 370 and 500 million people who consider themselves Indigenous, in more than 90 countries. Indigenous Peoples comprise approximately 6% of the global population, equating to an estimated 476 million individuals, and are distributed across more than 90 countries on every continent except Antarctica (United Nations, 2021). Representing an extraordinary diversity of cultures, they encompass over 5,000 distinct cultural groups and speak approximately 4,000 of the world's 7,000 languages, making them key stewards of global linguistic diversity (UNESCO, 2019). Many of these languages are endangered, further underscoring the cultural and historical significance of Indigenous Peoples in maintaining the world's intangible heritage. Their territories, which collectively cover about 28% of the world's land surface, are not only culturally rich but also critically important for ecological stability, as these areas overlap with some of the most biodiverse ecosystems on the planet (Garnett et al., 2018).

Indigenous Peoples manage or have rights over some of the most sparsely populated and ecologically intact regions of the world (Fig. 1). Their management institutions have proven remarkably resilient and sustainable, shaping human-landscape relationships that support conservation values. Even in areas where Indigenous Peoples are regaining land rights, the conservation of significant portions of the planet depends on their governance

Box 1. What is Indigeneity?

Indigeneity is not defined by a single universal framework; rather, it encompasses a combination of historical, cultural, and self-identification criteria. Indigenous Peoples are typically descendants of the original inhabitants of a region, maintaining historical continuity with pre-colonial or pre-settler societies. Their identities are deeply tied to specific territories, which form the foundation of their livelihoods, cultural practices, and spiritual beliefs. This unique relationship with the land and its resources is a defining characteristic of indigeneity, reflecting a holistic worldview that connects people, nature, and culture.

A critical aspect of indigeneity is the distinct cultural identity of Indigenous Peoples. They often preserve languages, knowledge systems, governance structures, and traditions that differ from those of the dominant society. These cultural elements are intertwined with their deep-rooted connection to the environment, emphasizing sustainability and respect for ecological balance. Moreover, Indigenous Peoples frequently occupy marginalised or non-dominant positions within broader political, social, and economic structures, which further shapes their experiences and challenges.

Self-identification is a cornerstone of defining indigeneity. Many Indigenous groups assert their identity based on shared ancestry, cultural traditions, and historical ties to their lands. International frameworks such as the International Labour Organization's (ILO) Convention 169 and the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) prioritize self-identification while acknowledging the diversity of Indigenous contexts. These frameworks avoid rigid definitions, emphasizing the importance of respecting the unique circumstances and perspectives of Indigenous communities.

Indigeneity is also defined by governance and autonomy. Indigenous Peoples often maintain traditional systems of governance, laws, and practices that coexist alongside or outside national frameworks. These governance structures are integral to their cultural resilience and ability to sustain their territories. However, defining indigeneity can be complex, as it varies across regions and contexts. Political, legal, and historical factors often influence whether groups are formally recognised as Indigenous. Consequently, many institutions and policymakers emphasize self-identification and context-specific approaches to ensure inclusivity and respect for Indigenous rights.

and actions. Despite their contributions, Indigenous communities often reside in remote or marginalised areas, ranging from the Amazon Basin and the Arctic to the savannahs of Africa and the rainforests of Southeast Asia. Their widespread distribution and intimate relationship with these ecologically significant regions make them indispensable partners in global conservation efforts and highlight the need for greater recognition and protection of their rights and knowledge systems.

3. Indigenous People lands: critical for biodiversity conservation

Indigenous Peoples manage approximately 28% of the world's land surface, including some of the planet's most biodiverse and ecologically critical regions (Garnett et al., 2018). These territories often overlap with biodiversity hotspots, underscoring their essential role in conservation. Research shows that lands under Indigenous management exhibit lower deforestation rates, higher biodiversity, and greater ecological resilience compared to other protected areas (O'Bryan et al., 2021; Fa et al., 2020). Indigenous territories provide vital ecosystems for climate regulation, carbon storage, and water cycling, making their stewardship indispensable for global environmental health. Due to their lifeways, traditional knowledge systems, and strong connection to place, approximately 92% of Indigenous Peoples' lands (35.4 million km^2) remain in good to moderate ecological condition, encompassing 39% of the planet's most intact landscapes.

The biodiversity value of Indigenous Peoples' lands is particularly evident in their overlap with key species distribution ranges. For instance, 10% of the global distribution range of 60% of all IUCN-assessed terrestrial mammals occurs within indigenous territories (O'Bryan et al., 2021). Similarly, these lands contain 30% of global primate distribution, 37% of the world's natural lands with low human disturbance, and 35% of the world's

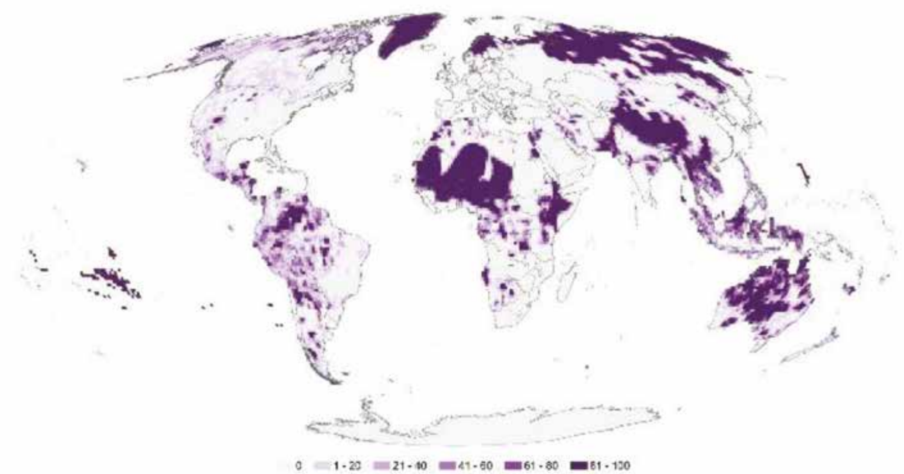

Figure 1. Global map of lands managed and/or controlled by Indigenous Peoples (percentage of each degree square mapped as Indigenous in at least one of 127 source documents). Taken from Garnett et al. (2018).

intact forest landscapes (Estrada et al., 2022; Garnett et al., 2018; Fa et al., 2020). The Amazon Rainforest provides a striking example of this overlap, where Indigenous Peoples manage extensive tracts of land that harbour 10% of the world's known species. These biodiverse regions also serve as critical carbon sinks, playing a central role in mitigating climate change (Watson et al., 2018). In addition to protecting biodiversity, Indigenous Peoples' territories sustain ecological integrity and support global climate regulation.

Indigenous communities in Africa further demonstrate the critical role of traditional knowledge in conservation. In the Congo Basin, the Baka and Aka people have preserved forest ecosystems for generations through sustainable hunting, gathering, and forest management practices. These practices not only support biodiversity but also maintain the health of the forests, which are vital for global climate regulation. In Namibia, the Community-Based Natural Resource Management (CBNRM) program offers an example of Indigenous and community-led conservation that has empowered local communities to manage wildlife and natural resources sustainably. Covering approximately 20% of Namibia's land area, this program benefits over 230,000 rural people, creating economic opportunities while supporting biodiversity. Through initiatives like tourism and resource-based enterprises, the program has led to the recovery of key species such as black rhinos and elephants, demonstrating the compatibility of conservation and development (MET Namibia, 2022).

In Southeast Asia, Indigenous forest management practices have been equally successful in preserving biodiversity and preventing deforestation. The Dayak people of Borneo employ traditional agroforestry systems that integrate tree crops, annual crops, and livestock. These systems maintain forest cover and biodiversity while supporting livelihoods, demonstrating how traditional ecological knowledge can enhance resilience to climate change and other external pressures. Similarly, in the Amazon, the Kayapo people have effectively managed their territories to protect vast areas of rainforest from deforestation and degradation. Their traditional practices, combined with modern conservation strategies, have resulted in lower deforestation rates and higher biodiversity compared to surrounding areas.

These examples highlight the transformative impact of Indigenous Peoples' management on biodiversity conservation. Their stewardship, traditional knowledge systems, and governance practices help sustain some of the most intact and biodiverse ecosystems on Earth. Supporting Indigenous-led conservation initiatives, ensuring land rights, and integrating traditional knowledge with contemporary conservation frameworks are essential for achieving global biodiversity and climate goals. By fostering equitable partnerships and recognizing Indigenous Peoples as indispensable partners, conservation efforts can achieve sustainable outcomes that benefit both people and nature.

4. The importance of wildlife for Indigenous Peoples

For Indigenous Peoples across the globe, wildlife is far more than a natural resource; it is an integral part of their cultural, spiritual, and economic identities. Their deep connection with wildlife is rooted in centuries of coexistence, reflected in traditional practices, knowledge systems, and worldviews that emphasize balance and respect for nature. Wildlife plays a crucial role in the livelihoods, diets, health, and ceremonies of Indigenous communities, underscoring its significance in their daily lives and cultural continuity.

In many regions, wildlife provides a primary source of sustenance. Indigenous communities often depend on wild animals for food security, with bushmeat, fish, and other wild species forming a cornerstone of their diets. For example, in the Congo Basin, Indigenous Peoples such as the Baka and Aka rely on hunting and fishing as key components of their subsistence practices. Similarly, in the Arctic, the Inuit depend on marine mammals and fish for nutrition and cultural practices, which are vital for their survival in harsh environments. Beyond food, wildlife also provides essential materials such as furs, hides, and bones for clothing, tools, and shelter, supporting Indigenous Peoples' self-sufficiency and resilience.

Wildlife also holds profound spiritual and cultural significance for Indigenous communities. Many Indigenous belief systems regard animals as sacred beings or spiritual guides, symbolizing strength, wisdom, or protection. These connections are expressed through storytelling, rituals, totems, and art that celebrate the intrinsic value of wildlife. The Māori of New Zealand consider certain bird species, like the kererū, as taonga (treasures) that are deeply tied to their cultural identity and heritage. Similarly, in North America, many Indigenous nations view animals such as bison, eagles, and wolves as sacred and central to their cosmology and traditional ceremonies.

Economically, wildlife supports Indigenous Peoples through sustainable livelihoods, including eco-tourism, artisanal crafts, and community-based resource management programs. Namibia's CBNRM program is an example of how sustainable wildlife management can create economic opportunities for Indigenous communities while promoting conservation. This model has empowered local people to sustainably manage wildlife resources, leading to improved livelihoods and the recovery of key species. Indigenous-led conservation initiatives such as these demonstrate the compatibility of wildlife management with both cultural preservation and economic development.

Moreover, wildlife conservation is inseparable from Indigenous Peoples' traditional knowledge and practices. Their ecological wisdom – developed through generations of close interaction with their environments – offers valuable insights into sustainable resource management and biodiversity conservation. The Dayak of Borneo use traditional agroforestry systems that integrate wildlife habitats with agricultural productivity, preserving forest cover while maintaining biodiversity. Indigenous knowledge systems also contribute to monitoring wildlife populations and managing ecosystems, complementing scientific conservation approaches.

Despite their critical role as stewards of wildlife, Indigenous Peoples often face challenges such as land dispossession, exploitation, and the imposition of conservation policies that do not respect their rights or traditions. These challenges not only threaten their cultural and economic survival but also undermine global biodiversity goals. Recognizing and supporting the role of wildlife in Indigenous Peoples' lives is essential for advancing both social justice and environmental sustainability. By ensuring their active participation in wildlife management and respecting their rights to traditional territories, conservation efforts can align with Indigenous aspirations and enhance the resilience of both communities and ecosystems.

Wildlife is not just a resource for Indigenous Peoples – it is a cornerstone of their cultural identity, livelihoods, and spiritual well-being. Recognising the importance of wildlife for Indigenous communities and integrating their knowledge and priorities into conservation frameworks is vital for fostering equitable and effective biodiversity conservation worldwide.

5. Importance of Traditional Ecological Knowledge in Conserving Indigenous Lands

Traditional Ecological Knowledge (TEK) embodies generations of observation, interaction, and adaptation to specific ecosystems, offering invaluable insights for conservation science. Unlike conventional approaches that often rely solely on modern scientific methodologies, TEK provides a holistic understanding of the intricate relationships between species, ecosystems, and human activity. It encompasses knowledge of species behaviour, ecological interactions, and sustainable harvesting techniques, which are critical for the effective management of biodiversity-rich regions. By integrating TEK with modern science, conservation outcomes can be significantly enhanced, creating strategies that are both ecologically sound and culturally appropriate.

TEK is fundamental to the effective conservation of the 28% of the world's land surface managed by Indigenous Peoples. Indigenous knowledge systems have evolved over millennia, providing practical and spiritual guidelines for resource use that maintain ecological balance. Seasonal hunting calendars, sacred groves, and cultural taboos protecting certain species are examples of practices rooted in TEK that align with principles of sustainability. For instance, many Indigenous communities have traditionally restricted hunting or harvesting during breeding seasons to ensure the regeneration of species. These culturally embedded practices contribute to the resilience of ecosystems and the preservation of biodiversity.

As detailed in Table 1, case studies from across the globe highlight the diverse ways Indigenous Peoples integrate TEK into sustainable wildlife management. The Kayapo people of the Amazon combine traditional practices such as rotational agriculture and sacred groves with modern tools like satellite imagery and drones to monitor and protect their lands. Similarly, the Martu people in Australia use "cool burning," a traditional fire management technique, to prevent destructive wildfires and promote biodiversity. These examples demonstrate how Indigenous practices, when supported by modern strategies, result in effective conservation outcomes such as reduced deforestation, enhanced biodiversity, and improved climate regulation.

In addition, the Dayak people of Borneo exemplify the use of TEK in agroforestry systems that maintain forest cover while providing livelihoods through sustainable crop production. By participating in certification programs like the Forest Stewardship Council (FSC) and accessing global markets for their sustainably produced goods, the Dayak have successfully merged traditional and modern approaches to ensure both environmental and economic sustainability. Similarly, the Inuit of Canada combine their traditional knowledge of wildlife behaviour and seasonal hunting practices with co-management agreements and scientific monitoring, ensuring sustainable use of Arctic resources while contributing to climate change adaptation.

In Australia, the Martu people show how traditional practices can address contemporary environmental challenges. Their fire management method, known as "cool burning," involves setting small, controlled fires during the cooler months to clear underbrush and create natural firebreaks. These fires reduce the risk of large-scale wildfires while promoting the regeneration of native plant species and habitats. Studies have shown that landscapes managed through Martu practices exhibit higher biodiversity and lower carbon emissions compared to areas managed solely through modern fire suppression techniques. TEK can complement scientific knowledge to deliver measurable conservation benefits.

TEK is particularly valuable in managing the interconnectedness of species and ecosystems. Indigenous Peoples' understanding of keystone species, for instance, often reflects their ecological importance and cultural significance. In the Congo Basin, Indigenous communities such as the Baka and Aka recognize the role of large mammals like elephants in seed dispersal and forest regeneration. Their sustainable hunting practices ensure that populations of these critical species remain viable, maintaining the ecological functions that support the broader forest ecosystem.

However, the erosion of TEK due to colonisation, globalisation, and the marginalization of Indigenous Peoples poses a significant threat to the conservation of biodiversity. Colonizers and post-colonial states often disregarded or suppressed Indigenous knowledge systems, leading to the loss of languages, practices, and resources that have been stewarded for centuries. For instance, policies that enforce centralized conservation models, such as the creation of protected areas without Indigenous participation, often disrupt traditional practices and sever communities from their ancestral lands. This not only undermines biodiversity conservation but also threatens the cultural survival of Indigenous Peoples.

Recognising and revitalising TEK is therefore essential for conserving Indigenous lands and the biodiversity they support. Conservation initiatives must prioritize the inclusion of Indigenous Peoples as equal partners, ensuring that their knowledge, practices, and governance systems are respected and integrated into management plans. Frameworks such as the Akwé: Kon Guidelines and the Whakatane Mechanism provide pathways for fostering meaningful collaboration, while examples like Namibia's CBNRM program demonstrate how Indigenous-led governance can lead to both ecological and socioeconomic benefits.

Integrating TEK into global conservation efforts requires more than acknowledging its value – it demands active efforts to protect the cultural and political rights of Indigenous Peoples. This includes securing land tenure, supporting the revitalisation of Indigenous languages and practices, and ensuring free, prior, and informed consent in all conservation activities. Only

Table 1. Case studies of sustainable wildlife management by Indigenous Peoples.

Case Study	Traditional Practices	Modern Strategies	Impact
The Kayapo People of the Amazon	Rotational Agriculture: Shifting cultivation to allow soil recovery. Sacred Groves: Protected areas from exploitation. Hunting Taboos: Protect species during breeding seasons.	Partnerships with NGOs: Collaborations with groups like Amazon Conservation Team. Use of Technology: Satellite imagery and drones to prevent illegal activities.	Biodiversity Conservation: Low deforestation rates. Climate Regulation: Forest cover aids carbon sequestration.
The Martu People of Australia	Cool Burning: Small, controlled fires during cooler months. Seasonal Hunting: Hunting specific species at certain times.	Collaboration with Scientists: Monitoring biodiversity effects of fire management. Government Support: Funding for land management activities.	Biodiversity Enhancement: Increased abundance of small mammals. Fire Prevention: Reduced large wildfires.
The Dayak People of Borneo	Agroforestry: Cultivating crops like rubber and fruit trees in natural ecosystems. Water Management: Sustainable irrigation techniques.	Certification Programs: Participation in FSC for sustainable standards. Market Access: Working with NGOs for sustainable product markets.	Forest Conservation: Maintains forest cover and prevents habitat loss. Economic Benefits: Stable incomes and cultural heritage preservation.
The Inuit of Canada	Seasonal Hunting: Strict seasonal practices to maintain marine populations. Community Quotas: Quotas based on traditional knowledge.	Co-Management Agreements: Shared responsibility with Canadian government. Scientific Collaboration: Monitoring wildlife and climate impacts.	Sustainable Harvesting: Ensures sustainable use of marine resources. Climate Adaptation: Informs understanding of climate change impacts.

by aligning conservation strategies with the knowledge and priorities of Indigenous communities can we achieve sustainable outcomes for the biodiversity-rich landscapes they have managed for generations. TEK is not merely a complement to scientific knowledge; it is an essential foundation for the stewardship of some of the world's most critical ecosystems.

By leveraging TEK, conservation can move beyond preservationist models that isolate humans from nature to embrace approaches that recognize humans as active participants in ecological systems. Indigenous Peoples, through their TEK, offer a blueprint for coexistence with nature that is rooted in sustainability, reciprocity, and respect. Their knowledge is not only a testament to the resilience of their cultures but also a critical tool for addressing the unprecedented environmental challenges of the 21st century.

6. Threats facing Indigenous communities and their lands

Indigenous communities worldwide face mounting threats that jeopardize their cultural survival, livelihoods, and the biodiversity-rich landscapes they have managed for generations. These threats are multifaceted, stemming from external pressures such as land encroachment, deforestation, climate change, and large-scale development projects. In the Amazon, for example, illegal logging, mining, and agricultural expansion significantly impact Indigenous territories, leading to habitat destruction and the loss of critical biodiversity. The Yanomami people in Brazil provide a stark example of these pressures, as their lands have been increasingly targeted by illegal gold mining operations. These activities contaminate water sources with mercury, degrade forest ecosystems, and introduce diseases, posing severe health risks and undermining the community's ability to maintain traditional livelihoods.

Climate change amplifies these threats by altering ecosystems, intensifying extreme weather events, and disrupting the balance of natural resources. For Indigenous Peoples who rely heavily on their local environments for food, water, and cultural practices, these changes are particularly devastating. In the Arctic, for instance, the Inuit face the rapid melting of sea ice, which not only threatens polar ecosystems but also disrupts traditional hunting practices that are central to their cultural identity. Similarly, in the Pacific Islands, rising sea levels threaten to displace Indigenous communities, eroding their connection to ancestral lands and cultural heritage.

Social and political challenges exacerbate these environmental pressures. Indigenous communities are often marginalized and underrepresented in decision-making processes at national and international levels, leaving them vulnerable to exploitation and exclusion. Inadequate legal protections and weak enforcement of existing rights further compound these vulnerabilities, making it easier for industries to encroach upon Indigenous territories. This lack of recognition and support undermines Indigenous Peoples' ability to sustainably manage natural resources, which not only affects their well-being but also has global implications for biodiversity and climate regulation.

Development projects present another significant threat to Indigenous lands. Large-scale infrastructure initiatives, including dams, roads, and extractive industries, frequently disregard Indigenous Peoples' rights and environmental considerations. The study by Kennedy et al. (2019) showed how development projects often lead to land dispossession. In North America, as an example, the extent and long-term effects of land dispossession and forced migration on Indigenous peoples, has increased exposure to climate change risks and diminished economic opportunities. habitat destruction, and cultural erosion. Hydropower dam projects in Southeast Asia have flooded Indigenous territories, forcing communities to relocate and disrupting their access to traditional resources. Similarly, road construction in the Amazon has facilitated illegal deforestation and the invasion of Indigenous lands by loggers and miners, leading to irreversible ecological and social damage.

More recently, Kennedy et al. (2023) have highlighted the alarming threats posed by industrial development to Indigenous Peoples' lands worldwide. Nearly 60% of these territories in 64 countries facing significant risk of degradation or conversion. The study identified 37 countries where Indigenous lands are particularly vulnerable, often due to weak legal protections, limited representation in decision-making processes, and insufficient access to financial and technical resources. These vulnerabilities exacerbate the likelihood of land conversion, undermining both the cultural integrity of Indigenous communities and the ecological health of these vital landscapes. However, the findings also underscore the importance of supporting Indigenous governance and stewardship, demonstrating that empowering Indigenous communities with secure rights, representation, and resources can substantially mitigate the risks of land conversion and contribute to sustainable land management.

The erosion of traditional lands and cultural practices profoundly affects Indigenous Peoples' well-being and ability to manage resources sustainably.

Traditional ecological knowledge, which has been passed down through generations, risks being lost as communities are displaced or disconnected from their ancestral territories. This loss not only diminishes cultural diversity but also weakens global conservation efforts, as Indigenous Peoples play a critical role in maintaining biodiversity and ecological integrity.

Addressing these challenges requires concerted efforts from governments, non-governmental organizations (NGOs), and the international community. Policies must prioritize securing land tenure and providing robust legal protections for Indigenous Peoples' territories. Governments should implement and enforce FPIC protocols, ensuring that Indigenous voices are integral to the planning and execution of development projects. Furthermore, inclusive conservation strategies must recognize and support the rights, knowledge, and governance systems of Indigenous Peoples. Collaborative initiatives, such as co-management agreements and community-based conservation programs, can help balance development needs with the protection of Indigenous rights and biodiversity.

As frontline stewards of some of the planet's most vital ecosystems, Indigenous communities play a pivotal role in preserving biodiversity, mitigating climate change, and ensuring ecological resilience. Their knowledge, practices, and governance systems are integral to maintaining the health of these landscapes, which provide essential benefits not only for local populations but for the global community as well. Recognising and protecting Indigenous Peoples' contributions is key to fostering a more equitable and sustainable future for all.

However, Indigenous Peoples and their territories face escalating threats from land encroachment, deforestation, climate change, and poorly planned development projects, which jeopardize their ability to manage and conserve these landscapes. Social and political marginalization, inadequate legal protections, and the erosion of traditional knowledge further compound these challenges. Addressing these threats is not only critical for the survival and well-being of Indigenous Peoples but also for achieving global biodiversity and climate goals. Protecting the rights, lands, and knowledge systems of Indigenous communities is a global imperative that requires urgent, sustained action.

Safeguarding the rights and lands of Indigenous Peoples is both a moral imperative and a critical step toward achieving global conservation and sustainability goals. This demands a holistic and equitable approach, emphasising partnerships that respect their autonomy, governance, and cultural heritage.

Below are key actions that can help ensure Indigenous Peoples are empowered to continue their vital contributions to biodiversity conservation:

- Strengthening Legal Protections: Ensuring that Indigenous land rights are recognized and protected under national and international law is essential. Clear and enforceable legal frameworks must secure Indigenous Peoples' tenure over their ancestral lands, preventing encroachment and exploitation by external actors. Legal protections should be aligned with the principles of free, prior, and informed consent (FPIC) to ensure that Indigenous communities have full authority over decisions affecting their territories.
- Promoting Inclusive Governance: Indigenous communities must be actively involved in decision-making processes related to conservation and natural resource management. Co-management frameworks and inclusive governance structures can foster collaboration between Indigenous Peoples, governments, and conservation organizations. These approaches not only enhance the legitimacy and effectiveness of conservation initiatives but also ensure that Indigenous knowledge and priorities are fully integrated into management strategies.
- Supporting Traditional Knowledge Systems: The integration of traditional ecological knowledge (TEK) with scientific research and conservation practices offers a powerful pathway for achieving sustainable outcomes. Efforts should focus on documenting, preserving, and revitalising traditional knowledge systems, while also ensuring that Indigenous Peoples maintain control over how their knowledge is used. Collaborative conservation projects that respect and incorporate TEK can create innovative solutions to pressing environmental challenges.
- Providing Financial and Technical Assistance: Indigenous-led conservation initiatives require adequate resources and capacity to thrive. Financial support, capacity-building programs, and access to technical expertise are critical for enabling Indigenous communities to manage their lands sustainably. Investments should prioritize community-led projects that align with Indigenous values and aspirations, such as eco-tourism, sustainable agriculture, and biodiversity monitoring programs.
- Raising Awareness: Public education and advocacy are essential for fostering greater understanding of the importance of Indigenous Peoples

in biodiversity conservation and sustainable wildlife management. Policymakers, conservation organizations, and the global public must recognize that Indigenous-led approaches are not only effective but also ethically imperative. Highlighting success stories and amplifying Indigenous voices in international forums can build momentum for stronger support and collaboration.

As we look to the future, the integration of Indigenous-led approaches into global conservation frameworks holds the promise of transformative change. By supporting Indigenous Peoples, we safeguard not only the landscapes they have managed for generations but also the ecological systems on which all life depends. Their stewardship is a beacon of hope for the planet and a powerful reminder of the value of working in harmony with nature.

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Traditional Knowledge in Forest Resource Management for Climate Change Adaptation in a Tibetan Village in the Eastern Himalayas Region of China

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Abstract

Climate change is having an increasing impact on forest resources in the East Himalaya region. It also poses a threat to the traditional livelihoods of the local Tibetan people, who depend heavily on forest resources. At the same time, the local Tibetans have formed the traditional knowledge of forest resource management through the accumulation of generations. Such knowledge includes observation, classification, utilization, protection and belief in forest resources. Today, in the context of climate change, this traditional knowledge has changed lot. Traditional knowledge is undergoing a dynamic process of change to help local Tibetans adapt to the impacts of climate change. In the context of the impact of global climate change on indigenous peoples, this local adaptation strategy also contains a global perspective. The value of traditional knowledge, the mechanism of cooperation among multi-stakeholders, and the special role of women embodied in it can be used for reference by indigenous peoples in other regions of the world in establishing adaptation strategies to climate change.

Keywords

Adaptation; Traditional Knowledge; Forest Resource Management; Eastern Himalayas; Tibetan

1. Introduction

Global climate is changing, and the frequency and intensity of extreme weather events are likely to increase in the future (IPCC, 2007). Climate change is now a major threat to environment, natural resource and ecosystem, including the forest. An estimated 350 million people around the globe who live adjacent to dense forests depend on them for subsistence and income (World Bank, 2004). Forest-dominated mountainous landscapes provide a wide range of ecosystem services for people residing in the mountains, as well as for people residing in lower hills and plains (Grêt-Regamey et al., 2012). For many indigenous peoples and local communities, their life depends on the surrounding environment, particularly forest resources and ecosystem. They are the first to face the direct or indirect consequences of climate change. The increasingly diverse effects of climate change pose a threat to them.

At the same time, indigenous peoples and local communities have rich and diverse traditional knowledge, technologies and culture that have been used for generations in planning and implementing natural resources management, climate change adaptation and disaster risk reduction related solutions (UNFCCC, 2013). The role and value of traditional knowledge and practices in climate change adaptation, mitigation, and disaster risk reduction is recognized at the global level (Shawoo & Thornton, 2019). Indigenous peoples and local communities use traditional knowledge as the basis for local level decision making for forest resources management. Traditional knowledge can take stock of the available forest ecosystem resources, enhance people's understanding of the nature of climatic risks, identify gaps in adaptive capacity of individuals and institutions and reduce the cost of adaptation by using local knowledge and physical resources (Kieu et al., 2022). Based on their traditional knowledge, indigenous peoples and local communities develop various approaches for coping with the impacts of climate change. While they have no previous experience with the effects of climate change specifically, they do have extensive accumulated experience adapting to environmental change. Traditional knowledge helps them reduce their vulnerability to the impacts of climate change and better survive in an increasingly adverse environment (Karki & Adhikari, 2015; Ahmed & Atiqul Haq, 2019).

In the Himalayas, the third pole of planet, compared with other regions of the world, the ecosystems are more fragile. The impact of climate change is more evident here. The Himalaya seems to be warming more than the global average rate (Shrestha et al., 1999; Liu & Cheng, 2000). Temperature increases are greater during the winter and autumn than during the summer. And the increases are larger at higher altitudes (Liu & Cheng, 2000). In this case, Himalayan forests are vulnerable to climate change and suffer severe ecological degradation due to anthropogenic pressures (Ma et al., 2012). Impacts of climate change are already evident on the forest systems in Himalayas, the direct and indirect role of climate change in vegetation degradation due to invasion of alien species, forest destruction due to over-increasing occurrences of forest fires, and reduction in forest productivity, including timber forest products and non-timber forest products. The forests in the Himalayan region are known to be multifunctional as they provide a range of ecosystem services for supporting livelihood options of local communities (Tripathi et al., 2022). Local communities are legacies of human-nature interactions that have been going on for a long time, creating cultural landscapes and traditional systems of forest resource management in many regions (Chakraborty et al., 2018).

In the East Himalaya region in southwest China, climate change is having an increasing impact on forest resources. It also poses a threat to the traditional livelihoods of the local Tibetan people, because of their livelihoods depending heavily on forest resources. Local Tibetans have also formed the traditional knowledge of forest resource management through the accumulation of generations. Such knowledge includes observation, classification, utilization, protection and belief in forest resources and this traditional knowledge is also undergoing a dynamic process of change. The present research explores, in the context of climate change, how traditional knowledge can help local Tibetans manage their forest resources, and how they develop the adaptation planning of climate change based on their traditional knowledge in the community level. Therefore, in the Eastern Himalayas, Tibetan traditional knowledge of forest resource management and its adaptation to climate change can provide a local perspective for understanding global climate change.

2. Background

2.1 Study Area

Deqin County belongs to the Diqing Tibetan Autonomous Prefecture of Yunnan Province, China. It is located in the northwest of Yunnan Province, at the eastern end of the Himalayan-Hengduan Mountains, the southern edge of the Qinghai-Tibet Plateau, and the upper reaches of the Lancang River (Mekong River). It is located at 98°35’06”-99°32’20” east longitude and 27°33’04”-29°15’12” north latitude. It borders Batang and Derong County in Sichuan Province to the east and Weixi County of Shangri-La City to the south. It borders Gongshan Dulong Autonomous County in Nujiang Prefecture to the west and Zuogong County, Qamdo City, Tibet Autonomous Region to the north. It has jurisdiction over 2 towns and 6 townships, with a total area of approximately 7,291 km2 (Fig. 1).

Being located at an altitude from 1755 meters to 6584 meters, Deqin lies in the transition between a subtropical highland climate and humid continental climate, which is remarkable for its latitude. Although mean maximum temperatures stay above freezing year-round, minima are below freezing from November to March, and temperatures average -2.1°C (28.2°F) in

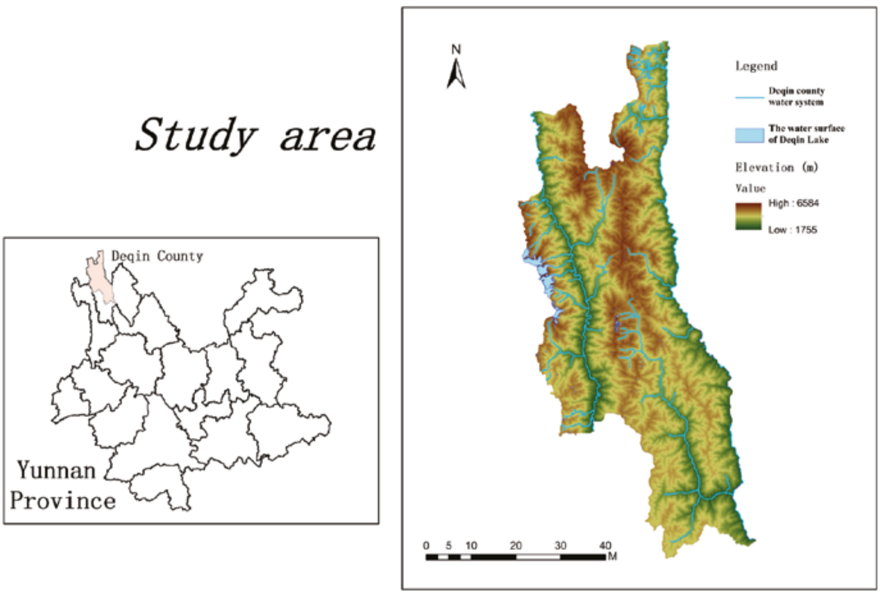

Figure 1. Map of the study area.

January, 12.7°C (54.9°F) in July, while the annual mean is 5.65°C (42.2°F). Rainfall is concentrated between June and September, accounting for nearly 60% of the annual total of 622 mm (24.5 in). Snowfall is rare but still causes major transport problems in the winter. With monthly percent possible sunshine ranging from 29% in July to 62% in December, the county seat receives 1,989 hours of bright sunshine annually, with autumn and winter sunnier than spring and summer (Chen et al., 2017).

Deqin is located in the Eastern Himalayas and also central part of the Hengduan Mountains, and contains the valleys of the Salween, Mekong, and Yangtze Rivers. Meili Snow Mountain is a mountain range in Deqin. It is bounded by the Salween River on the west and the Mekong on the east. The crest of the range rises to over 6,000 meters above sea level, making for impressive prominence over the river valleys to the east and west, which are between 1,500 meters and 1,900 meters in elevation. The highest peak is Kawagebo, which rises to 6,740 meters. Kawagebo is considered sacred for Tibetan Buddhists.

In Deqin, 80% of its 55,000 inhabitants are Tibetan, the Tibetans in this area live at a range of elevations, from relatively low-lying warm and dry valleys (around 2000 m) to high, cool and moist mountain area (above 3000 m). Most Tibetan people in Deqin make use of a diversity of ecological and climatic zones distributed along the elevation gradient (Sun et al., 2018). The agropastoralism is the main and important traditional livelihood to local Tibetan people in Deqin.

2.2 Forest belt and traditional livelihood

Due to the landform and climate of Deqin, there are obviously vertical forest belts. The traditional livelihood of the local Tibetan people is agropastoralism and the collection of non-timber forest products. The forest belts at different altitudes are closely related to the traditional livelihood of the local Tibetan people, providing a natural and material basis for them.

2.2.1 Alpine shrub, meadow and animal husbandry

The altitude of alpine shrub and meadow is between 4,200 m and 4,600 m above sea level. The climate is cold and the terrain is wide. The cold air convection is frequent. The common shrubs are azalea, cypress, willow, etc.

This is the summer pasture of the local Tibetans. The meadow provides the place and pasture for grazing. The herdsmen graze here every summer, and the main livestock include yaks, buffaloes and yellow cattle.

2.2.2 Temperate evergreen coniferous forest, cold temperate coniferous forest belt and collection of non-timber forest products

The temperate evergreen coniferous forest and the cold temperate coniferous forest belt are between 3,000 m and 4,200 m above sea level, with abundant rainfall and cold climate, mainly distributed in spruce, fir, hemlock, pine, cypress, etc.

Local Tibetans mainly collect non timber forest products (NTFP) here, including tricholoma matsutake and other wild bacteria with high economic value. The collection of NTFP is the main source of income for villagers.

2.2.3 Subtropical broad-leaved forest belt and agriculture

The altitude of the subtropical broad-leaved forest belt ranges from 2,200 meters to 3,000 meters, mainly distributed with arbors and shrubs, including linden, oak, hazel, yellow fir, pine, etc.

Here, local Tibetans mainly cut down trees and branches for firewood and farmyard manure; it provides important support for agriculture. In history, villagers also cut down the forest here for farmland. Today, due to the national policy of returning farmland to forest, most farmland has been abandoned and restored to forest.

3. Methodology

3.1 Ethno-ecology Methods

Through semi-structured interviews and questionnaires with villagers, the relationship among climate change, different forest belts and traditional livelihood were investigated. At the same time, we conducted the survey on the support of forest environment and resources to animal husbandry, collection and agriculture.

First of all, according to the forest belt and the traditional way of livelihood, we divided the surveyed villagers into three groups. Secondly, in the process of investigation, we attached great importance to gender perspective: each group had the same number of men and women (50). Three groups included 300 villagers.

3.2 Community based research

Community research methods are mainly used to investigate the villagers' traditional knowledge of using forest biodiversity resources, including traditional technology, customary law and culture. We also encourage villagers to conduct research, investigate and document the impact of climate change on forests.

We also divided the villagers into three research groups according to their traditional livelihood. Each research group is led by local experts with traditional knowledge, who organize and lead the villagers to carry out community research. In this process, we also take a gender perspective.

The first group is about animal husbandry research. Because it is often men who are engaged in animal husbandry, and men have more traditional knowledge of animal husbandry, most of the members of this group are men.

The second group is the research on the NTFP collection. Because women are often engaged in the collection, they have more traditional knowledge about it, so most of the members of this group are women.

The third group is the study of agriculture. Since both men and women are engaged in agriculture and have relevant traditional knowledge, the members of this group are more average in gender.

3.3 Traditional knowledge-based forest management and adaptation plan

On the basis of traditional knowledge and forest management, we discussed and established the climate change adaptation plan with villagers in view of the negative impact of climate change on forest resources and traditional livelihoods. Traditional knowledge, customary law, traditional organizations and belief culture are all included in this adaptation plan in response to different threats and challenges brought about by climate change (Granderson, 2017).

4. Results and Discussion

4.1 The perspective of forest in climate change

With increasing climate change, local villagers have observed and felt the impact of climate change on forests. These perspectives are also based on traditional livelihoods.

4.1.1 Expansion of alpine shrub and atrophy of meadow

In the alpine shrub and meadows of the high-altitude area, the villagers have obviously felt the temperature rise in this area in recent years, which is warmer than before. In this context, the villagers observed that the alpine shrubs were expanding and invading the high-altitude meadow, which made the meadow shrink year by year, and the shrinking of the meadow directly affected animal husbandry.

In response to this phenomenon, through a questionnaire survey of 50 men and 50 women, we found the following results.

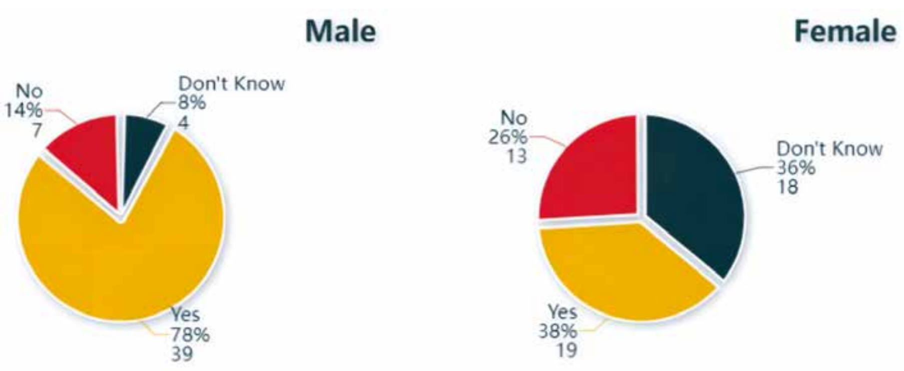

Figure 2. Men's and women's knowledge of the expansion of alpine shrubs and the shrinking of meadows.

From the above Fig. 2, we can see that compared with women, more men have observed the impact of climate change on alpine shrubs and meadows. This is because men are mainly engaged in animal husbandry in this area. In the process of grazing, they directly feel that due to the rising temperature, alpine shrubs are gradually expanding to high-altitude meadows, and the area of meadows is gradually becoming smaller. Women generally do not engage in animal husbandry or live in alpine pastures, so they do not have a very intuitive observation on the impact of climate change in this area on forest vegetation and animal husbandry.

4.1.2 Instability of the yield of NTFP

In the temperate evergreen coniferous forest and cold temperate coniferous forest area, villagers are more aware of the impact of climate instability and extreme weather phenomena such as drought and heavy rainfall. Climate instability and extreme weather directly affect the collection of NTFP. What's more, the yield of NTFP is becoming very unstable.

In response to this phenomenon, through a questionnaire survey of 50 men and 50 women, we found the following results.

From the above Fig. 3, we can see that women are mainly engaged in the collection of non-wood forest products. Therefore, compared with men, women are more aware of the instability of the climate, and extreme weather phenomena are more frequent in this region, which increases the uncertainty of their collection of NTFP. Because men are generally not engaged

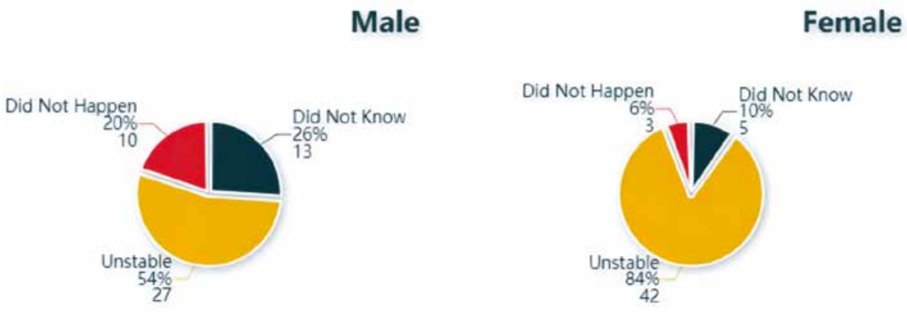

Figure 3. Showing the instability of the yield of NTFP for both men and women.

in the collection of NTFP, they do not have much direct observation on the impact of climate change on the collection. But since the collection of NTFP is the main source of economic income for local villagers, they will also have indirect feelings.

4.1.3 Slowdown of vegetation restoration

In the subtropical broad-leaved forest area, the villagers feel it more because of the rising temperature, and the speed of vegetation restoration which becomes slow after the deforestation in this forest belt. Compared with previous years, newly growing seedlings become less and less.

In response to this phenomenon, through a questionnaire survey of 50 men and 50 women, we found the following results.

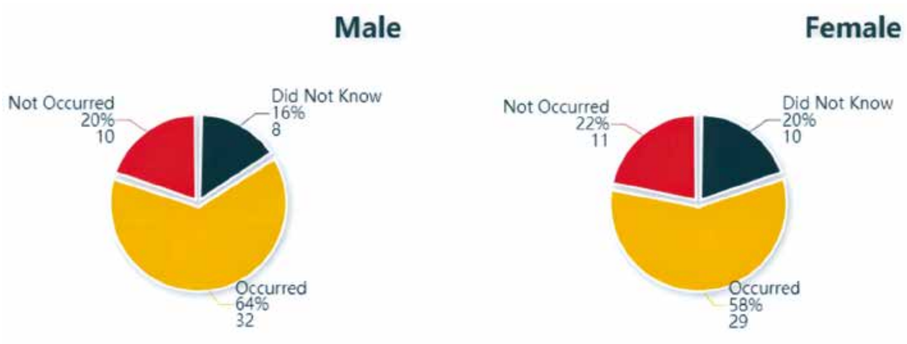

Figure 4. Showing the slowdown of vegetation restoration for both men and women.

From the above Fig. 4, we can see that as both men and women participate in agriculture, men are mainly engaged in firewood cutting in this forest belt, while women are cutting branches and leaves for farmhouse fertilizer, so they have a direct perspective of the impact of climate change on the forests in this region.

4.2 Traditional knowledge-based forest management

After generations of experience and knowledge accumulation, local villagers have formed their own forest management mode. This mode of forest management is based on traditional forest-related knowledge, including forest classification system, forest utilization and protection measures, forest belief and culture.

4.2.1 Classification and utilization of forest

For the villagers, based on the traditional knowledge, the forest has been classified in several ways based on different criterions.

First, based on traditional belief, the forest is divided into two parts: sacred forest and secular forest. The sacred forest belongs to the sacred mountain, and all the animals and plants in it also belong to the sacred mountain. There are also various deities in the sacred forest. Therefore, local customary law forbids cutting wood, hunting animals, gathering plants and graz-

Table 1. The classification of forest

Criterions	Types	Activities
Belief tradition	Sacred forest	Rituals for the deities in forest; ban on grazing, gathering, hunting and logging
	Secular forest	Grazing, gathering, hunting and logging
Utilization tradition	Firewood forest	Felling firewood
	Building wood forest	Cutting wood for construction
Livelihood tradition	Grazing forest	Grazing in the forest pasture, alpine meadow and sparse forest
	Gathering forest	Gathering of NTFP
	Agricultural forest	Cutting down branches and leaves for farmyard manure

ing livestock in the sacred forest. At the same time, white pagodas should be built near the sacred forest, and rituals should be held regularly. The small ceremony is presided over by old men, while the large ceremony is presided over by monks, praying for the blessing of the sacred forest and the sacred mountain to the village and people. In the secular forest, traditionally, villagers can use all the forest resources, including animals, trees and plants. In recent years, due to national laws, hunting is strictly prohibited, and logging is also strictly restricted (Rao et al., 2010).

Secondly, according to use, the forest is divided into two parts: firewood forest and building wood forest. Firewood forest is generally low in altitude. The trees here are loose in material quality level and suitable for firewood in families. The building wood forest is located in the high-altitude area, where the trees and wood are compact and suitable for building houses.

Third, according to traditional livelihoods, forests are divided into three parts: grazing forest, gathering forest and agricultural forest. The grazing forest is located in the high-altitude area, which is mainly composed of three parts: forest pasture, sparse forest and alpine meadow. The temperature is cold, herdsmen migrate here in summer, build wooden huts or build tents to temporarily live for three months, and graze livestock. The forest is located in the areas with medium altitude, most of which are primitive forests. The environment is humid, the vegetation is well preserved, and the biodiversity resources are rich. In summer and autumn, villagers gather different kinds of NTFP here. The agricultural forest is located in the low altitude area, where there are still traces of slash and burn cultivation in history. The villagers set fire to the mountains, making the forest become farmland. However, due to the prohibition of national laws and the change in villagers' agricultural methods, today it has been restored as a forest zone. In the forest here, the villagers mainly cut down branches and leaves and hoard them for farmyard manure.

4.2.2 Customary law for use of forest

In addition to the above-mentioned customary laws prohibiting the logging of sacred forests, there are also customary laws for the use of forest resources.

In the grazing forest area, herdsmen have the system of grazing in different forest pastures and alpine meadows to protect the pasture resources and forest vegetation to the greatest extent. In this way, the villagers can avoid the phenomenon of overgrazing in a certain place and the degradation of vegetation in a proper place. Thus, villagers can avoid the phenomenon of overgrazing in a certain place, which leads to vegetation degradation.

In the firewood forest and agricultural forest, the villagers will divide the forest into five to twelve areas and cut them in different areas in turn to form a cycle of forest vegetation restoration. At the same time, in villages with less forest resources, the villagers also distinguish between dry wood and wet wood when cutting wood. Dry wood is a tree that has naturally died and fallen. Wet wood is the living tree growing. In this context, the villagers formed a traditional custom of using dry wood for four days and wet wood for three days in a week.

In the building wood forest, the use of wood is very strict. Only the villagers who are building houses can cut wood, and they should apply to the village in advance and obtain permission. Whether it is national law or common law, cutting wood for sale is strictly prohibited (Zhou et al., 2020).

In the gathering forest, because the collection of NTFP is directly related to the household cash income of each farmer, customary law is also the strictest. Among all the NTFP, tricholoma matsutake is the most valuable, so the customary law for collecting tricholoma matsutake is the strictest. First of all, the collection of the seedlings of tricholoma matsutake is strictly prohibited by customary law to prevent damage to the habitat of the collection site and ensure that tricholoma matsutake will grow in the next year. Secondly, every village has its own forest area: villagers from other villages are strictly forbidden to enter to collect matsutake. If villagers from other villages want to enter, they must pay a sum of money called "mountain entry fee". If the villagers in the outer village are found without paying, there will be a huge fine waiting for them. Third, the villagers will select a special person to supervise whether there are villagers collecting and selling the seedlings of matsutake in the market. If there are villagers doing this, they will be fined.

4.2.3 Traditional cultures related to the forest

The forest is a kind of belief and culture for the local Tibetans: this belief and culture are closely connected with the protection of the whole forest ecosystem or an individual ancient tree.

First of all, the sacred forest belief and the protection of forest ecosystem: for local Tibetans, the forests on the sacred mountain are regarded as sacred forests. These forests belong to the mountain deity, and human beings have no right to use the resources in these forests. This belief objectively protects the ecosystems and biodiversity of these sacred forests. As a monk said:

> The worship of the sacred forest is our traditional belief. We believe that the sacred forest, its animals and plants, rivers and lakes are the property of the sacred mountain. People can't log and hunt in the sacred forest, or pollute the rivers, lakes and springs in the sacred forest. Otherwise, the sacred mountain will punish people. For example, if someone goes to the forest to cut down trees, he or his family will be seriously ill; if someone goes to the forest to kill animals, his livestock will die inexplicably. All this is the punishment of the sacred mountain and the deities in the forest"

Secondly, the divine tree belief and the protection of an ancient tree: in the forests and villages there are many ancient trees. These trees are huge and thick, so they are often regarded as divine trees by local Tibetans. These identified divine trees include walnut, pine, cypress, fir and so on. A piece of white silk, used as a greeting gift, and prayer flags are hung on the tree body to show their sanctity, and stone fences are built around the divine trees to protect them. People can't cut and destroy the trees that are regarded as divine trees. An elderly villager said:

> There is a huge walnut tree in our village. We don't know the age of the tree, but it must be hundreds of years old, judging by its diameter and girth. It must have been planted by our earliest ancestors who lived here. There is no historical record in our village. We don't know how long we have lived here, but this walnut tree is a witness of our village's history. It is connected with our ancestors, so this walnut tree is a divine tree and the guardian of our village,

A herdsman who often goes to the mountain for grazing said:

> There is a huge fir tree in the alpine forest of our village. It must be hundreds of years old. Every time we pass this tree, we must offer white silk and prayer flags to pray for its protection, keep the wild animals away from our livestock, and let us collect more matsutake and other mushrooms.

Because of this belief and traditional forest cultures, the forest ecosystem and its flora, fauna and biodiversity are well conserved, and many ancient trees in the area have been protected.

4.3 Community-based adaptation for climate change

In recent years, local Tibetans have become increasingly aware of climate change and its impact on the forest ecosystem, which in turn directly affects the traditional livelihood of the villagers. In this context, villagers developed a community-based approach that used their traditional knowledge to adapt to climate change.

This adaptation plan is first based on the community, and villagers are the core and leading of this plan, so that they can better play the role and value of their traditional knowledge. This adaptation plan is also an integrated approach, in addition to the villagers, but also including the government, researchers, NGO workers and other interest stakeholders, so as to maximize their own advantages, making the adaptation plan more effective.

Specifically, the adaptation plan addresses the impacts of climate change on forest ecosystems and the challenges of such changes to livelihoods. It includes the following three main parts.

4.3.1 Traditional knowledge of burning pasture and adaptive measures of animal husbandry

Historically, local herdsmen have used the traditional knowledge of burning pastures. The main reason for this is to burn the alpine shrubs and brambles that invade the pasture to maintain the area of the pasture and make the pasture have sufficient forage grass. At the same time, it can also improve the fertility of the pasture. In the next year, more forage grass will grow and its impact value will be higher.

It's a rigorous set of traditional knowledge, not a random set of fires in the pastures. Before setting the fire, the villagers have a detailed plan, including the location and area of the fire, observation of wind direction and climate conditions, division of labor, excavation of fire belts to isolate other parts of the forest, firefighting measures and emergency plans, etc. For thousands of years, these methods have effectively reduced the risk of forest fire caused by burning pasture, improved the quality of pasture and maintained the development of animal husbandry.

However, today, due to the National Forest Protection Law, this traditional custom is strictly prohibited to prevent forest fires. At the same time, due to the impact of climate change, alpine shrubs and brambles have invaded alpine meadows at a faster speed than before, so the degradation of pastures is more serious. Many pastures are even completely occupied and replaced by alpine shrubs, and no longer suitable for grazing. Therefore, current national laws and measures such as returning farmland to forest and banning fire aggravate the spatial imbalance of grassland, bring greater pressure to the pasture, and restrict the sustainable development of animal husbandry in practice.

In this context, the villagers believe that traditional knowledge and methods of burning pastures should continue to be used to reduce the degradation of pastures caused by climate change, and hope that local governments and forestry authorities will allow them to set fire to alpine pastures. The local government also recognized this situation and its threat to animal husbandry, so with the cooperation of villagers, local government, forestry department and fire department, some areas with serious grassland degradation began to pilot burning pastures. The value and role of this traditional knowledge has been gradually recognized as a local measure to deal with grassland degradation and adapt to climate change (Jiao & Xu,2022).

4.3.2 Traditional institution of women's organizations and adaptive measures of gathering

Traditionally, women are mainly engaged in the gathering of NTFP. In recent years, because of the variability of climate and the frequent occurrence of extreme weather disasters such as drought and rainstorms, the forest environment and the growth of mushrooms, including tricholoma matsutake, have been seriously affected.

As a result of long-term engagement in the collection of tricholoma matsutake and other mushrooms, women have accumulated rich traditional knowledge and formed a traditional management mechanism.

The impact of climate change makes some traditional knowledge invalid. For example, the gathering time of tricholoma matsutake is advanced or delayed; the local climate is changed, which leads to the decline of tricholoma matsutake production in traditional gathering areas; and the environment of tricholoma matsutake growth is changed etc. All these phenomena make it difficult for traditional knowledge to predict the growth of tricholoma matsutake, thus affecting women's collection activities.

In this context, women further strengthen traditional management mechanism to adapt to climate change. In the local villages, there is a traditional women's organization called "sisterhood", which traditionally organizes women's activities. After the negotiation and discussion of the villagers' meeting, it was agreed that the sisterhood would be responsible for the collection of non-timber forest products. So, the sisterhood started to manage the tricholoma matsutake collection based on the traditional institution. First of all, in order to cope with the impact of drought or rainstorms on the growth environment of tricholoma matsutake, the sisters will remind each woman to protect their own tricholoma collection area, backfill humus soil or cover with leaves after collecting tricholoma matsutake, so that the area can continue to grow tricholoma matsutake next year. Secondly, the sisterhood established a strict collection system, stipulating the size and length of the collected tricholoma matsutake: only mature tricholoma matsutake of more than 4 cm can be collected. At the same time, it restricted outside villagers from entering the forest to collect tricholoma matsutake, in order to protect resources and economic interests, and fined the outside villagers who collected without permission. A local woman said:

> It is more effective for women to manage forests and collect tricholoma matsutake. Women are more familiar with the growth environment and climate conditions of tricholoma matsutake and know how to protect its resources. The sisterhood can formulate and implement strict rules and regulations to protect the forest and manage the matsutake resources in our village. If men do these things, they are prone to conflict or even fight, so that the rules and regulations cannot be implemented. But now it's up to us women to do it. Men are embarrassed to quarrel with us, and there are few conflicts between women, so the implementation of rules and regulations is more effective.

Traditional organizations and traditional management mechanisms can play an irreplaceable role in climate change adaptation plans. The actions of the sisterhood have proved this. The rules and regulations of forest protection and matsutake resource management formulated by them are the specific methods of local adaptation to climate change (Yin et al., 2018).

4.3.3 Traditional ways of forest utilization and agricultural adaptive measures

Locally, forests provide farmyard manure for agriculture. As mentioned above, villagers cut down branches and leaves and stock them up for farmyard manure. In recent years, villagers have observed the impact of climate change on this part of the forest. They believe that climate warming makes the recovery and regeneration of trees in the forest slow down. Therefore, the villagers can no longer cut down as casually as before.

In order to adapt to this situation, the villagers divide the agricultural forest into different areas according to tradition, and formulate rules and regulations to regulate the cutting of trees. Specific regulations include: first, after dividing the forest into several areas, the first area that can be cut down is determined every year. The villagers should cut down trees in this area in accordance with the regulations. In the following years, they should cut down trees in other areas in turn, and finally return to the first area. Secondly, in the same area, dry wood and wet wood should be distinguished, and dry wood should be used as much as possible.

The villagers believe that the above methods can maximize the use of forest resources to provide farmyard manure for agriculture and adapt to the impact of climate warming.

5. Conclusion

This research shows the traditional forest knowledge of the Tibetan in the eastern Himalayas region of China, which includes the understanding, customary law and culture of forest. This research considers that traditional knowledge is the core and foundation of community-based forest management for local Tibetans. In the context of climate change, this research provides insights of high importance on the potential role and value of traditional knowledge and community-based forest management in enhancing the effectiveness of the local climate change adaption plan in the Eastern Himalayas.

Therefore, this research attempts to show the local Tibetan people's observation of climate change, management of forest resources, and adoption of coping strategies to adapt to climate change and its impact on forest resources. In this process, we can see that it is not enough to rely on traditional knowledge alone. To adapt to climate change, in addition to relying on community-based forest management, we must also form cooperation mechanisms among multi-stakeholders, including villagers, local governments, scientific researchers and NGOs, to coordinate traditional knowledge, national policies, scientific knowledge and technology together and finally build an integrated climate change adaptation plan.

This research also provides a gender perspective on climate change adaptation. Because of women's important position in forest management and livelihood, their traditional knowledge has potential value and forms a unique traditional institution, which makes women play a special role in the process of adapting to climate change.

Finally, in this research, although a climate change adaptation plan based on traditional knowledge and forest management methods is only a local strategy of the Tibetan in the East Himalaya region of China, this local adaptation strategy also contains a global perspective in the context of the impact of global climate change on indigenous peoples. The value of traditional knowledge, the mechanism of cooperation among multi-stakeholders, and the special role of women embodied in it can be used for reference by indigenous peoples in other regions of the world in establishing adaptation strategies to climate change.

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YOUTUBE PRESENTATIONS

A Global Outlook on Indigenous Peoples and the Importance of their Role for the Climate and Biodiversity Agenda. Challenges, Opportunities, and Solutions Supported by the UNDP Equator Initiative

Anna Giulia Medri
Head, Equator Initiative, United Nations Development Programme (UNDP)

https://youtu.be/wyD1bkmzZX0?si=nzvqGt-n3wbSCWUb

IFAD Engagement with Indigenous Peoples for Climate, Biodiversity, Food and Nutrition Agendas

Ilaria Firmian
IFAD Senior Technical Specialist – Indigenous Peoples

https://youtu.be/rk1LxGcPSo8?si=rRBovOIC737lsGJ7

Amazonian Forests Protected by Indigenous People

Paulo Artaxo
University of São Paulo, Director of the Center for Amazonian Sustainability

https://youtu.be/pMMDsOoFnFs?si=sqL5wEBm3PnFuLoi

The Role of Traditional Knowledge in the Kunming-Montreal Global Biodiversity Framework

Q"apaj Conde
Secretariat of the Convention on Biological Diversity,
Associate Programme Management Officer

https://youtu.be/05SAXkMhmCs?si=ij6IJFtJNr6bIdA1

4.2. FOOD SYSTEMS

New Wine into Old Wineskins: Indigenous Peoples' Food and Knowledge Systems as Key for a Sustainable Planet

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Abstract

Food insecurity has predominantly been addressed as a problem of food production; since the times of the Green Revolution, miracle seeds, pesticides, synthetic fertilizers, and irrigation have been promoted to maximize yield. However, this model has proven to be unsustainable as it causes 30% of the Greenhouse Gas Emissions, accounts for 70% of freshwater withdrawals, is responsible for 80% of the world's deforestation, and has had many disastrous social impacts, affecting many Indigenous Peoples, among others. As an alternative model for food insecurity, Indigenous Peoples' food and knowledge systems form the basis of the most time-tested models for stability and sustainability. Although Indigenous Peoples represent only 6% of the world's population and face ongoing systemic marginalization, discrimination, and criminalization, they protect 80% of the world's remaining biodiversity. In this paper, we present some key data on the unsustainability of the current food systems; then, we present some key features of Indigenous Peoples' food systems and the lessons that we could learn for food systems transformation. We then examine the questions of what a right to food for Indigenous Peoples means and what other rights and requirements are implicated in that process, and finally, we make some specific recommendations for food systems transformation while ensuring that we use a rights-based approach.

New Wine into Old Wineskins: Indigenous Peoples' food and knowledge systems as key for a sustainable planet

1. Food insecurity: a prevailing problem disproportionately affecting Indigenous Peoples'

Despite many national and international efforts, food insecurity remains a critical issue. According to the 2023 State of Food Security and Nutrition in the World (SOFI), approximately 737 million people faced hunger in 2022, which is 122 million more than those facing hunger in 2019 before the COVID-19 pandemic (FAO et al., 2023), and nearly one in every ten people. By 2030, 600 million people will be chronically malnourished, which is 25% or 119 million more than the initial projections before COVID-19 and the war in Ukraine (FAO et al., 2023). Just due to the war in Ukraine, food insecurity increased by 23 million people, a 5% increase (FAO et al., 2023). To understand and address rising hunger and food insecurity issues, we must think beyond individual examples of disruptive events and instead think of the systemic violence built into food systems as part of the global economy, such as how dominant regimes and regulations have created a dependency and extractivism that has made some people more vulnerable (Fakhiri, 2022).

Food insecurity does not strike all people equally and disproportionately affects women and children. In 2022, 148.1 million children under five years old were stunted, 45 million experienced wasting, and 37 million were overweight. These figures show the double burden of food security and why the focus should not only be on food but also on how to access healthy food (FAO et al., 2023).

Stunted growth emerged from food insecurity and broadly from poverty (Black et al., 2013). Poverty too does not affect all people equally, and Indigenous Peoples are disproportionately affected, as they account for 19% of the extremely poor despite being only 6% of the world's population (World Bank 2024), and they are 2.7 more likely to face poverty than their non-Indigenous counterparts (Pero et al., 2024). Food insecurity among Indigenous Peoples is being exacerbated by climate change, COVID-19, conflict, land grabbing (Martinez-Cruz, 2023), and historical and institutional discrimination from colonization until the present (Kuhnlein and Chotiboriboon et al., 2022). For example, in Canada, Indigenous households face 2-6 times more food insecurity than non-Indigenous households (Tarasuk and Mitchell, 2020). The situation for Indigenous Peoples is even worse for those confined to reservations where 28.2% face food insecurity compared to 12.7% in Canadian households (Deposition, 2016). Similarly, in Ecuador, Indigenous children face twice as much stunting compared to their non-Indigenous counterparts (Pero et al., 2023).

2. Purpose of this paper

One of the main challenges faced by Indigenous Peoples[1] is the systemic and institutional discrimination that they have suffered since colonization, and the ongoing violence that affects their livelihoods, undermining some of their fundamental rights, such as their right to food. In this paper, we will begin with the language of food security in our narrative in the first sections where we address the limitations of the dominant model and how an alternative model based on Indigenous Peoples food and knowledge systems can inform transformative food systems; later on, we expand the discussion to incorporate the right to food and food sovereignty. Our choice to use food security was a deliberate one, as this term is widely used in mainstream policy and agricultural research and development. Later in the discussion, in the second section, more emphasis will be placed on the right to food and rights as we advance to the end of the paper, with recommendations and conclusions on how we can do better.

In section three, this paper aims to highlight issues with the current dominant food systems as opposed to the Indigenous Peoples' food and knowledge systems and address some of the root causes of these issues. Section four describes the key features of Indigenous Peoples' food systems that make them game changers. In section five, we address the main differences between the right to food, food security, and food sovereignty and position ourselves on a rights-based approach. In section six, we discuss some important aspects of Indigenous Peoples' rights that should be included in the conversation on food security and the right to food. In section seven,

[1] There is not a generic definition of Indigenous Peoples, but the United Nations recognizes that Indigenous Peoples, communities, and nations are "those which, having a historical continuity with pre-invasion and pre-colonial societies, developed in a given territory and consider themselves distinct from other sectors of the societies now prevailing on those territories, or parts of them. They form at present non-dominant sectors of society and are determined to preserve, develop, and transmit to future generations their ancestral territories and their ethnic identity as the basis of their continued existence as peoples, following their cultural patterns, social institutions, and legal system" (ONU, 2004:2).

we conclude with some specific recommendations to support Indigenous Peoples' rights and food systems.

The authors of this paper are an interdisciplinary team that has worked on Indigenous Peoples' issues. One author self-identifies as Indigenous, the other does not; and we all have experience collaborating with Indigenous Peoples over the years. Our narratives, therefore, sometimes reflect both Indigenous voices and the voices of non-Indigenous allies as we both have played the role of experts or scientists in universities, research centers, or in our work as practitioners. In other instances, the voice portrayed is of the Indigenous author, especially in the section on recommendations, as some of them are better voiced when she embedded herself in the process. This paper is a reflection paper, so the quotes and stories that are brought into it aim to show the different experiences that the authors have had as experts working on Indigenous Peoples' issues and as reflections of their work that have emerged over time.

3. A need to transform food systems

The modern food system is in crisis: while there have been many technological advancements to support food security and achieve Sustainable Development Goal #2 of 'Zero hunger', we are experiencing the collapse of our current dominant food systems. While we have made progress in improving food security in the immediate present, with growing populations and other challenges we face, by 2050 it is anticipated that food demands will rise between 30-70% (Van Dijk et al., 2021), and pressure will be increased on the land, water, and natural resources needed to support our food system.

The current food system model relies on three main crops – wheat, rice, and maize – which make up 50% of the caloric intake of the world's population (Awika, 2011). One of the risks of relying on so few crops is reduced resilience, as individual extreme events can affect the availability of these significant crops and, therefore, the food access and security of billions of people. For example, due to Russia's invasion of Ukraine, with both countries being major wheat suppliers, price and market volatilization impacted over 38 countries that imported 30% of their wheat from Ukraine and Russia. Concerningly, the loss of wheat production during the first year of the invasion was less than 1%, suggesting that the main driver of the price and market volatilization around wheat was mainly due to fear, which strongly affected some of the poorest and most vulnerable countries (Fakhiri, 2022).

This raises the specter of far worse consequences when such regional production shocks affect not only supply fears but the supply itself. Additionally, with Ukraine, Russia, and Belarus playing key roles in the supply of fertilizers, a supply disruption on the chemical fertilizer supply chain also affected crop production (Fakhiri, 2022).

Another side effect of the current food systems is that the intensive farming methods they are based on account for 30% of the greenhouse gases contributing to climate change (Fanzo, 2021), consume 70% of the world's freshwater supplies (OECD, 2018), and are responsible for 80% of global deforestation (FAO, 2017). Additionally, 30% of the produced food also gets wasted from field to fork (FAO, 2022).

The obvious unsustainability and instability of the dominant food systems raises two key questions: What drove us to develop such unsustainable systems? And what can we do differently to achieve the SDG2 'Zero hunger' and ensure the sustainability of the planet?

3.1 The legacy of the Green Revolution and the productivity-oriented approach

For many years, technological advancement and agriculture intensification have been promoted to improve food security and lift farmers out of poverty (Martinez-Cruz, 2020). This paradigm, based on technology and productivity, dates from the so-called Green Revolution, which emerged in the 1960s with the promotion of the so-called High-Yielding Varieties or 'miracle seeds', chemicals, and irrigation, among other technologies, when there was a need to feed a world recovering from the Second World War (Harwood, 2009). The goal was to increase food production as several regions of the world were facing chronic food insecurity (Pingali, 2012 and Shiferaw, 2013). At the heart of the approach was producing more food per unit of input, e.g., water, land, money, and the means of technology advancements. The environment was not in the equation, nor were the questions of who the primary beneficiaries of such a system were and who the people most negatively affected by introducing these technologies.

While we cannot deny that the Green Revolution contributed to improving food security in some regions of the world (Pingali, 2012), yet we also cannot deny the harmful socioeconomic, cultural, and environmental impacts that it had (Pingali, 2012), primarily hitting smallholder farming and Indigenous Peoples (Griffin, 1979 and Conwall, 2019), and only benefiting the few farmers who had access to irrigation or technological advancements. For example, reflecting on agricultural irrigation, 80% of the cultivated land in the world is rainfed and produces 60% of the world's food, while the 20% that uses irrigation produces 40% of the food (OECD, 2028). If the only goal of agriculture is in terms of productivity, land with irrigation is more than 2.5 times more productive than non-irrigated lands. This singular drive for productivity has also provoked soil erosion, pollution, and health issues besides deforestation. In 2017, 192 million tons of synthetic fertilizers were used in agriculture (an increase of 37% since 2012), and the use of chemical pesticides also increased in 34% since 2022 (Tang, 2022). Indigenous children are said to be six times more likely than non-Indigenous children to die from the use of pesticide poisoning (FAO, 2022b), and people of color, in general, face disproportionate risks of pesticide exposure (Donley and Bullard, 2022).

Although new paradigms, technologies, and approaches have been promoted over the years as a means to improve food security, reduce environmental impacts, and increase social inclusion, the extent to which these are successful remains contested (Patel, 2012; Sumberg and Woodhouse, 2013; Martinez-Cruz, 2020). In some instances, new technologies or approaches are proposed, e.g. conservation tillage, conservation agriculture, or sustainable intensification (Anderson and Giller, 2012; Martinez-Cruz, 2019), and in others there are broad promises of a new Green Revolution that will be greener or more sustainable, such as the African Green Revolution or the Sustainable Modernization of the Traditional Agriculture program in Mexico. A special focus for many of these approaches is converting rainfed agriculture to intensive crop producing lands, as 80% of the agriculture is still rainfed, and we could produce twice as much food as we need if all rainfed lands were converted to irrigation.

Yet, these paradigms have not been sufficient in addressing the two problems of food security and food sustainability, and the need to change business as usual is imperative. The productivity-oriented paradigm, with its narrow focus on productional maximization to the exclusion of other values of a good system, has left out many other actors and their actual and potential contributions. It operates on a logic in which a few fit and others are left out, denying their agency and contributions to food security and climate change. For example, Fox and Height (2010) show how, in Mexico, the government has subsidized inequality through food policy because it has designed a bimodal food policy, in which one type of farmer, the big industrial farmers that have the potential to fit the productivity approach, can benefit and have access to subsidies and potentially contribute to food security issues. The rest of farmers, small-holder peasants and Indigenous Peoples, are seen as passive people, not actors, who cannot contribute to the food security issues and, therefore, should be supported through social development programs. This dichotomy, which would be expected push farmers toward industrialization in order to access government subsidies, emphasizes a curious reality. Despite many decades of a bimodal policy, many peasants and Indigenous Peoples are choosing to self-exclude or remain at the boundaries of such a system, and are protecting their native seeds, food and knowledge systems that continue to be essential for their livelihoods and survival.

In this paper, we want to argue that Indigenous Peoples, who are retaining time-tested technologies, knowledge, and science, which has made them resilient and champions of adaption, despite systemic and institutionalized discrimination, have a lot contribute to food security. Yet if we are to collectively benefit from their technologies, knowledge, and science, they need to be supported in many different ways. This process begins with recognizing Indigenous Peoples and rights- and knowledge-holders.

4. Indigenous Peoples as rights-holders and knowledge-holders that can support food systems transformation

While the multiple challenges to our goal of ensuring stable and sustainable food systems may seem overwhelming, we believe that Indigenous Peoples' knowledge and food systems offers essential direction for a positive transformation of our food systems. We can learn from some of the oldest and most sustainable food and knowledge systems in the world. We can learn from the food systems developed by Indigenous Peoples, who despite facing multiple challenges over centuries and ongoing discrimination and marginalization, has proven to be innovators, champions of adaptation and protectors of the planet's remaining biodiversity.

There are 476 million Indigenous Peoples, inhabiting more than 90 countries on less than 28% of the world's land surface (Sovrevila, 2008), distributed across seven socio-cultural regions[2] (ILO, 2019) They speak 4,000

[2] The seven Indigenous Peoples' sociocultural regions were determined following broad consultations with Indigenous Peoples during the process to establish the United Nations Permanent Forum on Indigenous Issues, a subsidiary body of the United Nations Economic and Social Council established by its resolution 2000/22. There is no definition of these regions stating which Member States belong to which region as the lands of Indigenous Peoples pre-date modern states and their geopolitical limits. The

of the 6,000 existing languages. Despite representing less than 6% of the world's population, they are the guardians of 80% of its remaining biodiversity (Sovrevila, 2008).

Indigenous Peoples have adapted to a broad range of conditions, from the cold lands of Siberia to the arid lands of the Mixtec region in Mexico (Martinez-Cruz et al., 2024), and in all of the locations they inhabit, they have innovated and developed food systems which provide healthy, stable, and sustainable sustenance. Although Indigenous Peoples have been shown to be crucial for global resilience, current dominant agricultural practices and policies, such as monocropping or those linked to the productivity paradigm, are displacing Indigenous Peoples' food systems and causing environmental damage and loss of biodiversity (Jacques et al., 2012). These harmful and displacing policies are destroying native biodiversity, such as the case of the native bees in the Mayan Indigenous regions of Mexico (Vides-Borrell et al., 2019), and are also destroying the lives of Indigenous Peoples themselves, as suggested in earlier sections on the effects of toxics and pesticides on Indigenous children.

In this section, we will describe critical features of Indigenous Peoples' food systems from a rights-based perspective on Indigenous Peoples' food and knowledge systems.

4.1 Indigenous Peoples' food systems are diverse, nutritious and sustainable

While mainstream policy and research have focused on monocropping and agricultural intensification as methods to address food insecurity, this approach has ignored many other food systems and knowledge systems because experts have failed to understand the potential of these systems (Martinez-Cruz, 2022). For example, in 2012, one of the authors was part of a project in Mexico that aimed to increase maize and wheat production using sustainable technologies, which assumed that the project would lead to more food security and improve the livelihoods of farmers. According to the logic of the program, both big farmers who used monocropping and irrigation technologies and also smallholder Indigenous farmers would be included and would benefit from the program; however, as the experts

seven regions are determined so as to give broad representation to the world's Indigenous Peoples and these seven regions are: 1) Africa; 2) Asia; 3) Central and South America, and the Caribbean; 4) the Arctic; 5) Central and Eastern Europe, the Russian Federation, Central Asia and Transcaucasia; 6) North America; 7) the Pacific (EMRIP, 2016).

learned when visited an Indigenous community in the state of Chiapas, their approach to achieving food security needed to be changed.

> *Scientist 1: Why do farmers use such low planting densities? Why do they plant maize every 2 meters? If we aim to increase crop yields as part of the MasAgro Program, the answer is easy: change the planting density and change the maize varieties.*
> *Scientist 2: Because it is a milpa, our method of intercropping to provide our needs.*
> *Hours later, at the end of the day…*
> *Scientist 1: A milpa, now I get it. A farmer needs potatoes, pumpkin, squash, beans, and other things he uses throughout the year. I also see that they keep their seed from one cropping cycle to the other, so they do not need to buy seeds.*
> (Adapted from Martinez-Cruz, 2020, p. 21).

At the end of the field visit, the scientist, who did not know what a milpa system (intercropping of maize, beans, squash, among other crops depending on the region where it is implemented) was, understood that simplifying the issue of food security to just one crop such as maize did not make sense for Indigenous Peoples in this region, as they required more than just maize for their diets. And why would they choose to become less self-sufficient? This example portrays a common issue in agricultural and food research and policy, where it neglects the richness of Indigenous Peoples' food systems, to the detriment of finding solutions to the many challenges.

Indigenous Peoples have a deep knowledge of their territories, which has allowed them to adapt to a broad range of environments, even to lands that many call hostile and in which many of the technologies of the Green Revolution, for example, could not fare well, given that they did not meet the ideal conditions of fertilization, irrigation, and climate that most of these technologies and approaches require. This ability to adapt and learn about the cycles of their territories is what has allowed Indigenous Peoples to know what to harvest, gather, fish, or hunt according to the seasonality of their territories, how to protect the land's sustainability, and how to rely on diverse foods. For example, according to FAO and Biodiversity International (2021), Indigenous Peoples' food systems can contain over 250 edible and medicinal plants which are collectively used for health and sustenance as compared to the main three crops that most of the world uses for 50% of its caloric intake.

Indigenous Peoples' food systems are nutritious; which is something also often neglected by mainstream science. Indeed, more research is needed to understand the nutritious role of the foods in Indigenous Peoples' food systems, and, most importantly, to respect the cultural adequacy or preference of Indigenous Peoples when designing nutrition interventions. For example, in the Solomon Islands, a study by FAO (2021) reported that Indigenous Peoples' food systems contain 238 foods, including 127 different species, and the *banana fe'i* which they eat are much richer in vitamin A than a conventional banana from the supermarket. Another example is how Indigenous Peoples in the Arctic get diets rich in Vitamin D from what they hunt or fish (Kuhnlein 2018), a critical nutrient for people who often face days with very few hours of sunlight. As another example, during the colonization of the Americas, maize was recognized by the colonizers as a very useful crop which could be the basis of a food system and grew relatively easily, and they brought it to Africa. However, the assumption that merely eating maize would reproduce the nutritious diet among Africans as among the Indigenous Peoples of America turned out to be incorrect. The nutritional value was not only about eating maize itself but also the more than 600 ways to cook it and combine it with other foods and crops as practiced by Indigenous Peoples of the Americas (El Poder del consumidor, 2017). For this reason and others, its adoption in Africa did not yield the expected nutritious outcomes.

4.2 Indigenous Peoples' knowledge and food systems are based on time-tested science and knowledge

One common misconception about agricultural research and development, as well as food policy, is that Indigenous Peoples have nothing to contribute, especially when it comes to knowledge creation and science. Despite the growing recognition of their role in conserving biodiversity, Indigenous Peoples are constantly required to prove that their knowledge systems and values are relevant to addressing the multiple crises we face, including food security.

Yet, Indigenous Peoples' food systems may hold the key to a sustainable transformation of our food systems. For example, some studies show how milpa systems (an intercropping system that relies on native maize beans and squash, among other crops depending on the region) support nutritious diets and are more sustainable from an ecological perspective. Lopez Ridaura (2021) found that farmers in Guatemala prefer milpa systems over maize monocropping because milpa provides them with a more diverse and nutritious diet. They show how milpa systems perform better than maize monocropping on the Potential Nutrient Adequacy (PNA) index, used to evaluate the recommended nutritional intake for a person per day. From an ecological perspective, intercropping systems can also help to compensate for the nitrogen needs of the system in a sustainable and healthy way. This argument about the benefits of intercropping for nitrogen supports the three sisters model: maize can be used to provide structural support to bean plants, beans fix nitrogen which can be used by other plants, and squash is used to reduce erosion.

According to Martinez-Cruz and Rosado-May (2024), generally, experts in mainstream research and development assume that Indigenous Peoples work on 'trial and error' basis to develop knowledge. However, this does not explain nor do justice to the complexity of Indigenous Peoples' ways of producing knowledge. Some researchers have tried to explain some of the processes they see in Indigenous Peoples' food and knowledge systems, in a way trying to validate Indigenous Peoples' knowledge in their own language and systems of knowledge development. According to Camacho-Villa et al. (2020), it would make more sense to treat Indigenous Peoples' knowledge as a system of knowledge to itself which can be used to address justice, epistemic violence, and appreciate Indigenous Peoples' systems and contributions. Instead of seeking to validate their knowledge through a different prism, we should instead recognize it for its own value to add knowledge which can be used not only as source material to bring into the science systems that we are familiar with, but as a knowledge system which can itself inform how we develop knowledge systems, which will be discussed at more length in the next section. It is therefore essential to open more discussions to create avenues for common understanding among different knowledge systems and acknowledge Indigenous Peoples as innovators in the past and present (Martinez-Cruz et al., forthcoming) and that Indigenous Peoples have contributed a great deal to the advancement of society (for example, through pharmaceutical discoveries and other knowledge that have revolutionized what we commonly call science; PAS and PASS, 2024).

4.3 Indigenous Peoples' food and knowledge systems are holistic, linked to their cosmogony, and surrounded by relational values

Indigenous Peoples' knowledge and food systems are amongst the oldest ones still surviving today. One reason these systems have persisted is that they are tied to Indigenous Peoples' cosmogonies, beliefs, and values that cannot be commodified or valued in conventional ways, i.e., cost-evaluation models that seek to create a numeric value of costs and benefits of any system, as has been shown in the case of water by Martinez-Cruz et al. (2024). For example, when scholars debate how native maize systems in Mexico survived decades of policies trying to replace them with intensive monocropping systems, they agree that cultural identity, cosmogony, and sovereignty played an important role in protecting the native maize systems (Fitting 2011 and Mullaney, 2014).

Indigenous Peoples take a holistic view on life and their role in the world. As a result, they reject a perspective in the world focused on benefiting only themselves, and instead retain a holistic appreciation for the entire system. For example, in Yucatan, a young Mayan man places his beehives near his milpa system, so if fruit trees do not flower on time, the bees can feed themselves from the milpa flowers. He explains that bees are an important part of his system, thus, ensuring they are okay will not only protect the bees but also support other ways of income from the honey he harvests from them (Martinez-Cruz and Rosado-May 2022). For the Zapotecan people of Oaxaca, looking after their forest, even when they do not seek immediate benefit from it, ensures that there will be water available for their milpa systems and, therefore, food for them (Martinez-Cruz et al., forthcoming).

For the Ëyuujk people of Oaxaca, native maize is sacred and is used for the spiritual guidance of the community; thus, ensuring these seeds are maintained through the generations is essential to keep the culture and identity of the community alive (one of the authors is Ëyuujk), and many foods and rituals involve maize dough figures that have important meanings in the lives of the Ëyuujk people.

Therefore, due to Indigenous Peoples' holistic understanding of their place in the world, in nature, and in their cosmology, Indigenous Peoples' food and knowledge systems cannot be described in conventional value systems or reduced to a mathematical equation, but must be appreciated in their holistic completeness, which appreciates the complexity of the environment and the interplay between humans and all other life.

4.4 Indigenous Peoples' food systems reduce waste, promote circularity, and adapt as seasons unfold

Another critical element of Indigenous Peoples' food and knowledge systems is how they promote circularity and reduce waste. For example, Martinez-Cruz and Rosado May (2022) explain how, during rituals, the different elements used for the offerings and rituals can be turned into different plates and dishes for the next week. This richness in turning every single component involved in the ritual into something else reduces waste. Even the elements that are not used for humans are turned into food for animals or composting that returns to nature. In the same paper, the authors show the richness of Indigenous Peoples in how they find food where others see empty fields; this is true of the Mirliton squash, or chayote, that Ëyuujk people dig out when all the milpa fields are empty, and when many others would not expect to find roots that can feed them in the dry season.

4.5 Indigenous Peoples' food, knowledge and value systems are essential for resilience and food security

As we have explained in the earlier sections, one of the common misconceptions is that Indigenous Peoples' food systems are incapable of providing food security. However, some instances prove otherwise.

> *"50 years ago, I remember that several events like rains and pests hit my town badly. However, my parents and grandparents back then, had many fields cropped, they had lots of maize, beans and crops. Thus, we did not feel it at all, we would manage to survive. All was different in 2010 when we were hit by a hurricane and strong rains blocked the entry to the mountains, and the stores run out from maize and food. We did not have food and the only solution we found was to go upper to the mountains to get maize from other Indigenous Peoples that were farming more than us. I was ashamed then, how come I could call myself a farmer if I could not cultivate what I needed to feed my family? I wondered how I let this situation happen and how come as a child I never faced a situation like this?"*
> (Susana, Interview 2016, retrieved from Martinez-Cruz et al., forthcoming).

Martinez-Cruz et al. (forthcoming) show in an ethnographic work how food policy affected Indigenous Peoples in a Zapotecan Indigenous community in Oaxaca. The Indigenous woman from the quotation above explains how when she was a child, they had several extreme weather events strike her community, yet the fact that they had several fields planted at different locations and with different characteristics made them resilient. If one of the fields failed due to strong winds, flooding, or pests, they had other fields that ensured their food security. However, as time passed, migration became a central part of these Indigenous Peoples' livelihoods. Many of the migrations were reinforced by the bimodal food policy in Mexico which assumed that Indigenous Peoples were better laborers than farmers. Thus, as time passed, Zapotecan families reduced their farming; they continued farming native maize for specific rituals and festivities, but no longer considered being self-sufficient to be a priority as they could buy maize cheaply from government stores. In 2010, their region was hit hard by Hurricane Matthew, and despite the fact they had money, they could not buy maize to feed their families. It was a combination of blocked roads, the boom of biofuels, the tortilla crisis in Mexico due to climate change, and a shortage of maize importations, that left these families without access to maize to feed themselves. These farmers did not forget the lesson from this incident and decided to restore their traditional milpas and adjust them to their current livelihood patterns through participatory native maize breeding, irrigation, organic fertilizers, and changing crop topologies, among others. Five years later, these Zapotecan farmers had tripled their milpa production and were self-sufficient again. When COVID-19 hit them in 2020, despite their decision to lock down their community and prevent outside people with possible infections from entering, they did not find themselves lacking food. They were once again able to supply themselves with the milpa and foods they needed and which they produced locally.

In support of this community's story of self-sufficiency, during COVID-19, the World Bank surveyed 17 Indigenous communities, and 70% reported accessing food either through self-production or exchanges with other communities. Of these, five reported no food shortages or hunger at all in 2020 (Cord and Pizarro, 2021).

One of the other specific elements that make Indigenous Peoples resilient are their values such as collectiveness. The social organization of the communities also ensures that actions are taken not only to preserve the natural resources and entities living within territories but also to ensure the welfare of everyone in the community, ensuring that no one is left behind. Similar to the community mentioned above, several Indigenous communities performed collective lockdowns, and as they did, they ensured that everyone was cared for (Martinez-Cruz et al., 2020b).

The holistic perspective that makes Indigenous Peoples' communities and food systems so resilient is sorely lacking in the commercialized and production-centered dominant narratives on food systems. Yet, it is this holistic perspective that enables Indigenous Peoples to engage in sustainable and stable practices which respect local environments, and can provide nutritious, diverse, and resilient food sources.

5. Indigenous Peoples and their right to food

5.1 The right to food, food security, and food sovereignty: key definitions

When we discuss food security, we rarely mention the right to food. However, both concepts exist, and the questions remains as to what the difference is between these concepts, and why they are relevant for the discussion here.

The right to food is recognized by international human rights law, and the Universal Declaration of Human Rights (UNHR) notes, in the context of an adequate standard of living, that: "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, ..." (art. 25; UN General Assembly, 1948).

The right to food, according to the UN Special Rapporteur on the Right to Food, is the '*right to have regular, permanent and free access, either directly or by means of financial purchases, to quantitatively and qualitatively adequate and sufficient food corresponding to the cultural traditions of the people to which the consumer belongs, and which ensures a physical and mental, individual and collective, fulfilling and dignified life free of fear*' (UNHRC, 2010). This means that the right to food is inclusive; it is not about providing a minimum ration of calories or nutrients. Instead, it focuses on providing a person with the nutritional elements required to have a healthy and active life and ensuring they can access these foods.

The right to food recognizes three critical dimensions, and they are not exclusionary: availability (whether it is produced or generated directly or obtained through other means such as buying in the market, shops, barter, etc.), accessibility (meaning it should be accessible physically and economically without compromising different basic needs), and adequacy (satisfying individual's needs which can depend on age, living conditions, cultural needs, among others).

In food and agricultural research, development, and policy, there are several misconceptions about the right to food, food security, and food sovereignty that are summarized in Table 1.

Food security focuses on people's access to food without considering the implications of the origin or source of that food. Food sovereignty, on the other hand, emphasizes that people should have control over what they eat and how they get what they eat. The second positioning assumes that a level of control might reduce hunger issues (Fakhri, 2019).

While this paper mainly addressed food security within its narrative, this was a deliberate choice, as this term is widely used in mainstream policy and agricultural research and development. Rather than aligning with the concept of food sovereignty, we will, from now on, include the right to food to elaborate on some of the discussion elements that come forward in this paper.

Table 1. Some misconceptions on the right to food.

The right to food is not the same as the right to being fed • The right to food indicates that it is not only about getting access to food but the ability to feed oneself with dignity; this means that while governments play a supporting role in ensuring that everyone has access to food, it is the right of a person to be able to produce it, buy it, or obtain it in another manner but with dignity. This also means that if a person requires land, water or other resources to generate his own food, these conditions should be provided. The role of the government then is as enabler. In areas in conflict or where these conditions cannot be easily met, the state should provide food.	**The right to food is different from food security and food sovereignty** • The right to food is not the same as food security or food sovereignty, even though they are interconnected. The right to food is a right recognized under international law, e.g., the UN Declaration of Human Rights, while food security is a pre-condition to the right to food. As FAO defines it, 'when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. In the same way, food sovereignty provides an alternative way to sustainably fulfil the right to food and recognizes asymmetries in power in guaranteeing the right to food. Both food security and sovereignty are ways to achieve the right to food, but neither are universal; instead, some national regulations recognize one or both.2
The denial of the right to food is not the result of the lack of food • One of the common misconceptions is that food insecurity or the inability to ensure the right to food is linked to a problem of 'availability' or, in other words, that there is not enough food. The problem goes beyond availability, and it is linked to distribution, causing some marginalized groups to not get access to food, e.g. climate change-displaced populations. It also entails a dimension of adequacy because one of the conditions of the right to food is that it fits people's cultural preferences and contexts.	**The right to adequate food is not the same as the right to safe food** • The right to adequate food refers to the idea of adequacy, food being nutritious, suitable for the person's physical, cultural and socio-economic conditions. • The right to safe food entails a 'safety' dimension, e.g., that food is free from chemicals, bacteria or contamination. This might refer, for example, to areas where food is produced with high levels of polluted water with chemicals or wastewater, as it will be presented later in this document.

5.2 The need to create adequate diets that are culturally adequate

An often-ignored dimension in food policy and research is the adequacy of diets in accordance with the right to food, food sovereignty, and security. While these three indicate that food must be culturally appropriate and adequate, this is not often the case when interventions are externally planned, and Indigenous Peoples' food systems are often seen as unimportant or inferior.

> *"One day, I was invited to meet the minister of social development of my country, so I thought I could get her some lovely presents. I decided to take her Suri, a worm that we eat in my region. As I gave the present to her, she screamed, and she told me, 'What do you want me to do with them?' I told her, 'This is how we feel when you get us food that we do not like. Imagine, they bring food to our children that is not healthy, and they do not like it, through School Meals Programs'"* (Awajun leader 2022, Personal Interview).

The displacement of diets has occurred for centuries since the times of colonization, and it has been reinforced by current dominant policies, causing effects on Peoples' cultures and identities, health issues, and even worse, violating a fundamental right as the right to food. As indicated by the Awajun leader in the quote above, Indigenous Peoples wish to have adequate diets that respect their food preferences, are culturally sensitive, and are conscious of the negative effects of other diets on their well-being. Kuhnlein (2018) has documented how displacement of diets negatively affects and has affected Indigenous Peoples' health; this displacement is usually driven by insensitive and culturally inappropriate policies, migration, assimilation processes, low incomes or forced displacement of Indigenous Peoples, among others. For example, in a study conducted in Canada, with Inuit people, younger generations present diseases that older generations do not have due to diet changes (Kuhnlein, 2009), also signalling that Indigenous Peoples that are living closer or in their communities can have better access to healthier and adequate diets. In another study, bison-reliant Indigenous Peoples from the US who were forced to transition to non-Indigenous diets following the mass slaughter of the American Bison had 10% higher infant mortality rates and lost nearly three centimeters of average height (Feir, Gillezeau, & Jones, 2024).

An assessment study performed by Pero et al. (2023) indicates that 30% of food in School Meals Programs gets wasted. However, they show how designing culturally appropriate diets can reduce waste and better support the program's goals. If Indigenous children do not consume the food, the issues of infant malnutrition or stunting will not be overcome.

6. Indigenous Peoples as Right and Knowledge Holders: innovation and self-determination are keys to a resilient planet

6.1 Indigenous Peoples are right holders, not an adjective[3]

Despite the growing importance and recognition of Indigenous Peoples' knowledge and food systems to tackle global challenges, popular dialogue on Indigenous Peoples still tends to treat Indigenous as an adjective, using terms such as 'traditional Indigenous knowledge, Indigenous knowledge, Indigenous languages, Indigenous lands'. This language and this narrative is a problem as it sidesteps the question of rights held by Indigenous Peoples. By using 'Indigenous' as a descriptor of knowledge or a food system, we erase the Indigenous Peoples who create and own that knowledge. On an even more worrying note, several researchers working on Indigenous Peoples' issues might not be aware of a declaration of Indigenous Peoples' rights or even understand the nature of the struggle and why 'naming us' using an adjective becomes problematic.

For example, in my case, I self-identify as an Ëyuujk woman before I identify as Mexican. Acknowledging us as Indigenous Peoples is also acknowledging that we come from distinct and unique nations, in a way, recognizing that modern states were, in most instances, built as a layer that overlaps with our internal lands; this is why we also have many Indigenous Peoples that live in transnational borders, forcing them to deal with different national or local legislations.

The UN Permanent Forum on Indigenous Issues has recommended the use of Indigenous Peoples as terminology to acknowledge that we are rights-holders, and these rights are also recognized in the ILO (International Labor Organization and Tribal Peoples) Indigenous and Tribal Convention 169 (ILO, 1989), to mention a few. We should not forget that the fight for rights is an important one that Indigenous peoples lead and has had success; for example, several countries have recognized and even set policies to support Indigenous Peoples' rights. However, in both countries recognizing and not recognizing Indigenous Peoples' rights, violations of Indigenous Peoples' rights continue. Thus, as academics or policymakers,

[3] This section is written by the Indigenous author and therefore, the narrative here will be in first person.

we should also learn to educate ourselves on basic frameworks and understand why specific terminology is necessary, engage in conversations that help us improve our understanding, and, through this, support more meaningful processes.

Using Indigenous as an adjective is denying our cultures, diversity, and uniqueness. In the examples referred to in the previous sections, we referred to a broad range of food and knowledge systems, from the ones of the Ëyuujk people in Oaxaca to the Indigenous Peoples in the Arctic, Awajun in the Amazon, or other regions. Naming these systems or cultures as distinctive is relevant because 'Indigenous' alone cannot enclose the richness of these different and unique cultures nor respect their right to self-determination.

More importantly, recognizing Indigenous Peoples as rights-holders also acknowledges their agency, their contributions to policy and science processes, and the fact that they must have a voice and meaningful participation in processes that affect their lives, the right to decide and self-determination.

6.2 Indigenous Peoples are knowledge holders whose languages do not die, 'they are killed.'

We cannot discuss Indigenous Peoples' knowledge without discussing Indigenous Peoples' languages in which that knowledge and the cosmologies that support it are maintained. Thus, it is worrying to hear about the death of Indigenous Peoples' languages.

But this is another problem. Despite many statements about Indigenous Peoples languages dying, especially now that the UN is running the International Decade on Indigenous Languages, there is something crucial to remember: languages do not die, it is Indigenous Peoples who die or whose livelihoods are affected or rights violated, causing the disappearance of a language.

We have argued that Indigenous Peoples' knowledge is essential for Indigenous Peoples' resilience, as their languages are the means through which Indigenous Peoples' knowledge can be shared and enriched. Indigenous Peoples speak 4,000 out of the 7,000 thousand languages in the world, and some researchers have shown the importance of linguistic diversity and their relationship with biodiversity. For example, Gorenflo et al. (2011) indicate that there is a positive association between linguistic diversity and biological diversity and that 70% of the languages spoken in the world cover 24% of the world's surface, and these regions are known as the most biologically diverse.

While the UN Decade of Indigenous Languages should be celebrated for recognizing the role of Indigenous Peoples' languages for their right to self-determination, it is also essential to recognize and address why these languages are being killed, for example the education systems that force assimilation, systemic discrimination and racism, the ongoing effects of colonization, land grabbing and forced displacement, not recognizing the role of Indigenous Peoples' knowledge in policy or their potential contributions to global challenges, among others (Martinez-Cruz, 2022).

6.3 Respecting Indigenous Peoples' tenure rights and Free, Prior and Informed Consent

I like to think of land and territory as a bubble that is interconnected and that allows Indigenous Peoples to keep their languages, plants, water, sacred places, identity, and social ties, among other things. As we take care of the land, we also know that the land takes care of us. Our knowledge systems are often maintained through practices, and what has made us the champions of adaptation is precisely getting to know the seasonality of our lands, the deep knowledge of the processes in them, and our connection to them.

For the Ëyuujk People, land is a crucial element of our cosmovision; we are known as the 'never conquered people', and part of the narrative in our community links to how nature and sacred elements have always come to defend us in the face of conflict or potential displacement or submission during colonization. Similarly to the Ëyuujk peoples, the Awajun or Zapotecan peoples also have stories about land and life working to protect humans and mother nature (Martinez-Cruz et al., 2024 and Martinez-Cruz, forthcoming).

Indigenous Peoples continue to struggle to protect their rights, having established several mechanisms that recognize their rights. Yet, even when some countries have ratified these mechanisms and have even implemented policies on Indigenous Peoples at national levels, this has not been sufficient, as Indigenous Peoples' rights continue to be violated in the name of development and even in the name of green transitions or just transitions. The UNDRIP and Convention ILO 169 indicate that Indigenous Peoples should be consulted and that they have the right to Free, Prior, and Informed Consent (FPIC; not only consultation), yet their rights continue to be subject to violation, and in some fields, these rights are not yet even considered.

Tens of millions of Indigenous Peoples have been displaced in the name of development-caused armed conflict and forced migration. In 2021, 358 land and environmental defenders were killed in 35 countries, with one-third being Indigenous Peoples defending their territories, forests and rivers against climate-destructive industries (Global Witness, 2021), and 75% of these land defenders were killed in Central and South America (ibid.). There are estimates that there were more than 200 killings of land and environmental defenders in 2022 (Global Witness, 2022). Furthermore, there is no precise data on how many have been imprisoned for defending their land and natural resources.

6.4 Free, Prior and Informed Consent and the right to food

Generally, it is easier to acknowledge consultation and FPIC when there is something tangible, such as a road, a dam, or a forest to be cleared. However, on issues such as education, the right to food, and the right to linguistic diversity, FPIC has become a grey area. When a food program or policy is implemented, consultations are rarely conducted, and therefore, a violation of FPIC and the rights of Indigenous Peoples occurs. In some instances, FPIC has been violated in agricultural programs; yet FPIC and the right to self-determination have also become tools to fight back against these policies that affect Indigenous Peoples. This is the case with the Mayan beekeepers who fought against permission granted to Monsanto to cultivate transgenic soy and won the battle. The cultivation of transgenic soy and associated practices was causing adverse effects on Mayan peoples' health, their bees, and the environment (Torres-Mazuera and Ramirez-Espinoza, 2022), and the people fought back using legal frameworks based on their right to self-determination and the right to a healthy environment.

In an ideal world, rather than relying on the courts and lawsuits, Indigenous Peoples should be consulted on the best way to fulfill their right to food and not have to fight back against the adverse effects after many policies or projects have been implemented because, as it has been seen, attempts to increase food security through displacement of diets or not policies without a culturally sensitive approach, can lead to unintended harmful consequences and end up causing more problems to Indigenous Peoples.

7. Some final remarks to transform food systems and include Indigenous Peoples in a meaningful way

We have analyzed why the current food systems need a transformation and what Indigenous Peoples can bring to the table. Here, we offer a summary of recommendations on how we can support Indigenous Peoples as we learn to create a transformed, stable, and sustainable food system.

a) *Emphasizing the right to food more than food security/sovereignty, ensuring FPIC for Indigenous Peoples, and setting guidelines for all the institutions dealing with food security and related issues.*

Shifting the conversation to the right to food and ensuring Indigenous Peoples' right to food means meaningfully including them in food systems and food policy processes. While FPIC is not a common practice in food systems, it is recommended that food-related institutions have protocols or guidelines on how to work with Indigenous Peoples and respect their right to food and self-determination. This recommendation is applicable to the ONE CGIAR, one of the biggest consortiums on food security and policy, as well as to their member organizations and donors, such as the Rockefeller Foundation and Bill and Melinda Gates, among others. Also, at the national level, if states do not have safeguards that know how to address food security in accordance with the right to food, they should create guidelines that allow them to respect Indigenous Peoples' rights.

b) *Investing in Indigenous Peoples' food and knowledge systems to promote innovation and ensuring these resources are allocated to Indigenous Peoples directly*

Policy and research processes, in general, have failed to embrace and include Indigenous Peoples in a meaningful way, in some instances because they have failed to understand the complexity of Indigenous Peoples' knowledge systems (Martinez-Cruz, 2022 and Martinez-Cruz et al, 2024) and livelihoods. For example, von Braun and Martinez-Cruz (2023) indicate that on the national pathways developed as part of the United Nations Food Systems Summit, among the 118 countries that submitted one, only 36% mentioned Indigenous Peoples. While this is an accomplishment, though falling woefully short of what is required, even here, it still remains to be seen how these pathways will actually work with Indigenous Peoples. As we analyzed in this paper, food policy in Mexico and other regions has denied Indigenous Peoples the opportunity to develop their food systems fully. It would be interesting to see if and how the 36% of countries committed through national pathways to support Indigenous Peoples truly support Indigenous Peoples' food systems.

Similarly, some suggest that despite money being allocated to Indigenous Peoples for Climate Action, only 2% of these funds actually reach Indigenous Peoples. Thus, mechanisms should be set in place to ensure that these resources truly directly support Indigenous Peoples.[4]

[4] https://news.mongabay.com/2023/12/despite-progress-small-share-of-climate-pledge-went-to-indigenous-groups-report/

a) *Supporting Indigenous Peoples' food systems research and Indigenous-led research*

Many gaps still need to be addressed in terms of the contributions of Indigenous Peoples to food systems transformation. However, this research, to be more in line with ethical guidelines and accordance with the right to self-determination, should be led by Indigenous Peoples. An example of a successful project and model for this is the Arramat Project[5] in which all the principal investigators are Indigenous and connected directly to Indigenous communities. This project, besides addressing climate change, loss of biodiversity and planetary health, also seeks to contribute to social justice, healing and reconciliation processes in countries where the project is being implemented.

b) *Investing in School Meals Programs that support Indigenous Peoples food systems*

School Meals are one of the oldest approaches to reduce food insecurity. However, as presented earlier, when adequacy is not considered in the equation, food is wasted, and therefore, the goals of the program are not achieved. Pero et al. (2023), through the experiences of Colombia and Brazil, show that it is possible to achieve the goals of supporting the nutrition and development of children while also respecting their right to food, reducing waste and logistics costs, and even better, supporting the local economy of Indigenous Peoples' and ownership of the process when the government buys food locally and invests in technology and innovation to improve Indigenous Peoples' food systems. This approach also helps reduce the impact of climate change. More such projects should be implemented in other regions of the world.

c) *Supporting financial Indigenous Peoples in situations of displacement*

Most of the research and work done is with settled Indigenous Peoples, but little has been done on Indigenous Peoples who have been forcibly displaced. The lessons and work to be done with displaced communities is crucial for justice and for an increasingly unstable world and multiple conflicts.

d) *Directing climate change funding to all Indigenous Peoples, not only in rainforest areas*

With the pledge of COP26 at Glasgow, growing attention has been given to rainforest areas. However, Indigenous Peoples are distributed in more than 90 countries and throughout seven regions. Many of these regions

[5] https://arramatproject.org/

are facing alarming desertification rates, and they should also be targeted, as they are also a key element of the world's sustainability. The planet is a single cohesive and holistic entity, and if we silo our support to individual regions, we cannot protect life, sustainability, and biodiversity anywhere.

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The Future of Food is Ancestral: Mesoamerican Plant-Centred Food Traditions as Climate Solutions

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I grew up listening to stories about the plants that grow in the tropical desert of Puebla, Mexico, home to a variety of indigenous communities – the *nahuas*, the *mixtecas*, the *totonacas* and the *ngiwas* – that I descend from. My grandfather says that when he was a child all that they ate were greens from the hills, seeds from the crops; that growing up he used to think that they were very poor for eating just that, since wealthy people in the city used to eat meat every day. But it is now that, strong and healthy at his 91 years of age, he has realized that what they ate was the best we could ever eat.

The experience of my grandfather, what he was influenced to believe, is not exclusive to our community or cultural region, it is shared across Mesoamerica and there are even records of chronicles where undervaluation narratives of indigenous food systems were being imposed during the colonization of Latin America. Even in the times of New Granada, present-day Colombia, indigenous peoples were told by the colonizers that the food they used to eat was non-nutritious, non-sustaining, worthless, inappropriate and even disgusting.[1]

This was part of the broader western intention to colonize not only our lands, but also our minds and our bodies. Food was one of the mechanisms used to force colonization, alongside religion and politics. This colonial intention, rooted in the ignorance of the nutrients, symbolism and knowledge behind the consumption of roots, weeds and insects, is however a historical testament of how food systems are vital for the recreation and transmission of a worldview, a system change and a cultural behaviour. Vandana Shiva has stated it already: those who control food, control life on earth.[2]

[1] Otte, *Cartas privadas de emigrantes a Indias*, p. 294; FDHNRG, tomo VIII, p. 155; Vargas Machuca, Milicia y descripción de las Indias, p. 24 in Saldarriaga, Gregorio. *Alimentación e identidades en el Nuevo Reino de Granada, siglos XVI y XVII: Segunda edición corregida y mejorada*. Editorial Universidad del Rosario, 2011.

[2] The seeds of Vandana Shiva, documentary https://vandanashivamovie.com/wp-content/uploads/2021/07/TSOVS-One-Sheet-Digital.pdf

Scientists say now that the *milpa* is the base of Mesoamerican civilizations, not only as crop but as a way of life, because it is through food that we conceive the world, that we share knowledge, that we reproduce life. As our elders tell stories, pass on recipes, teach gathering and sowing traditions, we indigenous peoples are the guardians of this vital knowledge that relies on ecological diversity, complementarities, reciprocity and symbiosis between the plant species that compose these ancestral food systems.

From our oral tradition, from the stories of the elders, but also from archaeological science, we know that in Mesoamerica the plant-rich diet was the one that gave health to our communities and to our territories. Plant-centered diets have been at the core of indigenous Mesoamerican civilizations for over 10,600 years.[3] Since pre-ceramic times, traditions of health and nutrition were centered on seeds, weeds, roots and mushrooms as major components of the traditional diet.

More than 20 years ago, Pimentel acknowledged that food production systems would be more sustainable by reducing the consumption of meat and dairy products, and including more vegetable species in overall diets.[4] Our communities have known and lived a plant-centred diet, centuries ago. In the Mesoamerican regions, the main dishes were made out of gathered leaves, flowers, roots, mushrooms, weeds (that we call *quelites, alaches)*, and even the edible cactus (*nopales*, *tetechas*, *palmitos*) that grow wild on the hills, but that have also been domesticated to be included in the traditional crops. These nutritious plants have been made into a variety of dishes, soups and drinks for generations. Together, the consumption of beans, vegetables, fruits, chili peppers and *nixtamal* (the nutritional enhancement process of corn to make tortillas) can constitute a complete, satisfactory diet, without animal proteins.

Mexico is home to the glorious and advanced pre-Hispanic Mesoamerican world. Paradoxically, today it is displaying the highest mortality rates due to diabetes, due to the active promotion of the Western diet (based on meat and highly processed foods that require large agricultural areas, great

[3] Zizumbo-Villarreal, Daniel, Alondra Flores-Silva, and Patricia Colunga-García Marín. "The Archaic Diet in Mesoamerica: Incentive for Milpa Development and Species Domestication". *Economic Botany* 66, no. 4 (2012): 328-43. http://www.jstor.org/stable/23325647

[4] David Pimentel, Marcia Pimentel, Sustainability of meat-based and plant-based diets and the environment, *The American Journal of Clinical Nutrition*, Volume 78, Issue 3, 2003, https://www.sciencedirect.com/science/article/pii/S0002916522033706

quantities of pesticides, and produce large amounts of greenhouse gases).[5] The expansion of industrial animal agriculture is displacing our traditional food, stealing our freshwater and harming our ancestral relations to the territory that has sustained us for generations.

Historically, meat consumption was a marginal complement to the diet, never the core: it was reserved for times of ritual celebrations. It was only with western colonization that food systems were transformed to serve the Spanish commercial system and cultural tendencies.[6] Neglecting indigenous food traditions and identities, they sought to legitimize the civilized foods of the colonizer: meat and bread. Given the different and unknown soil conditions, it was only using large-scale livestock production that they were able to sustain their dominant way of life, where the fundament was to reproduce large-scale animal agriculture as a superior western food practice that allowed the domination and transformation of the "wild and unproductive" land that required to be transformed if it was to be civilized, at the expense of any beings that were previously inhabiting it.

After 1940, this conception of the necessity to transform economically non-productive land originated into a major land use change process led by the state, that converted natural areas to animal agriculture farms that now occupy 60% of the Mexican national territory,[7] being now one of the major drivers of land degradation, ecosystem deforestation, loss of biodiversity and water scarcity. Even today, the continuous support towards this exploitative and extractivist industry continues to be within the agendas of the international finance mechanisms. Only between 2018 and 2021, the Inter-American Development Bank Invest invested ~$500M in factory farming operations across Latin America and the Caribbean after investing just ~$15M in the sector between 2011 and 2017,[8] putting forward a system based on western diets that does not feed people but corporations.

[5] Castillo AM, Alavez V, Castro-Porras L, Martínez Y and Cerritos R (2020) Analysis of the Current Agricultural Production System, Environmental, and Health Indicators: Necessary the Rediscovering of the Pre-hispanic Mesoamerican Diet? *Front. Sustain. Food Syst.* 4:5. doi: 10.3389/fsufs.2020.00005.

[6] Saldarriaga, Gregorio. *Alimentación e identidades en el Nuevo Reino de Granada, siglos XVI y XVII: Segunda edición corregida y mejorada.* Editorial Universidad del Rosario, 2011.

[7] INECOL, La ganadería y la pérdida de la biodiversidad, https://www.inecol.mx/inecol/index.php/es/ct-menu-item-25/ct-menu-item-27/17-ciencia-hoy/845-la-ganaderia-y-la-perdida-de-la-biodiversidad

[8] Stop Financing Factory Farming Coalition, CLIMATE MISALIGNMENT: How Development Bank Investments in Industrial Livestock Are at Odds With Their Paris

Every cent spent on factory farming harms communities like mine. The finance that goes to factory farming is financing the climate crisis and the violation of indigenous peoples' rights. Far from supporting global sustainability and development goals, the international financial structure, the multilateral development banks and private speculation is propping up a failing system and threatening to surpass the tipping points of the climate catastrophe.

Globally, animal agriculture is a leading cause of climate breakdown, already responsible for around 16% of global greenhouse gas emissions.[9] In Latin America, factory farming is the single largest driver of land conversion,[10] and that is being already experienced by our *ngiwa* land in the Tehuacán region, where the factory farming agribusiness is taking our ancestral land, an already fragile ecosystem, to create profit out of animal exploitation, indigenous rights violation, soil erosion, water stress and air pollution. Of the conflict cases in the region registered by the Environmental Justice Atlas, all are related to the factory farms and the poultry industry technologies to disseminate rainwater and dry up the groundwater.

Food systems transformation is an issue of indigenous peoples' rights, because as communitary feminists remind us, *land, body and territory* are intersected, and the effects of an extractive industry are felt across all our battle fronts. This is not only in theory, it responds to a lived experience and to an ancestral teaching that is embedded in quotidianity, spirituality, and conflict. Our relation to our territorial land, to ourselves and our history is being transformed by the expansion of this agribusiness, oftentimes at either the cost of the conservation of the biocultural diversity of our region or the lives of our brothers and sisters that resist and defend the land.

According to 2022 Global Witness report,[11] Latin America is the most dangerous region in the world to be a human rights defender. It is not a

Agreement Commitments https://foe.org/wp-content/uploads/2023/06/SFFF_Climate-Misalignment_final.pdf

[9] UNEP, Food system impacts on biodiversity loss, https://www.unep.org/resources/publication/food-system-impacts-biodiversity-loss

[10] Ritchie, H. (2021). Cutting down forests: what are the drivers of deforestation? Our World in Data (OWID). https://ourworldindata.org/what-are-drivers-deforestation; Skidmore, M., et al. (2021). Cattle ranchers and deforestation in the Brazilian Amazon: Production, location, and policies. *Global Environmental Change*. V. 68. DOI: https://doi.org/10.1016/j.gloenvcha.2021.102280 https://www.sciencedirect.com/science/article/pii/S0959378021000595

[11] Global Witness, Standing Firm. The land and environmental defenders on the frontlines of the climate crisis, https://www.globalwitness.org/en/campaigns/environmental-activists/standing-firm/

coincidence that the industry directly linked with the most human right violations and lethal attacks towards environmental defenders is the agribusiness, more than a third of lethal attacks being towards indigenous peoples. Factory farming is now not only a threat to the environment but a danger to the people defending water, forests, and life itself. In my *ngiwa* community in Tehuacán, Puebla, our youth and elders being openly against the expansion of poultry industries and factory farming, we are at risk, and some have already been threatened and deprived of their freedom.

Since the very first introduction of livestock through colonization, to the neocolonial tendencies of Big Ag promoting western meat-based diets consumption for the sake of human and planetary health, indigenous peoples are resisting *extractivist* industrial agriculture and factory farming systems and their impacts on the loss of both plant biodiversity and oral traditions on ancestral diets.[12] But the ecosystems, knowledge and traditions that for thousands of years have sustained these alternative forms of nurturing nature and societies, are still alive, they are here within ourselves, and we are actively working to protect them.

This is one of the reasons why the climate action movement, people and institutions committed to sustainability, have a duty to decolonization, to redistribution, to reparations and reciprocity if we aim to transform the system that created the climate crisis in the first place. These emerging and rising voices of green transformation can kickstart a process where (primarily privileged) societies and rich nations ask themselves, given our socioeconomic conditions and ecological contexts, if it still makes sense to sow food and belief systems that have fundamentally severed the bond between humans and nature, that have historically exploited our labor and our land, by questioning the values and principles of an economic system whose absolute condition of existence (life itself) has to be necessarily put at risk (exploited or extracted) in order to create profit and reproduce itself.[13]

Any food transformation that follows has to put the conservation and reproduction of life at the center. These bio-centric solutions to transform our food systems, which have a fighting chance against the worst effects of the climate crisis, already exist and are in need to teach their true healing potential. In order to protect our land-body-territory, the ancestral knowl-

[12] Plant Based Treaty, Safe & Just Report, https://plantbasedtreaty.org/vegando-nuteconomics/

[13] Enrique Dussel, *Ética de la liberación en la edad de la globalización y de la exclusión*, Trotta, Madrid, 1998, p. 64

edge that has sustained our culture, the self-determination and sense of community that sows our political vision, decolonisation of food systems transformation can be learned and resignified within the structures that feed societies all around the world. By making a shift within food systems, recognizing value in the ancestral plant-centered food traditions, and redirecting value chains and funding towards traditional methods and knowledge systems safeguarded by indigenous peoples, global ambition can increase global food sovereignty, strengthen sustainable livelihoods and preserve ecosystems.

To re-indigenously sow and gather our food, to lead a movement of liberation of communities and living beings, our values will be fundamentally rooted in climate justice, in committing to heal colonial wounds in our land-body-territory, acknowledging the power in civilizational alternatives to capitalism and continuously being able to imagine a future that is ancestral. By acknowledging the proposals of indigenous futurism, we can envision alternatives to the climate catastrophe, to the system that continuously endangers life, to the violence that comes from scarcity and ignorance; to dream (and therefore commit to sow) a future of ecological balance, of mutual help and solidarity that sustains and creates abundance and prosperity. Such a future exists, we are creating it, sowing it and feeding our bodies, minds and territories with it. The food systems and diets of the future that will allow us to address climate change are inherently ancestral, reclaiming ecological balance and reciprocal respect with our Mother Earth, that is not only possible but has already been a reality. We just need to remember, reclaim them back and share their seeds with the living beings that will come, with future and ancestral generations.

Leveraging Indigenous Knowledge and Modern Science for Sustainable Food System Transformation

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Abstract

This document underscores the urgency for a sustainable transformation of the global food system, which currently incurs significant environmental, social, and health costs while failing to provide universal access to affordable and nutritious food. Drawing on the integration of indigenous knowledge and modern science, the narrative navigates through the inherent sustainability of Indigenous Peoples' food systems and the potential of whole foods to enhance food security and sustainability. As an example, it explores the historical transition from whole to refined grains and advocates for a return to whole foods consumption. Leveraging institutional procurement channels, particularly school meals, presents a strategic opportunity to facilitate shifts in consumption patterns towards whole foods. The document concludes by highlighting the Rockefeller Foundation's commitment to expanding school meal programs in low- and middle- income countries (LMICs), with a focus on incorporating principles of sustainability, nutrition and equity into food system initiatives.

1. Introduction: Urgency for Sustainable Food System Transformation

The current food system is deficient, driving more than twice its economic value in additional costs. Current food systems are not sustainable. They generate substantial environmental, social and health costs while failing to provide affordable food to all (UNFSS, 2021). With a market value of

$9 trillion, the global food system imposes an additional $19 trillion burden in negative health, environment and economic externalities, totaling $28 trillion in costs as illustrated in Figure 1.

- *Health costs:* In addition to the direct impact of agricultural pollution on public health, food systems generate widespread malnutrition. Unhealthy dietary patterns, perpetuated by the prevailing food environment, contribute to one every five deaths worldwide (Global Nutrition Report, 2020).
- *Environmental costs:* Current food system generates 25-33% of all greenhouse gas (GHG) emissions fueling climate change and playing a central role in the ongoing biodiversity crisis (The Food and Land Use Coalition, 2019).
- *Socio-economic costs:* Two-thirds of the 740 million people living in extreme poverty (on less than $1.90 a day purchasing power parity) are agricultural workers and their dependents (The Food and Land Use Coalition, 2019). This reality underscores the structural inequities embedded within our current food system, which perpetuates cycles of poverty and vulnerability.

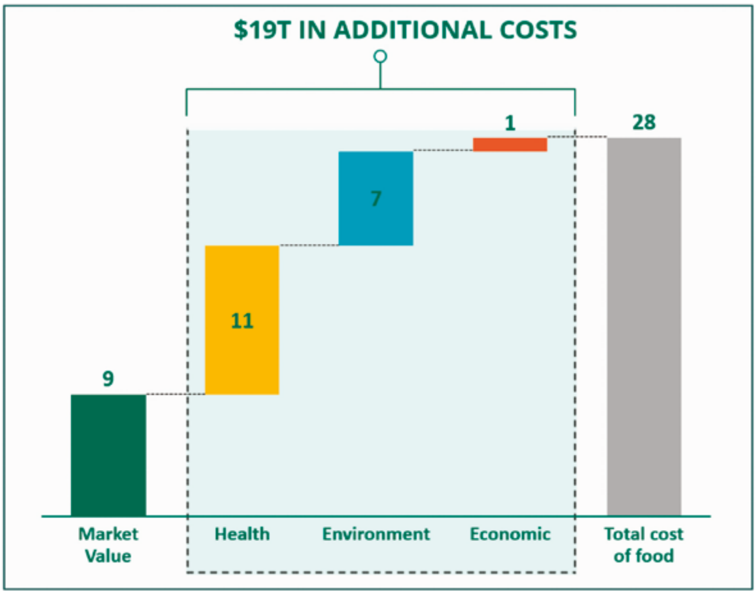

Figure 1. True Cost Analysis of the Food System Globally.

In light of the evident shortcomings in the food system, the inquiry arises as to how indigenous knowledge and modern sciences can jointly inform a sustainable food system transformation. This transformation aims to mitigate environmental, social, and health costs while ensuring universal access to nutritious and affordable food.

2. Elevating Indigenous Peoples' inherently regenerative food systems

Indigenous People's food systems offer invaluable insights into transforming our current food systems to enhance sustainability and human health. Historically grounded in wild and cultivated food environments and community exchange networks, many Indigenous Peoples' food systems inherently prioritize sustainability across environmental, socio-cultural, and human health dimensions (Ahmed, Dupuis, de la Parra, Adams, & Chunlin, 2022).

- *Environmental attributes:* From an environmental standpoint, these systems emphasize low-intensity practices that support ecosystem services and environmental health. They embrace principles such as utilization of local seasonal biodiversity, land stewardship, and ecological agricultural methods. Research shows that indigenous practices, such as agroforestry, rotational farming, and seed saving, can increase biodiversity and promote ecosystem resilience (Tianyu, García-Martín, & Plieninger, 2021; Swiderska, et al., 2022). Finally, indigenous communities have developed and refined strategies for coping with environmental change and variability over centuries, which can be invaluable for climate change adaptation (Santini & Miquelajauregui, 2022).
- *Socio-cultural attributes:* From a socio-cultural viewpoint, which encompasses spiritual dimensions, Indigenous Peoples' food systems uphold the cultural identities of their communities, recognizing food practices, rituals and socio-cultural significances that have evolved and passed down through generations (Smith, et al., 2019).
- *Health attributes:* Moreover, Indigenous food systems contribute to human health by enhancing dietary quality and diversity, promoting holistic health concepts and traditional food-as-medicine approaches. A research article published in the journal Current Developments in Nutrition reveals that numerous Indigenous foods boast high nutrient density, offering abundant macro- and micro-nutrients essential for a balanced diet (Sarkar, Walker-Swaney, & Shetty, 2020). Importantly, the study underscores the significance of preserving traditional knowledge

as a vital approach to combating diet- related chronic diseases within Indigenous communities. Finally, it is important to note that indigenous food systems prioritized the consumption of whole foods to conserve all existing nutrients. While food was lightly processed and prepared by soaking, drying, grinding, pounding, and cooking, the components generally were not separated.

Considering the environmental, socio-cultural, and health attributes outlined above, it is imperative to prioritize, elevate, and endorse indigenous knowledge and practices in initiatives aimed at achieving regenerative food system transformation.

The succeeding passages delve more deeply into one of the key learnings from Indigenous Peoples' food systems: the prioritization of whole foods' consumption, and particularly whole grains. Through the lens of modern science, this article will analyze the implications of consuming whole grains for human health and food system sustainability.

3. Advancing Modern Science on Fortified Whole Grains

In tandem with the indigenous practices of eating foods whole with only minimal processing, modern science heralds a paradigm shift towards fortified whole grain (FWG) and fortified whole blend (FWB) foods as pivotal in enhancing food security, promoting healthier diets, and buffering food systems against crises (Milani, et al., 2023).

3.1 Historical perspective: Transition from whole to refined grains

Grains have served as foundational elements in global food systems since ancient times, predating the emergence of agriculture itself. The consumption of grains by humans played a pivotal role in the inception of agriculture. Notably, wheat, rice, and maize, often referred to as the "Big 3", constitute nearly half of worldwide caloric and protein intake (Hunter, et al., 2020), and 42% of protein intake in low and middle-income countries (LMICs) (CIMMYT, 2019).

A combination of factors drove the widespread consumption of refined grains since the 19th century. Technological innovations, notably the introduction of the roller mill in Britain, drastically reduced production costs of refined flour while extending its shelf life. Concurrently, consumer preferences favored refined flour for its perceived cleanliness and associated status symbol. Market dynamics, particularly influenced by the Green Revolution, concentrated grain production and consumption on varieties already commonly consumed in refined form. Byproducts from grain refining processes were redirected to the animal feed sector, further solidifying the dominance of refined grain consumption.

3.2 The case for shifting to fortified whole grains and whole blend foods

Shifting from refined grains to fortified whole grains (FWG) and fortified whole blends (FWB) presents a transformative opportunity with substantial health and environmental benefits, without additional costs.

- *Health benefits:* Shifting to whole grains offers significant health benefits by preserving essential nutrients and fiber lost in refined grains, thus bolstering efforts to combat food insecurity. Currently, only 20-30% of grains are consumed in their whole form, leading to nutrient depletion and resource wastage (Milani, et al., 2023). Low consumption of whole grains is a major contributor to global mortality and disease burden as illustrated in Figure 2, with increased whole grain intake associated with reduced risks of various chronic diseases including cancer, cardiovascular disease, diabetes, and metabolic syndrome (IHME, 2019). Conversely, high intake of refined grains has been linked to elevated mortality and cardiovascular disease risks (Tieri, et al., 2020). Major dietary guidelines advocate for high consumption of FWG and FWB as part of a healthy diet.

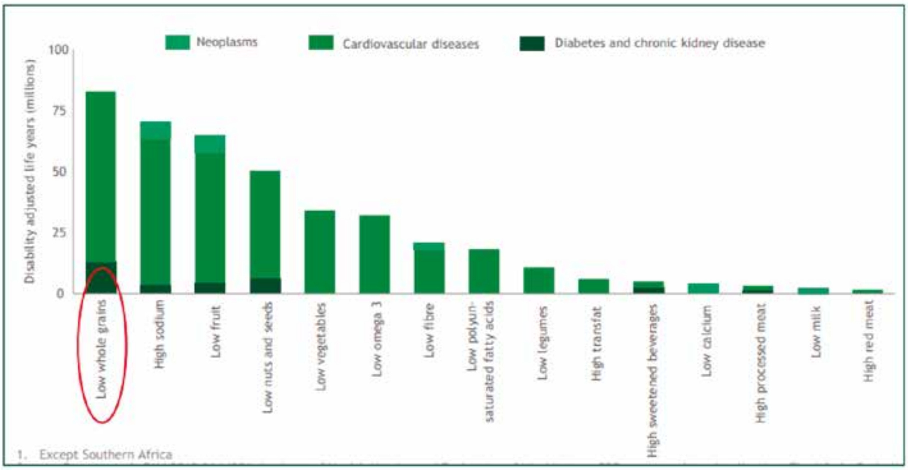

Figure 2. Specific dietary risk factor contributing to disease burden. Total DALYs lost by dietary risk factor, global, all sexes and age groups, 2017

- *Environmental benefits:* Shifting from refined to whole grains and diversifying crop consumption can lead to more diverse and resilient food systems, reducing reliance on a few staple crops like wheat, rice, and maize. This broader movement encompasses grains like sorghum, millet, and neglected grains, as well as pulses, nuts, and seeds, promoting sustainable diets for all. Additionally, transitioning to fortified whole grains offers significant environmental benefits, including reduced land, water, and fertilizer usage compared to conventional production as illustrated in Illustration 1. While other practices like regenerative agriculture may have a greater impact on greenhouse gas emissions and pesticide use, the nutritional benefits of fortified whole grains outweigh these factors.

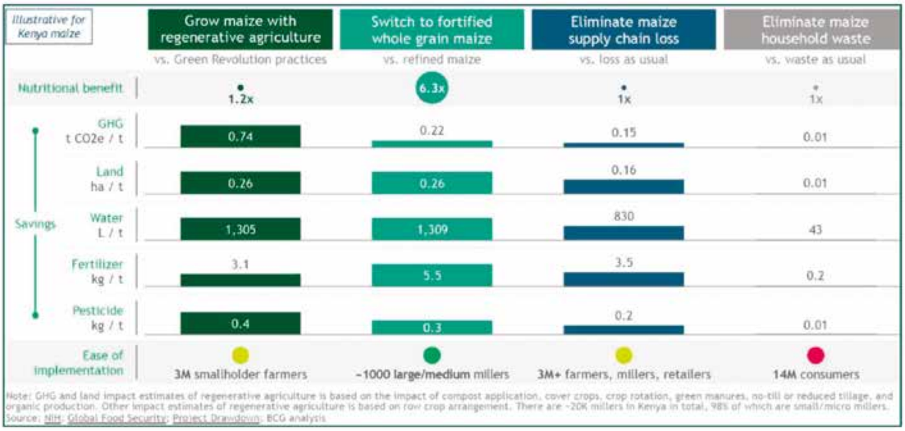

Illustration 1. Environmental and Nutritional Benefits per tonne of cereal unit from different levers (non-nutrition-weighted).

- *Economic benefits:* Switching to fortified whole grains presents a compelling economic case, offering enhanced nutritional value at a cost-effective rate. Fortifying grain-based foods, including flours and rice, is an efficient method to address nutritional deficiencies, particularly in undernourished populations. Unlike other fortification methods, whole grain foods inherently contain a wealth of micronutrients, making them a health- protective option. Additionally, fortification extends shelf life and mitigates nutrient absorption issues, further enhancing their value proposition. From a production standpoint, fortified whole grain foods can be budget-neutral substitutes for refined products, with higher extraction rates leading to increased yield. This higher yield offsets the costs of fortification, making fortified whole grain foods financially feasible. Bran and germ byproducts, typically sold at lower prices for animal feed, further contribute to cost savings (Milani, et al., 2023).

In summary, shifting to FWG and FWB offers substantial health and environmental benefits, providing an economically viable solution to address nutritional deficiencies and promote sustainability in food systems.

Finally, promoting a transition towards fortified whole grains and whole blends is a multi- step journey with increasing food systems benefits. In the short term, the transition to FWG and FWB should start by making affordable whole meals of the "Big 3" grains, with gradual incorporation of secondary grains such as sorghum and millet. As we progress into the medium to long term, product development should evolve to incorporate blends of the "Big 3" grains, sorghum, and millet with legumes and pulses, and later expanding to include neglected grains and other nutrient-dense foods.

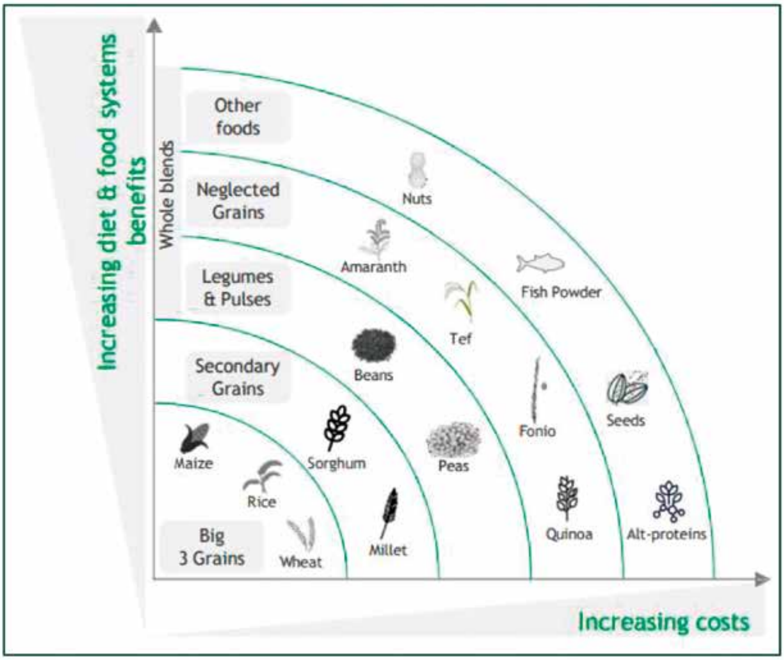

Illustration 2. The transition from refined grains to whole blend foods.

4. Intervention opportunities: Leveraging Institutional Markets as Catalysts for Sustainable Consumption

Shifting consumption patterns towards whole foods can be facilitated through the strategic utilization of institutional procurement channels, such as school meals, where children exhibit openness to dietary shifts. Leveraging the influence of institutional procurement channels, particularly in settings like school meals, presents a prime avenue for steering consumption patterns towards whole foods, FWG and FWB. Notably, children within these settings often exhibit greater receptivity to dietary changes, making them pivotal agents for broader shifts in eating habits. The effectiveness of institutional demand in driving supply chain shifts has been demonstrated previously. For example, in 2013, India initiated a pilot program introducing fortified rice in school midday meals. By 2021, India achieved self-sufficiency in fortified kernel production, benefiting over 400 million people (WFP, 2022).

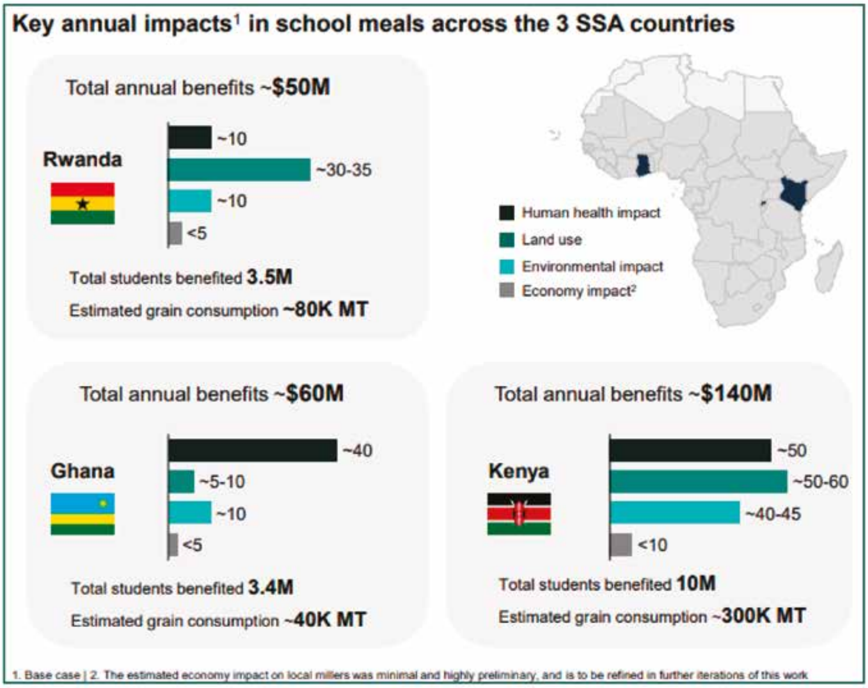

Illustration 3. Annual societal benefits of adopting fortified whole grains in school meals across Rwanda, Kenya and Ghana.

The transformation of institutional demand, notably within school meals, presents a significant opportunity. For instance, the potential annual societal benefits of adopting fortified whole grains in school meals across Rwanda, Ghana, and Kenya could reach up to $250 million, as depicted in Illustration (McKinsey & Company, 2022). This impact has already been partially demonstrated in an 18-month pilot study by the Rockefeller Foundation in Rwanda,[1] showcasing the feasibility of a large-scale, budget-neutral shift towards fortified whole-grain foods.

Five key steps would be crucial for a successful transition to sustainable foods within public food programs (example for switching to Fortified Whole Grains in School Meals):

- *Building awareness about the importance of healthy foods in diets:* This involves sensitizing the school community and the general population through nationwide social marketing campaigns about the benefits of more sustainable foods. The pilot study conducted in Rwanda exemplified the efficacy of awareness campaigns in fostering shifts in consumer preferences, especially among children. By the end of the pilot, a remarkable 73% of schoolchildren demonstrated awareness of the nutritional advantages associated with FWG foods. Moreover, an overwhelming 97% of Grade 6 students expressed a preference for whole grain over refined equivalents.
- *Switching maize flour procurement for schools to FWG locally produced flour*: By transitioning all maize flour procurement to FWG flour, budget-neutrally, structured demand can be provided to encourage investment by millers.
- *Investing in production economics to increase affordability*: This step entails investing in new machinery to efficiently produce FWG to meet the demand of national school feeding programs, while also engaging local farmers and aggregators to improve quality along the value chain.
- *Increasing distribution networks to enable access to FWG*: Investment in packaging, transportation, and storage infrastructure is necessary to ensure the safe, efficient, and sustainable delivery of FWG products to schools.

[1] The Rockefeller Foundation supported a pilot between August 2020 and December 2021 in Rwanda to replace refined maize flour in school meals with FWG flour. The pilot, implemented by Vanguard Economics in collaboration with the World Food Programme (WFP), developed an FWG maize flour for procurement by WFP for its school feeding program.

- *Including FWG in other government food programs*: By integrating FWG into safety nets instead of refined grains and investing in the transition for government subsidy programs, broader accessibility and acceptance can be achieved.

After establishing institutional demand, the next phase involves scaling production and reshaping consumer preferences towards FWG products. This entails a multifaceted approach, including raising awareness about FWG's benefits through various channels such as social media and partnerships with culinary experts. Additionally, investment in research and development is vital to enhance product quality and scalability, while expanding distribution networks ensures the widespread availability of FWG products, fostering sustainable consumption habits.

5. Conclusion

In conclusion, the path to fixing our deficient food system lies in a harmonious integration of Indigenous knowledge and modern science advancements. By embracing whole foods with minimal processing, we can preserve their nutritional integrity, optimize crop utilization, and enhance food system yields, thus bolstering food security and reducing environmental impact, supported by emerging scientific evidence. Leveraging new technologies enables us to achieve light processing and fortification of whole foods in a commercially viable manner, while meeting organoleptic qualities and shelf-life requirements. Furthermore, shifting consumption patterns towards whole foods can be facilitated through the strategic utilization of institutional procurement channels, such as school meals, where children exhibit openness to dietary shifts.

The Rockefeller Foundation is actively engaged in a developing a "Big Bet" aimed at expanding school meal programs in low- and middle-income countries (LMICs), and we aspire to integrate the principles outlined above in collaboration with our partners, forging a path towards a more sustainable and equitable food future.

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Recognizing Farmers' Indigenous Innovations in Africa[1]

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Abstract

This paper presents the experiences and outcomes of using contests to elicit farmers' indigenous innovations and to reward outstanding farmer innovators in selected districts in Ethiopia, Kenya, Malawi and Zambia. The contests attracted 349 eligible entries, most of which were submitted by male innovators. The most common domains of innovations were related to livestock (40%), crop management (26%), storage (10%), soil and water management (8%) and farm tools and implements (5%). Many of the innovators were using local resources to develop botanical pesticides and ethnoveterinary medicines with the goal of improving productivity and reducing production costs. The study concludes that farmers possess valuable ethnobotanical knowledge and innovation-generating potential that need to be harnessed and supported; and contests are an effective means to scout and acknowledge farmer innovators while raising awareness of farmer innovation approach among relevant stakeholders.

1. Introduction

Farmers are a rich source of indigenous knowledge and agricultural innovations (Biggs 1990; Van Huis and Meerman 1997). Driven by economic and environmental changes, curiosity, creativity, serendipity, and desire for social recognition, farmers have continuously been experimenting and generating innovations since the beginning of agriculture (Chambers et al. 1989; Sumberg and Okali 1997; Critchley 2000; Bentley 2006; Leitgeb et al. 2014; Bragdon and Smith 2015). Farmers develop innovations that are suitable for their diverse range of agro-ecological conditions and farming systems, and they make incremental improvements to traditional practices and promoted technologies to adapt them to local realities (Waters-Bayer et al. 2009). The

[1] This chapter is derived from a published paper: Tambo, J.A. (2018). Recognizing farmer-generated innovations through contests: insights from four African countries. *Food Security*, 10(5), 1237-1250.

innovations developed by farmers range from new or modified farm tools, techniques and practices to new ways of organizing, managing resources and communicating (Sumberg and Okali 1997; Reij and Waters-Bayer 2001). These farmer-generated innovations have been found to contribute positively to improved livelihoods (Tambo and Wünscher 2017a) and building resilience to climate shocks (Tambo and Wünscher 2017b).

Recognizing the importance of farmers' innovations, there has been a rapidly growing movement of scientists, non-governmental organisations (NGOs), agricultural ministries and farmer organizations that are drawing attention to and supporting farmer-led innovation processes, including scouting and documenting the innovations, as well as building farmers' capacity to test, adapt and develop their own innovations. Several initiatives and studies have been implemented in recent years to scout and document farmer innovations (Wettasinha et al. 2008; Critchley and Mutunga 2003; Gupta 2016; Tambo and Wünscher 2015; Find Your Feet 2012). Appreciating farmer innovators is likely to boost self-esteem of farmers as they start to see themselves as people rich in knowledge, thereby stimulating the generation of more innovations. In addition, it enhances mutual respect as it induces the scientific community to begin to see farmers as not mere adopters of promoted techniques but rather as people with valuable indigenous knowledge that can complement their own scientific knowledge (Waters-Bayer et al. 2009).

In this paper, we present the experience of the Program of Accompanying Research for Agricultural Innovation (PARI) in identifying and supporting farmers' indigenous innovations in Africa. PARI is a research-focused program funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) that, among other things, aims at promoting and supporting the scaling of proven innovations in the agri-food sector. One of the components of PARI focuses on identifying high-potential farmers' or bottom-up innovations and on recognizing and rewarding the innovators for their creativity. To this end, we implemented innovation contests in four African countries with the hope that the opportunity to win prizes through the contests would incentivize farmers to report their indigenous innovations.

2. Implementation of the innovation contests

This study was based on innovation contests that were implemented in 2016 in four African countries: Ethiopia, Kenya, Malawi and Zambia. In the contests, farmers competed to win prizes by revealing their independently developed innovations. Following Tambo and Wünscher (2015), we considered three conditions necessary for an activity to be considered a farmer innovation and eligible for the contests , i.e. (1) any practice or technique along the food chain; (2) that is done differently from known common or traditional practice; (3) and was developed primarily by a farmer or a group of farmers themselves (without direct support from extension and development agents or formal research). The contests were implemented in collaboration with PARI project partners, including the Ethiopian Development Research Institute (EDRI), Kenya Agricultural and Livestock Research Organization (KALRO), Malawi's Department of Agricultural and Research Services (DARS) and Zambia Agricultural Research Institute (ZARI). The innovations contests were implemented in Hitosa, Lude Hitosa and Digeluna Tijo districts in the Arsi Zone of Ethiopia; Bungoma, Kakamega and Siaya counties in Kenya; Rumphi Salima and Thyolo districts in Malawi; and Choma, Petauke and Katete districts in Zambia. The contests were open to farmers or groups working in the food value chain in the various study districts.

The first step in the contest process involved a visit to the selected districts to sensitize relevant stakeholders about the innovation contests. The stakeholders included leaders and staff of Ministries of Agriculture, research institutes, farmer associations and NGOs. The scoping visit provided an opportunity to obtain useful information to plan the actual implementation of contests in the various districts. This included identification of the best possible mechanisms through which farmers could obtain information about the contests as well as background information about the districts, including the most appropriate channels for disseminating information on the contests.

To create awareness about the contests, different information dissemination mechanisms, including extension officers, local radio stations, mobile phone text messages, churches, lead farmers, farmer organizations and community sensitization were considered. However, radio announcements and extension agents were the two main channels employed. Due to the low level of literacy of the farmers in the study regions, extension agents were instrumental in the implementation of the contests. An innovator interested in participating in the contest was required to submit a filled application form that was designed for this purpose. The roles of the extension agents in the contests included: informing farmers located in their operational areas about the contest; identifying those who had developed an innovation and assist them to complete an application form; and returning the completed forms to a designated location within a six-week period. The extension agents were offered monetary rewards (ranging from 12 to 25 USD) for each qualified application submitted. To ensure increased awareness of the contests, about two local radio stations with potential to reach wide audience were contracted in each country to broadcast jingles about the innovation contests in various local languages spoken in the study districts.

An independent evaluation committee was set up in each of the study countries to evaluate the applications. The committee members included 9 to 12 local experts who had been working on topics related to agricultural or farmer innovations and were familiar with the local farming systems. The experts were drawn from Ministries of Agriculture in the study districts, research institutions, extension service providers, farmer organizations and NGOs. Following Tambo and Wünscher (2015), a multi-criteria decision-making approach was adopted for the grading of eligible applications. The criteria agreed upon for the evaluation of the innovations included originality, economic potential, gender responsiveness, environmental friendliness, adoption potential and social acceptability.

The high-ranking innovations were then short-listed for verification, which involved visiting the applicants to get detailed information about their innovations and confirming if they were the true originators of the reported innovations. Based on satisfactory verifications, the short-listed innovators to be awarded prizes were selected. Prizes were awarded at the district level, and there were separate prizes for men, women and youth applicants. In each category of applicants, there were awards (such as farm inputs and machineries) for the first, second and third best innovators that were worth 1000 USD, 750 USD and 500 USD, respectively. The prizes were given out during district agricultural shows or events where stakeholders from the agricultural sector, award winners and media persons were present. The award winners together with all eligible applicants were given certificates of participation in the contests.

3. Main findings

Overall, 774 applications were submitted to the contests across the four countries, suggesting high levels of interest in the contests. However, about 425 (55%) of the submitted applications were rejected as they were deemed to be common, traditional or externally promoted techniques and practices. The number of successful entries received were 49, 66, 85 and 149 for Ethiopia, Zambia, Malawi and Kenya, respectively. Nearly two-thirds of the eligible innovations were developed by men. The women and youth innovators were about 24% and 13%, respectively. This is in line with previous evidence showing that most farmer innovators are middle-aged men (Reij and Waters-Bayer 2001).

A large share (98%) of the innovations were developed by individuals rather than groups. Nearly two-thirds of the innovations were incremental innovations, which involve the modification of existing techniques, tools or practices, while the generation of practices or technologies that are completely novel (radical innovations) constituted about a third of the innovations. Roughly 42% of the innovators had created commercial products and services from their innovations. Nearly 70% of the innovators claimed that they spent less than 20 USD to develop their innovations, which resonates with arguments that smallholder farmers use locally available resources develop simple and low-cost innovations (Reij and Waters-Bayer 2001; Reij et al. 2009).

Table 1. Domains of innovations identified through the contests

Domain	Ethiopia	Kenya	Malawi	Zambia	Overall
Crop management	12.77	32.89	25.88	21.21	26.20
Livestock production	34.04	34.90	38.82	56.06	39.80
Soil and water management	6.38	8.05	12.94	4.55	8.30
Farm tool and implement	25.53	2.01	3.53	1.52	5.50
Processing	6.38	4.70	2.35	3.03	4.00
Storage	4.26	10.74	11.76	10.61	10.10
Tree management	0.00	1.34	2.35	0.00	1.40
Apiculture	6.38	1.34	1.18	0.00	1.70
Aquaculture	0.00	0.00	1.18	0.00	0.90
Others	4.26	2.68	0.00	3.03	2.10

Table 1 displays the domains of the farmer-generated innovations that were identified through the innovation contests. We find that livestock-related innovations dominate in all the study countries, particularly in Zambia where about 56% of the identified innovations were in the domain of livestock production. Overall, innovations in livestock production constituted roughly 40% of the identified innovations. A large share (82%) of the 138 innovations in livestock production involved livestock health management through ethnoveterinary practices. Others include innovations related to incubation, as well as feeding, breeding and housing of livestock.

Table 1 indicates that another important category of innovations identified through the contests was crop management innovations. Nearly half of this category of innovation was related to crop protection using botanical pesticides, which are concoctions containing extracts of fruits, pods, seeds, roots, barks or leaves of plants or trees with pesticidal properties. The botanical pesticides were used to control insect pests, including ants, termites, stem borers, stalk borers and aphids, as well as weeds, such as witchweed. Other examples of crop management innovations included various modified methods of land preparation and planting in order to optimize land use, quicken growth process, increase nutrient uptake, prevent lodging and increase yield; breeding and grafting activities to generate cultivars that are stress tolerant, fast growing and high yielding; introduction of a novel type of intercropping that increases crop yields; using local materials to make simple traps that prevent crop damage by rodents (such as mice and rats) and monkeys; and making liquid fertilizers by mixing extracts of plants (such as Tithonia), and human or rabbit urine, which are used as top dressing and foliar spray.

Inspired by modern farm implements, some of the innovators were using local materials to develop simple farm tools and implements to save time and labour or decrease production costs. A greater share of the innovations related to farm tools and implements were scouted in Ethiopia. Moreover, such innovations were mostly reported by youths, suggesting that youth farmers are relatively more involved in generating time-saving and drudgery-reducing farm implements.

The soil and water management innovations consisted of soil fertility enhancing techniques, irrigation practices and water conservation technologies. The storage innovations mainly involved the use of ashes of plants or pulverized plant materials to protect stored grains and seeds against storages pests, such as larger grain borers and weevils. We also identified a few simple processes or tools for adding value to farm products, which we termed processing innovations, as well as a few innovations in the areas of agroforestry, apiculture and aquaculture.

All the innovators were asked about the key motivations for developing their innovations, and their responses are summarized in Table 2. An important motivating factor for developing an innovation is to reduce the cost of production, as cited by about 62% of the innovators. The identified innovators were mostly smallholder resource-poor farmers who often faced difficulties in accessing affordable modern agricultural technologies, and this may have induced them to develop cost-saving practices and techniques. Achieving productivity increases in crops and livestock was the primary goal of about half of the innovators. Another important driver of the innovations was curiosity. Around 41% of the innovators were curious to find out if a harboured idea will work or not, and this resulted in innovation outcomes. Other driving factors mentioned by the innovators included reduction in the amounts of inputs and labour used, improving the quality of farm products, adaptation to environmental shocks, exploitation of market opportunities, and desire to gain social recognition. A few of the innovators (11%) asserted that their innovations were unplanned and occurred serendipitously.

Table 2. Motivation for generating the innovations

Motive	Ethiopia	Kenya	Malawi	Zambia	Overall
Curiosity	57.45	54.36	18.52	27.27	41.11
Coincidence	14.89	9.40	11.11	12.12	11.08
Reduce inputs	6.38	43.62	24.69	16.67	28.86
Saving labour	29.79	20.81	14.81	9.09	18.37
Reduce expenses	46.81	62.42	69.14	60.61	61.52
Increasing production	38.30	65.10	51.85	28.79	51.31
Improving quality	12.77	49.66	25.93	15.15	32.36
Adaptation to environmental change	4.26	30.87	17.28	16.67	21.28
Market demands	12.77	22.82	7.41	9.09	15.16
Desire for social recognition	2.13	19.46	3.70	4.55	10.50

Note: Multiple responses recorded

At the country level, the Ethiopian innovators cited curiosity and reducing expenses as the main motivations behind their innovations. Similarly, curiosity and reducing expenses, in addition to increasing production and improving product quality, were the important factors that spurred the implementation of the identified innovations in Kenya. We also found that the innovators in Malawi were inspired to innovate mainly because of the desire to increase agricultural production and reduce production costs, which was also the key motive for the innovators in Zambia.

4. Concluding remarks

This paper presents the experiences and outcomes of applying contests to elicit farmer-generated innovations and to reward outstanding farmer innovators in Ethiopia, Kenya, Malawi and Zambia. In the contests, smallholder farmers competed to win prizes ranging from 500 USD to 1000 USD by revealing their own generated innovations. The contests attracted about 350 eligible entries, mostly from male innovators. The most common categories of innovations include livestock (40%), crop management (26%), storage (10%), soil and water management (8%) and farm tools and implements (5%). Most of the identified innovations relate to reducing crop losses using plant-based biopesticides and preventing or treating livestock pests and diseases using ethnoveterinary practices. We found that the innovators were mainly driven by economic motives such as reducing production costs and increasing production, but intrinsic motives such as curiosity were also important drivers.

The findings suggest that contest is a good mechanism to scout farmers' indigenous innovations while simultaneously acknowledging the ingenuity of the innovators and raising awareness among relevant stakeholders. The contests helped in revealing practices and tools developed by farmers that were hitherto kept in secrecy. Furthermore, this study reaffirms the notion that farmers are active experimenters who continuously generate remarkable and locally adapted innovations. They use local resources to develop low external input technologies to reduce production costs, improve food production and cushion the effects of climate change. In conclusion, farmers possess valuable ethnobotanical knowledge and innovation-generating potential that need to be harnessed and supported.

Acknowledgements

This research was financially supported by the German Federal Ministry for Economic Cooperation and Development (BMZ) through the research project "Program of Accompanying Research for Agricultural Innovation" (PARI). The author gratefully acknowledges project partners from EDRI, KALRO, DARS, ZARI and the Forum for Agricultural Research in Africa (FARA) as well as stakeholders who supported the implementation of the contests in the four study countries.

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Indigenous Knowledge in Participatory and Evolutionary Plant Breeding

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1. Introduction

Context and Relevance

Indigenous Knowledge has played a pivotal role in the development and preservation of agricultural biodiversity, particularly among family and smallholder farmers who are often at the forefront of maintaining and enhancing crop diversity. This paper examines how the integration of Indigenous Knowledge into Participatory Plant Breeding (PPB) and Evolutionary Plant Breeding (EPB) offers significant benefits for sustainable agriculture, food security, food sovereignty, and adaptation to changing conditions and resilience.

Thesis Statement

Practicing the integration of Indigenous Knowledge into PPB and EPB is not only vital for enhancing plant genetic diversity but also a crucial strategy for addressing global food system challenges such as climate change, water scarcity, droughts, pests, diseases, and other environmental and climatic challenges.

2. Indigenous Knowledge in Agriculture: A Historical Overview

Traditional Practices

Plant breeding began with the advent of agriculture. Over thousands of years, Indigenous Peoples selected the best seeds and saved them for future planting. This careful selection led to the development of crops adapted to local conditions and environmental stresses. For example, ancient civilizations in the Fertile Crescent practiced selective breeding of wheat and barley, laying the foundation for modern agricultural systems (Harlan, 1995).

Examples from the Middle East and Asia

In the Fertile Crescent, traditional farming communities have long engaged in the selection of cereal crops such as wheat and barley, which are well-suited to the local's diverse microclimates. Similarly, in the Himalayan region, Indigenous farmers have cultivated diverse rice varieties adapted to different altitudes, reflecting an intimate understanding of local ecosystems (Rerkasem, 2007). These ancient practices are mirrored in modern EPB projects, which build upon the genetic diversity preserved by Indigenous farmers.

Link to Modern Breeding

The evolutionary breeding approach is grounded in Indigenous knowledge, where farmers traditionally used mixtures for cultivation, believing that planting two or three varieties together was more beneficial than monoculture (Cleveland & Soleri, 2007). Modern breeding science, however, began with the collection of diversity from farmers' fields, moving towards the purification of single varieties (Ceccarelli & Grando, 2007). Participatory breeding, on the other hand, is based on the principle that agricultural research should move out of research stations and into farmers' fields, integrating farmers' knowledge and regional needs into the selection of the final variety to be produced. This approach decentralizes the breeding process (Witcombe & Joshi, 1996). EPB introduces a different concept, where the focus is not on a single variety but on a large mixture of different varieties, with natural selection as the foundation (Ceccarelli & Grando, 2007). When EPB is conducted in research stations, it remains non-participatory and centralized; however, when implemented in farmers' fields with their input, it becomes participatory and decentralized. The core of these methods is to increase genetic diversity in farmers' fields and to promote in-situ conservation (Cleveland & Soleri, 2007).

3. Participatory Plant Breeding (PPB) and Evolutionary Plant Breeding (EPB)

Overview

Participatory Plant Breeding (PPB) and Evolutionary-Participatory Plant Breeding (EPPB) involve active collaboration between scientists and farmers, aiming to enhance genetic diversity in farmers' fields and increase farmers' access to crop genetic materials. In this study the focus is on the methodologies that support decentralized agricultural research and are designed to strengthen in-situ conservation, boost adaptive capacity, and increase farmers' resilience to climate-related extreme events and other stresses. Both methods are adaptive, allowing for continuous feedback from farmers and adaptation to local conditions and climate changes.

Distinction Between Participatory and Evolutionary Plant Breeding

Participatory Plant Breeding (PPB): This approach involves a collaborative effort where farmers and researchers work together to develop and select crop varieties. PPB decentralizes the breeding process by incorporating the needs and preferences of farmers into decision-making. Unlike lab methods that rely solely on researcher-driven selection, PPB fosters a communicative space between scientists and farmers, ensuring that the resulting varieties are both scientifically robust and practically suited to local agricultural conditions (Ceccarelli & Grando, 2007). In PPB, farmers' insights and local knowledge play a crucial role, leading to higher acceptance and effectiveness of the new varieties (Cleveland & Soleri, 2007). This process bridges the gap between scientific research and practical farming needs, promoting varieties adapted to specific local environments and challenges (Witcombe, Joshi, & McGregor, 2007).

Evolutionary Plant Breeding (EPB): EPB is grounded in Indigenous knowledge and practices, focusing on maintaining and enhancing genetic diversity through natural selection rather than selecting specific traits in controlled environments. This approach is based on the idea that agricultural systems evolve naturally over time. By managing diverse populations in farmers' fields, EPB supports resilience to environmental changes and stresses (Ceccarelli, Grando, & Baum, 2007). EPB leverages the traditional knowledge of Indigenous farmers, who have developed and maintained diverse crop mixtures adapted to their specific ecological conditions. This method reflects a deep understanding of local ecosystems and agricultural practices, fostering a dynamic and adaptive breeding process (Ceccarelli & Grando, 2007).

In essence, while PPB integrates modern scientific techniques with local farmer knowledge to improve crop varieties, EPB relies on the principles of natural selection and genetic diversity rooted in traditional agricultural practices. Both approaches benefit from Indigenous knowledge but apply it differently: PPB incorporates farmer feedback into the breeding process, and EPB utilizes natural evolutionary processes guided by traditional practices. The integration of these methodologies highlights the importance of combining scientific advancements with traditional wisdom to enhance agricultural sustainability and effectiveness.

Case Studies in Asia and the Middle East

- **Iraq:** In Iraq, PPB initiatives have focused on barley, particularly in the northern regions where the crop is a staple. Farmers have collaborated with researchers to select varieties that are high-yielding and drought-resistant, leading to the development of barley varieties well-suited to Iraq's semi-arid conditions (Ceccarelli, Grando, & Baum, 2007).
- **Iran:** In Iran, EPB and PPB projects involving wheat and barley have demonstrated increased resilience to climate variability through the use of diverse genetic populations, leading to varieties better adapted to local conditions (Ceccarelli & Grando, 2007).
- **India:** In India, PPB has been widely implemented in rice and maize. Farmers have worked closely with scientists to select varieties that meet local needs, such as resistance to specific pests or adaptability to particular climates. This has resulted in the widespread adoption of PPB-derived varieties, contributing to increased agricultural productivity and farmer empowerment (Joshi, Sthapit, & Witcombe, 2007).
- **Bhutan:** In Bhutan, participatory approaches in rice breeding have been successful. Farmers and scientists have collaborated to develop rice varieties well-adapted to the country's diverse agro-ecological zones, resulting in varieties that are high-yielding and resistant to local pests and diseases (Witcombe, R.J., et al., 2001).
- **China:** In China, PPB programs have focused on rice and wheat. The participatory approach has allowed farmers to collaborate in selecting varieties that are high-yielding, disease-resistant, and adaptable to changing climate conditions, enhancing food security and agricultural sustainability (Zhao, X., et al., 2014).
- **Syria:** In Syria, PPB efforts have been concentrated on wheat and barley. Farmers have been involved in selecting varieties adapted to the harsh, dry conditions of the region, leading to cultivars that thrive under low-input conditions and contribute to genetic diversity conservation (Ceccarelli & Grando, 2007).

- **Jordan:** In Jordan, PPB has focused on improving the resilience of wheat and barley to water scarcity. Farmers have identified and selected varieties more tolerant to drought, crucial for Jordan's water-stressed environment (Ceccarelli, Grando, & Singh, 2011).
- **Nepal:** In Nepal, participatory approaches in rice breeding have led to the development of high-yielding and pest-resistant varieties (Joshi, Sthapit, & Witcombe, 2007).
- **Lebanon:** In Lebanon, farmers practice EPB by cultivating mixtures of barley and wheat that have evolved over generations. These evolutionary populations show remarkable adaptability to Lebanon's varied climates (Zencirci, 2005).

4. The Role of Indigenous Knowledge in Modern Plant Breeding

The domestication of crops such as wheat, barley, and lentils in the Fertile Crescent represents some of the earliest examples of plant breeding. Early farmers practiced selection and cross-breeding to improve crop yields and resistance to local pests and diseases, practices closely related to what is now recognized as Indigenous Knowledge in agriculture (Zohary & Hopf, 2000).

The principles underlying ancient plant breeding, such as the use of diverse genetic material and selection for environmental adaptability, are foundational to modern PPB and EPB. Many crops first domesticated by Indigenous Peoples are still central to food security today. Modern breeding science needs to integrate Indigenous knowledge and address farmers' needs to enhance program effectiveness. The integration of modern techniques with Indigenous knowledge is essential for achieving optimal results (Ceccarelli & Grando, 2007). Modern breeding approaches traditionally focused on optimizing single-variety crops can benefit significantly from incorporating local agricultural practices and traditional knowledge. By leveraging the insights of Indigenous farming communities, modern breeding efforts can become more inclusive and effective (Cleveland & Soleri, 2007). Indigenous Knowledge provides crucial insights into local agroecosystems, pest management, and soil fertility that modern breeding programs often overlook. For instance, Indigenous farmers in Jordan have been actively involved in PPB projects focused on developing drought-resistant wheat varieties, which are crucial for the region's arid conditions (Al-Khatib, 2014).

Examples:

- **Lebanon:** In Lebanon, participatory plant breeding efforts have led to the development of barley varieties that are both high-yielding and resilient to local environmental stresses. These efforts build on traditional knowledge of crop management and selection (Zencirci, 2005).
- **Bhutan:** Indigenous practices of barley cultivation in Bhutan have been integrated into modern breeding programs, resulting in varieties that are culturally significant and agronomically superior (Rai & Sherpa, 2018).
- **Iran:** Participatory Plant Breeding (PPB) has been applied to bread wheat and barley, particularly under rainfed and supplementary irrigation conditions. Farmers from various regions actively participated in the process, helping to identify the best seeds that not only offer good yields but also exhibit high resistance to drought, diseases, and pests.

Barriers to Integration

Despite the potential benefits, barriers such as legal restrictions on seed exchange, lack of recognition of Indigenous rights, and limited access to scientific resources hinder the full integration of Indigenous Knowledge into modern breeding programs. In some countries, for instance, legal frameworks often restrict the free exchange of seeds, which can limit the effectiveness of participatory approaches (Brush, 2005).

Policy Recommendations:

- **Revision of Seed Laws:** Allowing greater exchange and use of Indigenous varieties is essential for fostering innovation and resilience in agriculture.
- **Protection of Indigenous Knowledge:** Strengthening legal frameworks to protect Indigenous Knowledge and Intellectual Property Rights is crucial for sustaining agricultural diversity.
- **Collaborative Research:** Promoting collaborative research programs that prioritize the participation of Indigenous communities will enhance the effectiveness of breeding programs and ensure that they are aligned with local needs.

7. Conclusion

Summary of Key Points

The paper underscores the importance of Indigenous knowledge in enhancing the efficiency and effectiveness of plant breeding programs such as PPB and EPB. It highlights the need for greater collaboration between Indigenous communities, breeders, and research stations to address global challenges of food system. In order to achieve these two important issues, it is necessary to provide the necessary resources for the implementation of research, development and promotion of projects to the stakeholders and organizations.

Call to Action

There is an urgent need to reform agricultural research and policy to better incorporate Indigenous Knowledge and support sustainable, resilient farming practices. By doing so, we can enhance food security, preserve biodiversity, and mitigate the impacts of climate change.

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YOUTUBE PRESENTATION

Food System and Indigenous Knowledge and Science

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https://youtu.be/OhcfDL_wpjI?si=hLgcsqRO72ZsK8c3

4.3. CLIMATE – ADAPTATION, MITIGATION, TRANSFORMATION

Enhancing Synergies Between Knowledge Systems in Climate Action and the Mobilization of Indigenous Knowledge at the Green Climate Fund

Jennifer Theresa Rubis
Green Climate Fund

The year was 2013 and my father was visiting me in Paris. There was a symposium on Indigenous Knowledge and Climate Change in UNESCO[1] and they needed an expert speaker: would he – an indigenous Dayak shaman from Borneo – come and speak? "What expert things do they want me to speak about?" he asked. "Maybe you could tell them about the different types of forest we have and how we look after them – you know like *obut* (communal forest), *tiboie* (forest that has been farmed), *toyah* (small orchard)," I said. "Oh, but that is nothing expert," he said, somewhat disappointed I was not going to let him talk about his theories about climate change (he would anyway): "Why would they want me to talk about things so simple that even our children should know?"

As the world grapples with global environmental challenges, there is an increasing need for more data and concrete solutions. Dialogues between knowledge systems, that of science and that of diverse knowledges, become a source of urgent interest, not just for the discovery of novel information held by each knowledge system, but for the potential to uncover innovative solutions and shifts in paradigms – potentially present when multiple knowledge systems are brought to bear on a common problem. In an era of multiple uncertainties, acquiring more knowledge rather than less becomes the logical strategy of any decision-maker, whether it be a pastoralist looking at the skies to decide the timing of when to move the herds, or a meteorologist looking at the same skies through instruments to opine on the probable forecast in oncoming days.

To be able to reach the important outcomes of a dialogue between holders of knowledge is not, though, a matter of simply bringing a pastoralist

[1] United Nations Educational, Scientific and Cultural Organization.

and meteorologist into one room, perhaps with interpreters, and engaging the experts in conversation. Attention needs to be paid to prosaic matters – the institutional arrangements and conditions in which dialogue can be productively held, as well as an understanding of the potential complexities of a dialogue between knowledge systems. One may imagine that enough barriers such as language and methodological bias may already exist between experts coming from multiple scientific disciplines that hamper mutual communication and understanding. Appreciate then the additional levels of 'translation' that both scientific experts and experts from Indigenous Knowledge systems must undergo to learn from one another. It is equally important to acknowledge the historical power imbalance at the start of any conversation on the subject of the meeting of these diverse knowledge systems, whether such efforts are done in the name of interdisciplinary collaboration, transdisciplinarity, knowledge co-production or braiding.

My contribution to this worthy volume is divided into two complementary areas, first a reflection on the history of Indigenous Knowledge and international science policy and second, an example of the mobilization of Indigenous knowledge at the Green Climate Fund.

However, if we were to go back to the beginning, it might be useful to recall that the first encounter between experts of Western science and Dayak knowledge would not have been with my father in a UN meeting room (or even with his long-suffering daughter in the years preceding), but a few hundred years earlier when European scientists, most likely botanists, first set foot in Borneo, accompanying the wave of Dutch or British colonizers. One could argue that modern botany and zoology owes not just finds of 'exotic' species to long forgotten local guides and their traditional knowledge, but their constructions of taxonomies which Ellen and Harris (2000) note were also 'borrowed' from local ways of classifying the natural world around them (Nakashima et al., 2012). Over the last six decades, science has gradually begun to shift in its attitude towards indigenous knowledge, with a steady change in approach, moving from 'importing' knowledge to recognizing and respecting knowledge as a distinctive 'other' source, to seeking areas of mutual exchange. Collaboration would grow particularly around health and biological diversity – for

> *Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices.*
>
> Principle 22, Rio Declaration

example knowledge of animals and plants, and associated production systems – for example on resource management in forest, water systems, agriculture, drylands, rangeland use etc.

In parallel, and due in no small part to the advocacy of Indigenous Peoples ourselves, a policy shift was also underway. Principle 22 of the Rio Declaration, the outcome of the 1992 Earth Summit, set in motion a global policy basis for intergovernmental engagement with Indigenous Peoples with the aim of achieving sustainable development. By linking indigenous knowledge to environmental management, the principle also provided the genesis for intergovernmental work on traditional knowledge, notably UNESCO's Local and Indigenous Knowledge Programme (LINKS) and Article 8(j) of the Convention on Biological Diversity. Established in 2012, the Intergovernmental Platform on Biodiversity and Ecosystem Services also incorporates a systematic and deliberative approach to ensuring Indigenous and Local Knowledge Systems are included in their assessments.

Alongside the Convention on Biological Diversity, the Earth Summit also saw the emergence of the United Nations Framework Convention on Climate Change. The growing concern with the worsening impacts of climate change has also increased research interest related to indigenous knowledge of weather and climate over the last few decades. Responding to the increasing mentions of indigenous knowledge in the regional chapters in the 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the authors of Working Group II of the Fifth Assessment Report sought a deliberative approach to incorporating consideration of indigenous knowledge by convening an international meeting on the topic in 2011 together with UNESCO's Local and Indigenous Knowledge Systems Programme and the United Nations University Traditional Knowledge Initiative. The 2011 meeting convened knowledge holders from Indigenous Peoples and local communities, indigenous knowledge experts and developing country scientists and produced three publications, including a review of the scientific and grey literature on indigenous knowledge of climate change assessment and adaptation that contained over three hundred sources and was made available to IPCC authors (Nakashima et al., 2012).

At this point it may be useful to explain why it is important to invest in a deliberative approach, as well as ensure that those with experience in Indigenous Knowledge, including Indigenous Peoples themselves, are involved in the design of the dialogues and encounters.

The voices from remote milieus and diverse ontologies are of no doubt compelling to the intellectual mind, but moving from mutual respect to building productive action and outcomes between knowledge systems may bring additional challenges. How can engagements and dialogues be productively designed to have clear knowledge outcomes, moving to joint decision-making and mobilization?

Knowledge systems are different and unique ways of knowing and understanding the world around us. Indigenous knowledge systems are dynamic, diverse and adaptive, transmitted across the generations and containing meticulous descriptions about the surrounding environment, and their production systems (Nakashima, Rubis, Bates and Avila, 2017). Nomadic pastoralists, for example, acquire expertise relevant for the well-being of their animals; clouds, birds and wind indicators portend the rains, soils that create good pasture, and they are able to study the land surface and water table. By contrast, western science acquires knowledge through high specialization and mastery of a specific but narrow domain. So when a single pastoralist expert discusses his knowledge relevant for adaptation, for science to completely understand, a meteorologist, biologist, hydrologist, ethnopedologist and an ethnolinguist would need to be at the table.

Nakashima, Krupnik and Rubis (2018) review early case studies on climate change that reveal some of these complexities (see Orlove, Chiang and Cane 2000, 2002; Weatherhead, Gearheard and Barry, 2010; Marin, 2010). For example, there are differences in what Indigenous Peoples need to observe versus what a scientist can observe – or provide as data. In the case of Marin (2010), Mongolian pastoralists analyzed the quality – as expressed in their local languages – rather than the quantity of rain – as measured by standard meteorological records. In the case of the Inuit, while scientists focus on averages, 'the primary preoccupations of indigenous observers of weather may be the intensity and frequency of peaks and lows' (Weatherhead, Gearheard and Barry, 2010).

The point being made is that as systems of knowledge, both Indigenous Knowledge and science bring unique contributions to bear towards solving a common problem – that of, in the words of the *Laudato Si'*, 'caring for our common home'. If it is recognized that these ways of knowing can be largely complementary but are fundamentally not meant to be validated by the other, then it should also be recognized that the spaces of engagement need to be mutually inclusive and deliberative approaches to Indigenous Knowledge are essential to avoid unintentionally subsuming it with science.

Mobilizing indigenous knowledge at the Green Climate Fund

The Green Climate Fund (GCF or the Fund) is the world's largest fund dedicated solely to supporting developing countries' climate action. Established in 2010, the GCF serves as a finance mechanism of the United Nations Framework Convention on Climate Change and the Paris Agreement. Reaching over 130 countries and with a growing portfolio of 300 projects and 15 billion US dollars committed in financing, the GCF provides rich opportunities for knowledge generation and learnings.

Within the Green Climate Fund's institutional framework are a number of arrangements that are instrumental to enhancing the perspectives of Indigenous Peoples, and their knowledge. These include the Governing Instrument of the Fund that identifies Indigenous Peoples as a distinct and separate stakeholder group of the Fund (UNFCCC, 2012, p. 66). From the Governing Instrument came a dedicated Indigenous Peoples Policy that was adopted at the nineteenth session of the GCF Board. As the main instrument that provides a structure for ensuring that GCF activities are developed and implemented in such a way that 'fosters full respect, promotion, and safeguarding of Indigenous Peoples so that they (a) benefit from GCF activities and projects in a culturally appropriate manner; and (b) do not suffer harm or adverse effects from the design and implementation of GCF-financed activities' (GCF, 2019, p. 4), the policy further sets out operational arrangements for GCF in order to effectively execute the policy. Among these are the establishment of a Fund-wide Indigenous Peoples Advisory Group (IPAG) and a dedicated specialist within the Secretariat vested with operational responsibility of the policy.

The IPAG aims to enhance coordination between GCF, its accredited entities, states and Indigenous Peoples. The three functions are: to provide advice on GCF-financed activities affecting Indigenous Peoples, to review implementation and monitoring of the Policy, and to provide guidance and advice to the Board as may be requested (GCF, 2019, p. 20). Members of IPAG are nominated through an Indigenous Peoples-led self-selection process and are Indigenous Peoples who come from the regions of developing states where GCF may fund activities (GCF, 2019, p. 20). Meetings of the IPAG are held twice a year at the GCF Headquarters, and updates on the work of the IPAG are provided to the GCF Board on a regular basis (GCF, 2022). The first membership term of the IPAG is from 2022-2026 and has six members. The IPAG provides a means through which Indigenous Peoples' concerns can be reflected and heard at an operational level.

The promotion and respect of indigenous knowledge is also taken up in the policy. In its objectives, the GCF Indigenous Peoples Policy highlights the importance of promoting traditional knowledge, recognizing the link between indigenous knowledge systems, and climate change leadership and mitigation and adaptation action. The policy recognizes inherent characteristics of indigenous knowledge systems, including that it is holistic, linked to culture and heritage, and that there are gender dimensions.

In practice then, these frameworks enhance the tracking and collation of good practices on indigenous knowledge on climate. Most projects where communities are encouraged to promote their indigenous knowledge within the Fund are in adaptation. For example in Vanuatu, the Secretariat of the Pacific Regional Environment Programme is working with the Government of Vanuatu through the Vanuatu Meteorology and Geo-Hazards Department (VMGHD) toward a greater understanding of climate patterns to ensure adaptation planning is informed by the right data by building on indigenous knowledge systems.[2] By coupling participatory methods and mobile apps, local communities are also encouraged to contribute their observations to the VMGHD. In terms of mitigation, Indigenous Peoples in Ecuador are using their Indigenous Knowledge to sustainably manage their forest resources through community-built Life Plans.[3]

Crucial to understanding the potential that Indigenous knowledge can play in climate action, and the role of Indigenous Peoples as climate leaders, is the example of Australian First Nation fire knowledge (see Box 1.1). Through the Green Climate Fund's Readiness Programme, seven developing countries[4] are given the building blocks to improve their management of wildfires through knowledge transfer from Indigenous Peoples of Australia, a demonstration of Indigenous Knowledge as a source of innovation.

Being a financial mechanism of the UNFCCC, the Fund receives guidance from the Conference of Parties (COP), the decision-making body of the UNFCCC. Keenly concerned with the need to ensure that all knowledge was made available for decision-making, and aware of the importance of Indigenous Knowledge for adaptation to climate change, the COP made

[2] https://www.greenclimate.fund/project/fp035

[3] https://www.greenclimate.fund/project/fp019

[4] For example https://www.greenclimate.fund/document/advancing-national-approach-fire-management-guatemala; https://www.greenclimate.fund/document/traditional-savanna-fire-management-readiness-proposal-facilitate-emissions-reductions

a particular point of highlighting the issue in several decisions[5] *inter alia* to request the Fund to 'enhance consideration of local, indigenous and traditional knowledge and practices and their integration into adaptation planning and practices, as well as procedures for monitoring, evaluation and reporting'. A key response by the GCF Board has been the decision to recognize that 'traditional, local and indigenous knowledge and practices is sufficient to form the basis for the demonstration of impact potential for GCF-supported activities' (subparagraph (h) of Decision B33/12 in Green Climate Fund, 2022). In practice therefore, partners may work with the GCF to elaborate rationale for climate impact based on available knowledge.

These case studies demonstrate just a few avenues through which Indigenous Knowledge for climate action is promoted and supported at the Fund. These avenues would not be possible without a deliberative approach to Indigenous Knowledge that is embedded both into the operations and institutional framework of the Fund. These also demonstrate the richness and possibilities of the contributions that Indigenous Peoples, and their knowledge systems, can bring to solving the various global challenges of our time. What is clear is that in order to achieve collective action one needs to reach beyond mutual respect and address the need for strategic and dedicated resourcing that overcomes historic biases and builds inclusivity into the institution.

[5] Decision 4/CP.20, Paragraph 4 (UNFCCC, 2015), Decision 6/CP.26, Paragraph 7 (UNFCCC, 2022), Decision 16/CP.27, Paragraph 20.

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Indigenous-led Solutions and the Extensive Corridors Approach – at the Heart of Climate and Nature Action

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1. Introduction

With global warming and the escalating loss of biodiversity threatening the planet's life support systems, the need for effective and lasting solutions has never been greater. Over the past three decades, there has been a growing awareness of the critical role of tropical rainforests as the linchpin of these two interlinked global challenges. Although they cover a mere 6% of the Earth's terrestrial surface, they harbor up to 80% of all animal and plant species and contain about 50% of all carbon stored in live biomass.

At the same time, the role of indigenous peoples as stewards of natural landscapes, who have contributed to the preservation and enrichment of ecosystems for thousands of years, has also gained recognition. Research consistently shows that areas stewarded by indigenous peoples continue to be among the best-preserved natural environments on Earth, harboring greater biodiversity and storing more carbon per hectare than most areas under other forms of management and protection. Their deep knowledge of the natural world combined with a holistic approach to its stewardship, is at the heart of their success.

Perhaps more than others, indigenous peoples tend to perceive and treat the environment in which they live as much more than the sum of its parts. Their holistic relationship to their ancestral territories – often vast and contiguous natural landscapes – harmonizes well with the preservation of natural environments which, in both their spatial and symbiotic interconnectedness, produce the ecosystem services on which we all depend. Efforts to halt the ongoing destruction of our natural world must, to a much larger degree, draw on these realities and align the financial and strategic support for the conservation of nature accordingly.

2. Indigenous peoples' knowledge of tropical rainforests

The extreme diversity of plants and animal species in a tropical rainforest is characterized by a small number of individual species per geographical unit. Plants and animals are widely scattered. This is the opposite of the African savannah, where we find vast grasslands with huge herds of antelopes, gazelles, and buffaloes. In the Amazon, almost all animals are solitary or live in pairs. An exception is one of the two species of wild boar, which can roam in groups of more than 100 animals. The same dispersion applies to most tree species – including those that bear edible fruit. There can easily be hundreds or even thousands of meters between two trees of the same species.

This basic ecological characteristic means that it requires in-depth knowledge and a very advanced, versatile resource strategy to live well in this complex environment. Scientists have, time and again, been impressed by the intimate knowledge and high level of observational skills they encounter when visiting traditional rainforest communities.

The same admiration applies to the extensive knowledge of the medicinal properties of a variety of plant stems, roots, leaves and barks that is often found. And although the untrained eye perceives an intact stretch of rainforest as "virgin" or untouched, the botanist or ethnobotanist has long ago concluded that large parts of the vast Amazon rainforest have been care-

Figure 1. Indigenous rainforest peoples are intimately connected to their forest environment. Here are some members of Waiãpi people, Brazil. Photo: Bo Mathisen.

fully managed or manipulated over generations, so that the occurrence of trees useful to humans and animals is higher than if it had been left to itself.

Societies and peoples who live in the rainforest and have adapted to it over generations are connected to their natural environment in ways that urban, so-called modern people may completely overlook or fail to understand. The environment in which they feel at home is the forest. The stories they have heard from their grandparents are rooted in their forest environment. Their mythologies and fairy tales come from the forest. Their sacred places are there. We may say that where the so-called modern man is concerned with the value, or potential value, of the forest and the resources it contains, forest peoples value the forest as home, as the basis for a good life and as the foundation for their future.

We should neither forget nor underestimate the many social values found in traditional rainforest societies: Reciprocity, autonomy, no or minimal hierarchy, plenty of time for social activities, a high degree of individual freedom and a warm, safe and unconstrained upbringing of children. This is not to say that everything is better in traditional rainforest societies, but we should not take the opposite for granted either. Modern society and modern life lack many of the qualities found in traditional rainforest societies, and it might do us all good to be open to mutual learning and to strive for interaction based on equality.

Indigenous forest peoples have proven that they are capable of living well in an extremely complex and therefore challenging environment, and we should rejoice when they continue to choose their own alternative models for their future – even after they have become more familiar with the modern, industrialized and globalized societies that surround their forest areas.

3. Preventing fragmentation and restoring connectivity

When humans cut up natural landscapes into increasingly smaller pieces, plants and animals struggle to survive. Habitat fragmentation is one of the greatest threats to the world's biodiversity. In forests, it can reduce the richness of animal and plant species by up to 75%, depending on the size of the fragments.

The areas of a forest that are within 1 km of the forest edge are less productive than interior forests, with increased tree mortality and lower biodiversity, carbon storage, and water recycling capacity.[1] The closer to the edge, the stronger this "edge effect". As contiguous forests are progressively fragmented into islands of smaller forest patches, mainly through infrastructure development and agricultural expansion, the impact of the edge effect on the entire forest biome increases. Today, more than 70% of the world's forests are less than 1 km from a forest edge, and almost 20% are less than 100 meters from the edge.[2] In the Brazilian Amazon, humans are creating up to 50,000 km of new forest edges every year.[3]

The ability of our planet to provide vital ecosystem services is closely linked to the spatial connectivity of its natural landscapes. Large, connected biomes enable the natural processes of migration, gene flow, adaptation, and nutrient recycling, contributing to genetic variability and ecosystem resilience to environmental change.[4] Therefore, climate and biodiversity goals can only be achieved if conservation efforts are more strongly focused on the integral management of large blocks of contiguous natural environments and on restoring ecosystem connectivity where it has been lost.

The connection of indigenous peoples with the natural environment in which they live has a deep, holistic dimension, embedded in their cultural, spiritual, and social practices. Their worldview often recognizes the interconnectedness of all elements of a natural landscape and views the land not as a commodity, but as a complex living entity with which they have an intimate relationship. This provides a comprehensive foundation that is particularly conducive to effective conservation of large interconnected natural landscapes.

4. Promising initiatives and solutions that all need additional support and upscaling

4.1 Territorial corridors of isolated indigenous peoples in Brazil and Peru

The border region of Peru and Brazil is the location of the two largest contiguous areas in the world inhabited by indigenous peoples who live have chosen to live without contact or drastically limit contact with the outside world.

Combined, the two territorial corridors cover 250,000 km^2, an area larger than the United Kingdom, and consist almost entirely of pristine tropical rainforest. They are of true world heritage quality, both culturally and ecologically. There is still virtually no infrastructural development here, and deforestation and degradation are very low. Nevertheless, both areas are under rapidly increasing pressure from a range of legal and illegal activities such as logging, mining, and road building.

Combined, these areas store a total of 26 billion tons of CO_2, equivalent to the United States' emissions over 5 years. At the same time, they seques-

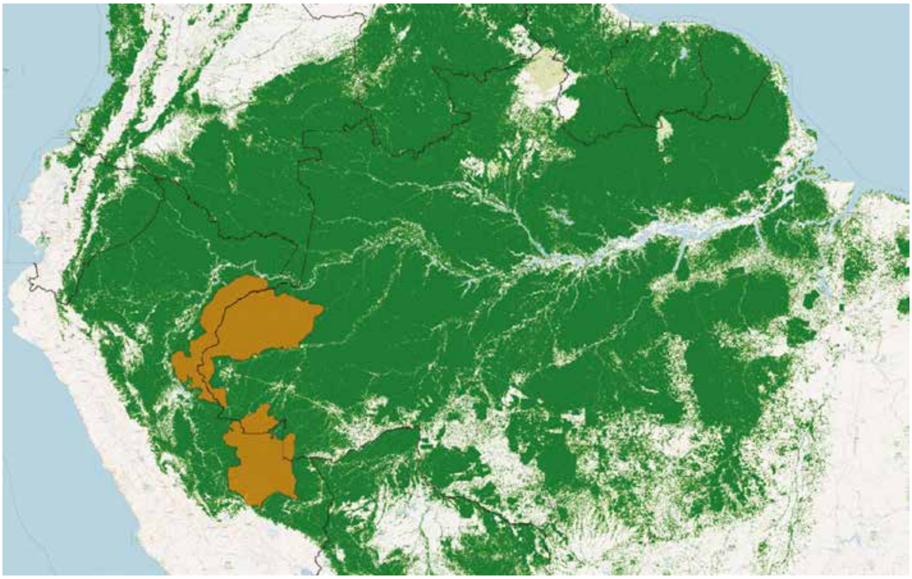

Figure 2. The two proposed territorial corridors for isolated indigenous peoples represent 5% of the entire Amazon.

ter 50 million tons of CO_2 every year – equivalent to Norway's total annual greenhouse gas emissions. The high degree of forest intactness and the remote location in the western Amazon basin indicate that these areas harbor a richer biodiversity than most other places on earth.

Isolated indigenous peoples (also referred to as uncontacted tribes) are entire ethnic groups or parts thereof that have chosen to not make contact with people from the surrounding society. They present a very high degree of autonomy and are neither familiar with nor integrated into the culture, laws, and regulations of the nation-state in which they are located. They also tend to avoid contact with other neighboring indigenous peoples.

Contact with outsiders carries the risk of being exposed to infectious diseases against which they have no immunological resistance. A common cold or flu can easily turn into a deadly epidemic, which can wipe out more than 50% of the population within a terrifying short period. Any major damage to the environment upon which they depend and have stewarded sustainably for generations may lead to starvation, forced migration, and violent conflict with neighboring peoples. The same is true if the interconnectedness of their vast territories is broken.

The catastrophic history of forced contact with outsiders has made it clear that the best way to protect the right of isolated indigenous peoples to life and health, culture, land and self-determination is to respect their decision to live without contact with our modern, industrialized society. This is also enshrined in law in Peru and public policy in Brazil.

After decades of research, conducted mainly by indigenous organizations in Peru and the National Government Agency for Indigenous Peoples in Brazil (FUNAI), it was clear that these unique indigenous societies are stewards of incredibly large and contiguous rainforest territories. Their historical presence here and close relationship with the forest are the very reasons for the continued existence of these two well-preserved rainforest areas. Securing their basic human rights is therefore tantamount to preserving the rainforest ecology in their territories and preventing the fragmentation of some of the largest contiguous intact tropical rainforests left on earth.

In a groundbreaking demonstration of solidarity and commitment to safeguarding the rights and territories of the isolated indigenous peoples, indigenous organizations from Peru and Brazil have joined forces to create and implement a pioneering initiative. At the core of the strategy lies the involvement of the hundreds of local communities who inhabit the buffer zones of these corridors and where they border and share territory with their isolated brothers and sisters.

Through strengthened local governance and tenure rights, and enhanced territorial management and protection, the local communities and their representative organizations will form an effective shield against the emerging threats – both as on-the-ground barriers against destructive intrusion, and as grassroot alliances strong enough to influence political decisions and private companies.

The initiative emphasizes broad cross-sectoral cooperation between relevant state and civil society actors and requires financial support in line with its huge spatial and strategic dimensions. Alone, the protection of these unique territorial corridors represents 0.6% of the entire global 30x30 target of the Convention on Biological Diversity.

4.2 Contiguous Pygmy Indigenous Peoples' territories in the Democratic Republic of Congo

Central Africa harbors the world's second-largest contiguous tropical rainforest, of which 58% is located in the Democratic Republic of the Congo (DRC).

Among the many ethnic groups inhabiting the region, the indigenous peoples commonly known as Pygmies (and self-identified as Batwa, Baka, Mbuti, etc.) are characterized by their deep historical and spiritual ties to the forest. According to anthropologist Jerome Lewis of Britain's Royal Anthropological Institute, the Pygmy indigenous peoples are direct descendants of the very first people to colonize the Central African rainforest some 100,000 years ago. They have played a pivotal role in shaping the cultural mosaic of this remarkable forest biome. As custodians of ancestral knowledge and stewards of vast rainforest landscapes, Pygmy communities are integral to the preservation of culture, knowledge, biodiversity and the interconnectedness of the vast Central African rainforest.

Until recently, little was known about the total extent of the land inhabited and used by Pygmy indigenous peoples in DRC. This knowledge gap, combined with a complete lack of official acknowledgement of indigenous peoples in DRC, have prevented progress in the recognition of Pygmy indigenous peoples' right to their traditional land. To counteract this, the in-

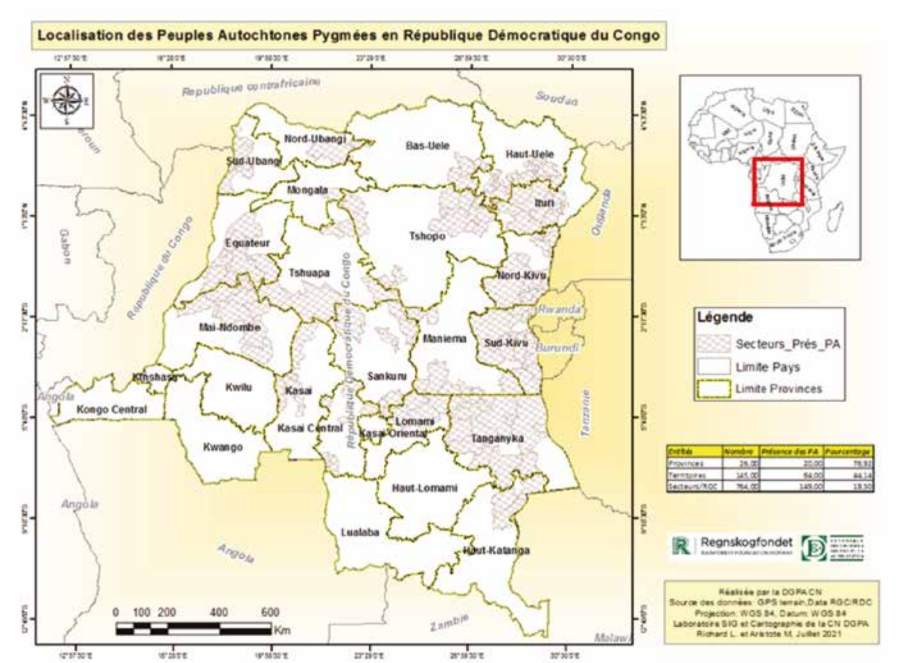

Figure 3. The territories of Pygmy indigenous peoples in DRC cover at least 240,000 km².

digenous organization "Dynamique des Groupes des Peuples Autochtones" (DGPA) have long advocated for a national legislation in favour of Pygmy indigenous peoples' land rights and has carried out an extensive, collaborative mapping initiative to create a comprehensive atlas that provide evidence for and visualizes the true location and extent of the vast territories of these ancient indigenous groups.

The atlas is a scientific tool presenting the history, way of life, habits, and traditions of the Pygmy indigenous peoples throughout the national territory of DRC. Rich in relevant and reliable information derived from participatory fieldwork with indigenous Pygmy communities and other stakeholders, this tool contains monographic data and maps of indigenous Pygmy locations superimposed on other allocations throughout the country.

The maps provide geographical reference points for visualizing the traditional areas of Pygmy indigenous peoples in the DRC in relation to natural biotopes located in their traditional territories, and areas of extractive or sectoral activity, with a view to understanding legal, social, economic, environmental and cultural problems created by the superimposition of the rights of different users over their ancestral lands. They show the location of indigenous Pygmy territories in relation to protected areas, forest concessions, intact forests, mining permits, petroleum permits, and vegetation types.

In the wake of the huge victory of the approval of the 2022 national Law for Pygmy indigenous peoples' land rights, DGPA and allies have elaborated a comprehensive strategy for the legal recognition and sustainable management of the Pygmy indigenous peoples' territories that have already been mapped in the atlas. In total, this unprecedented tenure initiative will cover at least 240, 000 km^2 of contiguous tropical rainforest in DRC, and this is just the first phase. The mapping and advocacy for recognition of Pygmy indigenous peoples' territories in DRC will continue and it represent the most significant contribution towards securing the vital interconnectivity of the vast Central African rainforest.

By mapping the contiguous territories of the Pygmy indigenous peoples, the aim is to provide a foundation for evidence-based advocacy, promoting awareness and collaboration for the conservation of DRC's vast contiguous rainforests by supporting the continued existence and prosperity of the indigenous Pygmy populations on their traditional territories.

4.3 Eastern Indonesia Forest Facility

Indonesian non-governmental organizations EcoNusa and Bentara are working closely with indigenous and other local communities in Eastern

Indonesia, focusing on Papua and the Maluku islands. Culturally and linguistically extremely diverse, with more than 500 languages spoken, Eastern Indonesia also contains Asia's largest tracts of intact, contiguous, biologically mega-diverse rainforest – which is why this area is also coveted by all sorts of economic interest groups.

Together with local indigenous communities, these two NGOs have managed, from 2019 to 2023, to facilitate the participatory mapping of 4,520 km^2 of community lands, essential for obtaining recognition of their ancestral land rights. 120 village natural resource management plans have been submitted to the relevant authorities during this period, and a series of ecologically sustainable income opportunities have been developed. Ongoing community-based income-generating activities range from the cultivation and commercialization of a series of spices, like the Banda nutmeg from Maluku and Negeri nutmeg from Papua, cloves, cinnamon, and vanilla, to the gathering of the very nutritious almond-like Kenari nuts, and the production of high-quality Ransiki cocoa and organic Papuan coffee. USD 1,2 million have been distributed to 45 indigenous communities through the EcoFund created within the project (see EcoNusa website) [5], including to 13 local cooperatives. The social enterprise Kobumi (see Kobumi website)[6] has been created, marketing the products from the 13 member cooperatives through a joint attractive products website, where orders can be placed.

We all know that the island of New Guinea is essential for the future of the mega-diverse rainforest of Asia and Oceania, and it is thus very encouraging to see that the project has been instrumental in having 3,700 km^2 of irregular and illegal palm-oil concessions cancelled during this period. This means that some 60 million tons of carbon continue to be stored on lands that would otherwise have become oil palm plantations. An area this size, if completely deforested to allow for plantation activities, would have emitted some 220 million tons of CO_2 – or equivalent to what my country, Norway, emits in five and a half years.

Investing in such initiatives is essential, and it does two things. It avoids destruction of nature and local peoples' livelihoods, exacerbating the climate and biodiversity crises, and it invigorates local solutions for creating social development while maintaining the forest environment that is the foundation for their culture and way of life. All of these economic and social initiatives are viable and working – but they could easily be scaled up manyfold through increased support.

4.4 The Pará-Amapá Corridor in a Mosaic Context

The Mosaic of Western Amapá and Northern Pará (called "Eastern Amazon Mosaic") covers part of the Guianas Plateau, a region known for its rich biodiversity and sociocultural diversity. It covers almost 123,000 km² and is composed of three indigenous territories and six conservation units. Recognized in 2013 by the Brazilian Ministry of Environment, it is one of 17 officially recognized federal mosaics in Brazil, and the first (and still the only one) to include Indigenous territories.

The legislation on mosaics in Brazil, LEI FEDERAL Nº 9.985-00 Art. 26, was approved in the year 2000 and defines the following: "When there is a set of conservation units of different categories or not, close, juxtaposed or overlapping, and other public or private protected areas, constituting a mosaic, the management of the set must be carried out in an integrated and participatory manner, considering its distinct conservation objectives, in order to reconcile the presence of biodiversity, the valorization of sociodiversity and sustainable development in the regional context."

Figure 4. The "Eastern Amazon Mosaic" in Brazil is an interconnected conservation area larger than Nicaragua.

Although the indigenous territories that make up parts of the mosaic are different from the other units, they form part of a single territorial mosaic, with the common goal of conserving the rainforest and its vast interconnectedness. To achieve this, it is vital that all land units in the mosaic be managed and administrated in an integrated manner. The management of mosaics is monitored by an Advisory Council, which in the case of the "Eastern Amazon Mosaic" is made up of 30 chairs – 14 of them governmental and 16 of them from civil society. It is within this council that decisions and discussions take place.

The Mosaic Council promotes public discussion forums and common management and protection strategies, and meetings between community groups such as youth – many of whom have become community leaders or work in conservation efforts. These strategies and meetings result in actions on forest conservation, contamination and forest destruction from mining, oil and gas exploration and the impacts of hydroelectric dams.

The Mosaic also has an executive secretariat, which is responsible for organizing meetings and making the necessary arrangements between the meetings. In times before the Bolsonaro government, the council had established working groups to take care of specific issues, such as environmental monitoring, where more technical discussions and referrals between government bodies could take place.

The "Eastern Amazon Mosaic" is a success story on collaborative efforts between different stakeholders to conserve a large, interconnected rainforest corridor backed by legislation. Unfortunately, it has not been followed-up by public commitments on financing. The financial backing required to operate at the scale envisioned by the mosaic legislation has been lacking and is mostly reliant on private donors. Recognizing the substantial positive impact of such collaborative conservation efforts on both global biodiversity and climate agendas, there emerges a pressing need to channel a greater portion of public and private funds dedicated to these issues toward such initiatives. This strategic allocation of resources is essential to sustain and expand the success story, ensuring the conservation of extensive rainforest corridors and their broader contributions to environmental and climate change mitigation outputs.

4.5 Forests for Life

Although the essential role of forests in reducing man-made climate change and protecting biological diversity has been increasingly recognized by decision-makers over the last 10 to 15 years, the particular importance

Figure 5. New and effective financial incentives for protecting high-integrity forests are urgently needed. Photo: Walter Silvera.

of intact, high-integrity forests continues to escape the needed attention. All forests are important, but the areas of large, contiguous, intact forest landscapes are crucial for upholding ecosystem services that are vital parts of the Earth's life-support systems: climate regulation, production and distribution of rainfall, maintenance of biological diversity, and the removal of massive amounts of carbon dioxide from the atmosphere to be stored as above- and below-ground carbon in vegetation and soil.

It is estimated that without the active role of high integrity forests in removing CO_2 from the atmosphere, the world would already have been 0.5°C hotter than it is today. And these forests also provide livelihood opportunities and natural resources for large populations, not least indigenous peoples and local communities who live in and manage some 35% of the world's most intact forests. Despite their essential functions, the main blocks of high integrity forests have declined by 12% between 2000 and 2020, and they are increasingly being threatened by fragmentation, encroachment, and degradation. Increasing the awareness of the unique importance of these large, intact forest landscapes – and thus prioritizing their protection in a real, effective and systematic way – is urgently needed.

Financing mechanisms in a climate context have tended to reward the reduction of deforestation and its associated climate gas emissions in countries and areas with high historical deforestation, and few financial incentives have been created for stimulating and rewarding the protection of high integrity forests. In order to enhance awareness, uplift priorities, develop new finance mechanisms and upscale effective protective measures on the ground, Wildlife Conservation Society, Rainforest Foundation Norway, UNDP, World Resources Institute, and Re:wild created the Forests for Life partnership in 2019. Each with different characteristics and strengths, the Forests for Life partners unite in making the vital role of high integrity forest known to decision-makers, develop and test new financial incentives for maintaining forest integrity, and collaborate on the ground where possible and feasible.

4.6 Indigenous-led funds and funding mechanisms

Given the essential historical and present-day role of Indigenous Peoples and Local Communities (IP&LCs) in managing and protecting huge forest areas and their biodiversity, it is both striking and outrageous how little funding, general support and investments that have been directed at supporting and strengthening traditional forest stewards. The indigenous movement has complained and presented demands for years.

Although numerous studies have documented the effectiveness of indigenous peoples and traditional forest communities in preventing deforestation and maintaining biodiversity through their collective management of ancestral territories, particularly when those territorial rights are officially recognized, only minimal fractions of public and private investments in climate mitigation and biodiversity preservation reach these peoples and communities. As documented by the Falling Short report in 2021, less than 1% of the official development assistance for climate change mitigation and adaptation was dedicated to Indigenous Peoples and Local Communities' tenure and forest management in tropical countries. And of this less than 1%, only a fraction actually reaches communities on the ground – as only 17% of the projects in this category even mentions the name of an IPLC organization in their implementation documents.

The encouraging news is that more and more indigenous organizations and initiatives are presently developing their own, indigenous-led funds and funding mechanisms. The Global Alliance of Territorial Communities (GATC) has launched the Shandia Vision, focused on ensuring that indigenous peoples and local communities have access to direct funding for actions that combat climate change, conserve biodiversity and sustain their rights and self-determined development in their own territories, based on identity and traditional knowledge. The Alliance, with member organizations based in Indonesia, Central Africa, Central and South America, are advocating strongly for a fundamental reform in funding streams, monitoring progress, requesting more adequate and meaningful donor requirements, strengthening local capacity for financial management, and developing their own funds. The Nusantara Fund in Indonesia and the Mesoamerican Territorial Fund are examples of this.

Likewise, national, regional and local funds or funding mechanisms are being developed and discussed in many corners of the world. The Podaali Fund, created by the indigenous umbrella organization for the Brazilian Amazon (COIAB), covers all of the Brazilian Amazon and is quite advanced. And so is the regional indigenous fund for Rio Negro (FIRN), managed by the indigenous organization FOIRN. In the DRC, a special funding mechanism, the IPLC Forest Facility, has been created exactly for facilitating and increasing funding to local communities in forest areas. In Asia, the Indigenous Peoples of Asia Solidarity Fund (IPAS), meant to support indigenous peoples in all of Asia, has developed a solid governance structure and an ambitious 2024-2028 strategy, and is presently seeking funding. And there are many more at national levels, like the Kehati Foundation and the Credit Union Pancur Kasih in Indonesia.

The 1.7-billion-dollar pledge made by the so-called Forest Tenure Funders Group during the UNFCCC climate conference in Glasgow in 2021 to support the advancement of Indigenous and community forest tenure, marked a breakthrough for this agenda, and funders are presently busy delivering on their pledges while investigating the best and most effective ways for reaching the ground. The key task now, for donors, environmental organizations and philanthropists in general, is to challenge their own preconceptions, traditional routines and bureaucratic practices, and engaging directly with local communities and their representative organizations, prioritizing results on the ground over formalities.

5. Conclusion

The protection and sustainable management of large contiguous natural landscapes to prevent ecosystem degradation and fragmentation stand as a critical imperative for the preservation of global biodiversity and the mitigation of climate change. This report highlights the crucial role indigenous peoples play as stewards of tropical rainforests, drawing attention to the delicate balance between extensive interconnected natural landscapes, biodiversity preservation, climate change mitigation, and traditional knowledge and practices.

The immense importance of extensive interconnected tropical rainforests must be unequivocally embedded in the national plans aimed at achieving the 2030 targets outlined in the Global Biodiversity Framework. The fulfillment of a nation's commitment to target 1, "to bring the loss of areas of high biodiversity importance, including ecosystems of high ecological integrity, close to zero by 2030, while respecting the rights of indigenous peoples and local communities", necessitates a comprehensive and uncompromising approach to safeguarding tropical rainforests in their entirety. Any national plan for the preservation of biodiversity by a tropical forest country that overlooks this reality is inherently poised for failure. It is simply not possible to end, or even significantly reduce, the loss of biodiversity by conserving bits and pieces of otherwise vast, contiguous tropical rainforests or any other high-productive natural landscape. Which is also why substantial international financial support is needed, if we are to succeed.

The intricate relationship between biological diversity and climate change underscores the need for an approach that acknowledges the mutual dependence inherent in the two global frameworks addressing these critical issues. To attain meaningful progress, funding levels must be commensurate with the urgency and scale of the challenges. It will require a multi-faceted approach that combines public and private funding, international cooperation, and innovative financial mechanisms aligned with a holistic approach that can secure vast contiguous natural landscapes.

This comprehensive strategy, aligned with evolving scientific insights and respect for indigenous peoples' rights, holds the key to fostering a resilient and balanced coexistence between humanity and the intricate web of life on our planet.

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Traditional Indigenous Knowledge vs Scientific Knowledge in Addressing Climate Change

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As Africa, Kenya, to be exact, just like the rest of the world today, experiences severe problems due to climate change, there has never been a critical time to examine and apply different sources of wisdom and knowledge to combat climate change challenges like now. Indigenous people's knowledge remains one such viable and vital resource that should not only be nurtured and improved but also put into use by governments and communities across the globe.

Today, I want to discuss the crucial role of Indigenous people's knowledge about climate change mitigation and adaptation in Africa. This continent remains one of the most affected, despite her decimal contribution to climate change and the potential of indigenous people's knowledge in promoting sustainable climate change actions.

The Maasai have a fascinating culture and a strong connection with the environment; for the longest time, Maasai people have remained faithful to their culture and traditional knowledge, which, among several other things, perceive natural resources, like grazing land and water, as a great treasure that must be protected and respected. They subscribe to the ideology that Enkai-God created cows for them and bestowed the responsibility of taking care of all grazing land (nature) on them. They deeply respect the environment and recognize the interconnectedness of nature and life. This understanding inspires me as an indigenous Maasai to examine the potential of indigenous knowledge in addressing climate change problems.

I would like to examine how the wisdom of the indigenous Maasai community and other communities can lead to climate change mitigation and adaptation efforts and discuss opportunities and challenges that lie ahead as we strive to integrate this Indigenous knowledge into our modern world.

Knowing Indigenous Knowledge

Indigenous knowledge, also called local or traditional knowledge, is the collective practices, beliefs, and wisdom held by Indigenous communities that have been passed down through generations. The indigenous Maasai people, for example, have a deep knowledge that is deeply rooted and connected to their resources, environment, and land. Indigenous knowledge is usually based on an intimate apprehension of the natural world and experiential learning, enabling these communities to flourish in their ecosystems.

Indigenous knowledge plays a vital role in the lives of these communities, informing their cultural practices, decision-making processes, and resource management. Indigenous knowledge is invaluable, as it not only assists the well-being of Indigenous communities but can also provide insight into environmental management and sustainable development for the broader global community.

I live in Kenya, where I've engaged with members of my indigenous communities at different levels. As a Maasai, we have a traditional way of conserving grazing lands and are semi-nomadic pastoralists. Through generations, we have lived closely with the land and developed an intricate understanding of grazing ecology, from using predictions made by rainmakers to using controlled grazing to increase the harvestable yield of forages by more effective and efficient harvesting, reduce fossil fuel energy, and maintain the health of their grazing lands. In one of my conversations with community elders, I noted that these cultural practices, refined over several years, should be addressed in modern-day environmental management strategies, for example, predictions made by traditional weather forecasters. As a result, we have seen severe impacts of climate change, such as the recent massive loss of livestock due to prolonged drought.

This experience made me realize the importance of recognizing and valuing indigenous knowledge as a resource for addressing contemporary environmental challenges, such as early warning of drought or rain and climate change mitigation.

The Profound Link Indigenous Communities Have with Their Environment

Indigenous Maasai communities possess a profound and intricate connection with their environment, usually at the center of their identity, culture, and spirituality. This connection is forged through years of living in peace and harmony with nature, depending on the land and its resources for sustenance, well-being, and shelter. For indigenous Maasai peoples, the environment is not seen as a different entity but as an integral part of their existence, where all living beings are interdependent and interconnected.

This holistic worldview fosters a sense of obligation towards the environment and resource management and encourages sustainable practices prioritizing long-term environmental balance over short-term benefits. Indigenous Maasai communities have, for centuries, formulated a wealth of knowledge and strategies to hold the health of their ecosystems, which may give valuable insights for modern societies as we address the challenges of environmental degradation and climate change.

The Indigenous Maasai community offers an impressive example of an enduring and successful relationship with the land. Despite years of globalization and external pressures, the Maasai have managed to conserve their traditional way of life, which is deeply tangled with their surrounding ecosystem. The Maasai people believe in the central human figure in the religious system called *laibon*, whose duties include healing, divination, prophecy and ensuring success in getting adequate rainfall.

The Maasai spiritual leaders are liable for ensuring the environment's well-being through mediation and sustainable resource management. Additionally, the Maasai community's agricultural practices stressed agroforestry, terracing, and crop rotation, permitting them to prevent soil erosion and maintain soil fertility, as an example of how indigenous Maasai knowledge contributes to sustainable land management.

The nomadic way of life practiced by the Maasai depicts their immense understanding of the natural world and their responsibility to maintain and protect the balance of the environment. In practice, the Maasai relied heavily on the traditional weather forecasters to make migratory decisions that would allow land in a given area to rest and regenerate. When migrating with their livestock, the Maasai people ensured that ecosystems could recover and regenerate, maintaining their long-term health and productivity. A practice that exhibits a deep respect for the environment and a profound apprehension of the need to manage resources sustainably. By learning from and embracing these indigenous practices, modern societies could develop more efficient and effective land management strategies and contribute to a more sustainable future.

Traditional Adaptation Strategies

Indigenous communities have also long demonstrated significant adaptability and resilience concerning environmental changes. Over generations, indigenous Maasai communities developed a wealth of traditional adaptation strategies that allowed them to thrive within their respective ecosystems. These strategies were often based on a profound understanding of their local environment and the natural cycles that govern it.

Construction of resilient housing, seasonal migration, the establishment of communal resource management systems, and the cultivation of diverse crops to ensure food security were some of the strategies adopted by the Maasai. These practices, evolved over centuries, enabled the indigenous Maasai community to cope with and adapt to different environmental stressors, such as changes in temperature, precipitation, and resource availability.

Today, the Maasai community faces harsh environmental conditions, such as extreme altitude, prolonged droughts, and variable precipitation. To cope with these challenges, they have resorted to the construction of water pans to harness rainwater, terraced farming systems, agroforestry, adoption of new technology in farming, and microclimate that help in the cultivation of different crops.

One will automatically be impressed by the extensive knowledge of Maasai women's beading and weaving skills, which they use to ensure that they reduce their reliance on rain-fed agriculture and over-reliance on livestock as a source of livelihood as the weather patterns are no longer predictable. By indulging in other income-generating activities and adopting new agricultural technology, the Maasai community is now able to adapt to climate fluctuations.

Modern Applications of Indigenous Knowledge

Indigenous knowledge can provide important lessons and insights for modern climate change adaptation efforts since it is rooted in a profound understanding of local environments and the natural processes that govern them. By drawing on the wisdom and experience of indigenous communities, we can develop more efficient and effective climate change adaptation strategies that address the unique challenges faced by different ecosystems and regions.

By incorporating Indigenous knowledge into climate change adaptation efforts, we will foster a sense of empowerment and ownership among local communities and encourage their active participation in developing and implementing these strategies, thereby leading to more sustainable outcomes and assisting in bridging the gap between modern science and traditional practices.

Examples of Successful Projects that Incorporate Indigenous Knowledge

The Indigenous Guardians program in northern Canada has empowered First World communities to protect and monitor their traditional territories, manage resources, and draw on their ancestral knowledge of the land.

This initiative has resulted in establishing indigenous-led climate adaptation strategies, like restoring wetlands to address flooding.

In India and Bangladesh, the traditional knowledge of honey collectors and local fishermen has been used to develop early warning systems for storm surges and cyclones. These systems, which integrate indigenous knowledge of tidal changes, wind patterns, and animal behavior, have saved countless lives and enhanced community readiness in the face of extreme weather events.

Traditional knowledge of coastal ecosystems, sustainable resource management, and weather patterns in the Pacific Islands has been integrated into community-based climate change adaptation plans. By incorporating indigenous knowledge with modern science, these systems have assisted communities in the region in better preparing and understanding the impacts of changing weather patterns, coastal erosion, and sea-level rise.

These examples depict the great potential of Indigenous knowledge to improve modern climate change adaptation efforts, mutual learning, and showcasing the benefits of collaboration between Indigenous communities and the broader global community.

Indigenous Knowledge and Climate Change Mitigation

Indigenous communities have long had practices, such as land management practices, consistently recognized for their contributions to climate change mitigation. Additionally, these practices have changed over time and often prioritize the sustainable use and conservation of resources, ensuring ecosystems' long-term health and resilience. Maintaining and promoting biodiversity, the balance of natural processes, and indigenous land management practices can help reduce greenhouse gas emissions, sequester carbon, and increase ecosystems' capacity to withstand climate change's effects.

In Brazil, the indigenous communities living in the Amazon forest have adopted exemplary land management practices. Through their informal knowledge of the forest ecosystem, the community developed a sustainable agricultural system called "chakra," which entails cultivating various crops in small clearings, thereby mimicking the natural regeneration of the forest.

This approach not only ensures that the community is food secure but also conserves the integrity of the forest ecosystem and maintains its capacity to keep carbon and support a rich diversity of animal and plant life. The Indigenous community also practices selective timber harvesting, removing only specific trees, allowing the forest to regenerate naturally. With such an exemplary land management practice, it is vividly clear that Indigenous knowledge can inspire and inform modern efforts to mitigate climate change.

The Importance of Collaboration between Indigenous Communities and Modern Societies

Fusion between modern societies and indigenous communities remains critical to the fight against climate change. By merging the scientific advancements and resources of contemporary societies with the traditional wisdom of indigenous peoples, we can develop more sustainable, efficient, and effective mitigation strategies. This merger will foster understanding and mutual learning and empower indigenous communities by valuing and recognizing their contributions to global climate action.

Engaging indigenous communities in decision-making also ensures that their cultural values, interests, and rights are respected and protected. This comprehensive approach may result in more sustainable and equitable outcomes that benefit the broader global community and indigenous peoples.

Examples of Successful Collaborative Projects for Climate Change Mitigation

The Indigenous Dayak people of Indonesia have partnered with both non-governmental organizations and the government to implement reducing emissions from deforestation and forest degradation programs. The program seeks to protect the forests of Borneo through supporting community-based forest management, drawing on the traditional practices and knowledge of the Dayak people. As a result of this collaboration, there has been a significant decline in carbon emissions due to a decrease in deforestation.

The indigenous Zapotec and Chinantec communities of Mexico have merged with the National Forestry Commission to implement sustainable forest management practices that preserve biodiversity and reduce greenhouse gas emissions. By combining modern technologies with traditional knowledge, the project has successfully promoted sustainable livelihoods, conservation of local ecosystems, and reforestation.

The above example provides an insight into the power of collaboration between modern societies and indigenous communities in addressing climate change.

Opportunities and Challenges in Integrating Indigenous Knowledge

Integrating indigenous knowledge into modern climate change mitigation and adaptation efforts has its fair share of challenges.

Erosion of culture: fusion between modern science and traditional knowledge may result in erosion of cultural identity, and the indigenous people may lose control of their resources or even get marginalized.

Misappropriation and exploitation of Indigenous knowledge: many times, traditional knowledge has always been used either consciously or subconsciously without proper acknowledgment or proper consent from the Indigenous community.

There is a potential clash between scientific and traditional perspectives; both conventional and scientific perspectives subscribe to different environmental notions and approaches, thereby, resulting in misunderstanding, resistance to partnerships, and mistrust.

These factors may make it hard for Indigenous communities to participate fully in climate change mitigation and adaptation efforts and may result in their exclusion from decision-making processes.

Opportunities for Sustainable Development through the Integration of Indigenous Knowledge

As submitted, integrating Indigenous knowledge into sustainable development efforts creates opportunities for creating more equitable, resilient, environmentally sound, and valid solutions. By incorporating and valuing the wisdom of indigenous communities, we can make context-specific strategies that solve the unique problems faced by different ecosystems and regions. Indigenous knowledge can give an insight into sustainable resource management, traditional adaptation strategies, and conservation practices, all of which can help modern societies respond better to the problems posed by climate change.

In a future where indigenous knowledge is more widely respected and embraced, we would see a world that values and celebrates the diverse wisdom of all its inhabitants. Indigenous communities would be acknowledged as equal partners in the quest for sustainable development and climate change mitigation, with their rights, interests, and cultural values protected and promoted.

In this vision, indigenous communities and modern societies would work together to develop innovative solutions that blend scientific advancements with traditional wisdom. This partnership would lead to more suitable and sustainable resource management practices, more effective and efficient climate adaptation strategies, and a greater understanding of the intricate connections between man and his environment.

Integrating indigenous knowledge would also speed up great cultural awareness and appreciation, help break down barriers, and promote mutual understanding, besides creating a more just and equitable world. By respecting and valuing indigenous wisdom, engaging in meaningful partnerships, and overcoming the problems that arise, we can harness the power of traditional knowledge to create innovative solutions for a changing world.

Our collective responsibility is to learn and preserve this vital knowledge for the sake of Indigenous communities and the well-being of our future generations and the world at large.

Indigenous Peoples Versus False Prophets – How "Nature-Based Solutions" to Climate Change Threaten Indigenous Rights, their Knowledge and Our Planet

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1. Introduction – the global climate crisis, Indigenous peoples, and Nature Based Solutions

Indigenous peoples are on the frontline of the global climate crisis. Their lands and livelihoods are most affected by it, even though they have the lightest footprint on the planet and are the least to blame.

Despite this, efforts to address the climate crisis vary in the extent to which they recognize the specific perspectives and roles of Indigenous peoples. And even those responses which purport to acknowledge the centrality of Indigenous people often pay lip service to Indigenous engagement without being rooted in – or in any way properly taking account of – the rights of Indigenous peoples, and in particular their collective land rights.

By failing to properly respect Indigenous rights, current efforts to tackle the climate and biodiversity crises are threatening Indigenous peoples, while also falling far short of meeting their own aspirations. This paper will set out how, in contrast, taking Indigenous rights as the starting point is not only a moral and legal imperative, but will also lead to better outcomes for the planet.

Increasingly, projects to address climate change are being designed – or branded – as 'Nature-based Solutions (NBS)', which sounds innocuous, or even positive. Yet such projects in Indigenous territories often result in land theft and are increasingly commodifying and monetizing their lands and knowledge, posing serious threats to Indigenous peoples' rights – without tackling the cause of the climate crisis.

NBS uses mechanisms such as planting trees, restoring habitats and preserving forests to absorb or avoid release of atmospheric CO_2. "Nature" is considered a capital or an asset where, for example, polluting companies can buy carbon credits to offset their CO_2 emissions. Indigenous peoples' careful stewardship of their territories means they store much CO_2; a recent study found that Indigenous community forests contain 36% more carbon per hectare than other areas of the Brazilian Amazon. As a result, their territories are prime targets for NBS such as carbon-offsetting schemes now rebranded as NBS.

NBS are heavily promoted and supported by governments, companies (particularly the fossil fuel industry) and financial markets and are frequently imposed without Indigenous peoples' free, prior and informed consent (FPIC). The conservation industry is pushing carbon offsetting hard because it can make huge sums selling carbon credits from Protected Areas which it creates and manages.

However, NBS have failed to tackle the central issue: i.e. they enable the biggest polluters and emitters of carbon dioxide (such as the fossil fuel industry usually based in the global north) to carry on polluting as usual by offsetting their emissions elsewhere. In other words, emissions are not being reduced as fossil fuel emissions continue to rise.

Carbon offsetting doesn't reduce CO_2 overall. The carbon stored in trees and other 'natural ecosystems' is very easily released again through fires (a major concern for example in parts of the Amazon Basin) or other disturbances. It can also result in vast monocultures of fast-growing trees which destroy biodiversity – 80% of the planet's biodiversity is found in Indigenous territories.

This huge monetary value NBS puts on Indigenous owned ecosystems makes them the targets of unscrupulous investors which puts even more pressure on territories that are already invaded and plundered for their natural resources. As Tom Goldtooth of the Diné people and executive director of the Indigenous Environmental Network says: "What we are fighting here is the privatisation of nature ... Who owns nature? The way things are developing it will be the corporations that own nature... Energy companies are getting rich while the local people suffer".

For many Indigenous peoples, putting a monetary value on nature is inconceivable as Pope Francis recognises in his *Laudato Si'* encyclical "On care for our common home": "For them, land is not a commodity but rather a gift from God and from their ancestors who rest there, a sacred space with which they need to interact if they are to maintain their identity and values. When they remain on their land, they themselves care for it best".

2. The impact of NBS on Indigenous communities

2.1 Protected Areas

A heavily promoted NBS is the creation of Protected Areas. There is a long and shameful history of colonisers stealing land from Indigenous peoples since the first national park in the USA was created over 150 years ago. Yet fortress conservation is still being pushed by big conservation NGOs like WWF, WCS and African Parks as the "solution" to our environmental problems, including the biodiversity and climate crises. They divert attention from the real causes of environmental destruction, climate change and biodiversity loss, and from those who are most responsible for it.

Indigenous organizations and NGOs including Survival have denounced widespread and horrific human rights abuses in Africa and Asia where Indigenous peoples have been violently evicted from their lands by armed rangers funded by large conservation organizations in the name of conservation.

Once their land is stolen, Indigenous peoples' sustainable ways of life are criminalized, and they are pushed into "alternative livelihoods" to conform with mainstream society. Self-sufficient people are rendered landless and dependent "beneficiaries" of conservation-funded projects or into tourist attractions; while the real culprits of environmental destruction, like mining, oil and logging companies, and trophy hunters are considered "partners" of conservation and allowed to carry on with business as usual.

While African Parks has been at the forefront of the militarization of conservation areas in Africa and runs the largest counter-poaching force of any private organization on the continent, other conservation organizations like WWF and WCS are also deeply involved. Rangers often receive paramilitary training from former military officers. In some cases, bonuses are awarded to the most zealous rangers, who have made the most arrests or discovered the most animal traps, giving an economic incentive to carry out arbitrary arrests, torture and other human rights violations.

Odzala-Kokoua National Park is one of the oldest parks in Africa which was established in 1935 by French colonisers on Baka land in the Republic of Congo. The park has been managed by African Parks since 2010 when Baka people say that violence and abuse dramatically increased. Rape, torture and evictions at the hands of African Parks' rangers have been widely reported in the area. While the Baka are being persecuted for hunting to feed their families and accused of destroying the forest, two mining concessions are located inside the park and its buffer zone, and six logging concessions hug its borders. There are now reports of plans to sell carbon credits from Odzala-Kokoua park.

This is the daily reality for Baka on the ground, as one woman describes: "My Baka relatives were handcuffed. The rangers forcibly removed their clothes and made them lie down on the ground. They lit a candle and let the burning wax drip on them. Then they hit their burnt skin with a whip". Baka people told Survival researchers that rangers held their heads underwater in a river; raped a Baka woman while she was holding her two-month-old baby and sexually abused an 18-year-old Baka boy among other horrific abuses. As a Baka leader says: "This is not conservation, it's destruction".

Yet the Baka are the best conservationists. Their relationship to the forest is central to their way of life and their identity as a people and they cannot survive without it. Generations have developed their own sophisticated conservation practices which prevent overhunting, since the Baka believe that successful hunting and gathering depends on sharing well, both between themselves and with their environment. They have in-depth knowledge of forest plants and are expert botanists, using around 500 plants for medicinal purposes, soap. epilation, and birth control. Baka say that important medicines are only found in specific forests which have become "Protected Areas" which are now no-go zones following their eviction.

The Baka are expert zoologists and astute observers of animal behaviour – they have dozens of words for the forest elephant, depending on its age, sex and personality. Studies show that the Baka work to improve the forest environment for their animal neighbours. For example, when the Baka harvest wild yams, they often leave part of the root intact in the soil, or bury parts of the tubers, with the intention of encouraging their regeneration. This spreads pockets of yams through the forest, which are a favourite food of elephants and wild boar. There is evidence that when Baka discard inedible parts of the yam in new places density increases. When they make seasonal camps, the Baka they clear vegetation, creating "secondary forest" which improves levels of light that favour yam growth in new areas. This has been called "paracultivation" rather than simply gathering.

Many Baka report that all this important knowledge is not being passed on to the younger generations, as parents are too afraid to take their children into the forest because of abusive anti-poaching squads.

2.2 Carbon offsetting and credits

Under a carbon offset scheme, a company which is releasing CO_2 into the atmosphere can carry on releasing exactly the same amount of CO_2 and yet claim to be "carbon neutral", as long as it "offsets" its emissions by also supporting the creation of a Protected Area that stocks the same amount of CO_2, or planting some trees that are supposed to absorb the same amount of CO_2. This exchange is carried out in the financial markets, through the creation of carbon credits. This is what governments mean by "net zero": they do not really intend to reduce emissions to zero, they will simply claim to "offset" those emissions somewhere else.

Carbon offsetting is largely unregulated – and much of it is based on Indigenous land. Increasingly, Indigenous land that has been seized to make a Protected Area is now being used to sell carbon credits. Research by Rights and Resources Initiative shows that despite more than a decade of investment in REDD+ (Reducing emissions from deforestation and forest degradation in developing countries) programs, few countries have established the necessary conditions for fair, effective, and transparent carbon or REDD+ transactions.

Two recent cases in Brazil involved Carbonext, a company partly owned by oil giant Shell. Carbonext allegedly got Tembé people to sign blank pieces of paper, and pressurized Kayapo into signing agreements. When federal prosecutors launched investigations into these irregularities, the company cancelled its contracts with the communities. Many Indigenous peoples have been locked into non-negotiable contracts which run for 50 years or more, clearly unfair as nobody can predict conditions of future markets. Some face draconian conditions and have effectively lost control of their resources and are banned from harvesting produce or cutting down trees. Others receive a paltry percentage of the profits, most of which go to companies and shareholders while the Indigenous peoples on the ground are doing the work conserving their forest homes.

In February, Akawaio from Guyana attended a hearing on the impact of carbon market expansion on Indigenous Peoples, held by the Inter American Commission on Human Rights. They denounced a carbon offsetting scheme on their land by a private US-based carbon credit certification body called ART (Architecture for REDD+ Transactions) about which they were not consulted. Akawaio leader Mario Hastings said: "We have not seen any proof that selling carbon is helping Mother Earth. Even though the Government is selling carbon credits and promising to keep the trees standing, the Government continues to give out mining concessions without caring about the destruction of our forests. My village of Kako is covered with mining concessions. We have a land title, but the Government refuses to acknowledge that the title exists. And the Government is now doing oil drilling and polluting the climate. In all these ways, our rights have not been respected and protected in this carbon credit process. The true solution to the climate crisis is to recognize that Indigenous peoples are the owners and stewards of our lands and forests".

In some cases, it has proven nearly impossible to track whether offsetting projects have actually taken place, and how much carbon has truly been offset. A recent investigation into Verra, the world's leading certifier of carbon offsets, found that more than 90% of the rainforest offset credits were likely to be "phantom credits" and did not represent genuine carbon reductions and may have worsened global warming.

2.3 Afforestation

To date, supposedly the most effective way of taking carbon dioxide out of the atmosphere is by planting trees. According to 2017 estimates, afforestation accounted for nearly half of the potential for climate mitigation through NBS. To chieve this would require planting trees over an estimated area of nearly 700 million hectares, almost the size of Australia. Where is that land going to come from? Certainly not in countries like France and the United Kingdom who are pushing NBS. Most likely Indigenous peoples' and local communities' lands will be targeted.

In India, when forests are destroyed for resource extraction like mining, the companies responsible must give money to a fund called CAMPA (Compensatory Afforestation Fund Management and Planning Authority), which is spent on afforestation projects. However, biodiverse forests are usually replaced with monoculture plantations, often on the land of Adivasi (Indigenous and tribal) peoples. For example, much of the Baiga's land has been taken as part of a compensatory afforestation project as Amarlal Baiga explains: "The forest department has forcefully put fences around my field and around everyone else's fields and planted teak trees. They made us plant the trees, they made fools out of us saying: 'These plants will benefit you' but now they are harassing us and saying: 'This jungle is ours and this land doesn't belong to you anymore'. But this land is ours and belonged to our ancestors".

The territories of uncontacted tribes, also known as peoples living in isolation, are extremely vulnerable to NBS. Their rejection of contact with neighbouring peoples and national society means it is impossible to obtain their FPIC for projects on their land, like carbon offsetting. They are also vulnerable to so-called green alternatives to fossil fuels, such as electric car batteries that rely on minerals like nickel. The world's largest nickel mine on

Halmahera Island in Indonesia is operating on the territory of uncontacted Hongana Manyawa, who only number between 300 and 500 people. They face annihilation through the introduction of diseases by mine workers, to which they have no immunity, and the wholesale destruction of their forests on which they rely totally for food and shelter.

3. What are the solutions?

There is a clear solution to this situation: full respect for Indigenous rights, including formal recognition and active protection of collective land ownership rights. As UN Special Rapporteur John Boyd says: "Implementing rights-based conservation approaches is both a legal obligation under international law and the most equitable, effective, and efficient conservation strategy available to protect biodiversity at the scale required to end the current global crisis".

Indigenous land covers a significant portion of the globe: one study found that Indigenous peoples manage or have tenure rights over at least a quarter of the world's land surface. Ensuring that this land is legally held and controlled by the Indigenous peoples who have always stewarded and protected it is crucial for the full realisation of Indigenous rights, the protection of Indigenous knowledge, and for the future of the planet.

International Labour Organization Convention 169, the international law on Indigenous and tribal peoples, and the UN and the American Declarations on the Rights of Indigenous Peoples uphold their collective land ownership rights. However, many states, especially in Africa, Asia and Oceania have yet to enshrine this fundamental right in national law. Even where land rights are legally recognised, as in most Latin American countries, there is an ongoing struggle against concerted efforts by politicians and industries linked to agri-business and mining, oil and gas sectors to overturn the laws which uphold Indigenous land rights.

Scientific studies show that when Indigenous peoples' land rights are upheld there is minimal or significantly less deforestation (and therefore fewer carbon dioxide emissions), fewer forest fires and high levels of biodiversity which includes ecosystem diversity, genetic diversity and species diversity. One study in the Brazilian Amazon found that a 75% decrease in deforestation in Indigenous territories that were demarcated and ratified.

Indigenous peoples must be the decision makers in all projects and initiatives that affect them and their territories. It is simply not ethical to expect them to engage meaningfully in projects and exchange of knowledge, let alone give their FPIC when they are not in full legal and actual possession of their territories, and thus not in a position to assert their full authority over what happens on their land.

This needs a radical change in mindsets. We need to sensitise public opinion, governments, consumers, scientists, industry and conservationists – to counter the ingrained prejudice and racism which prevails in many regions, and which fails to understand that Indigenous peoples are contemporary and dynamic societies, continually adapting and changing whether hunter-gatherers, shifting cultivators or nomadic herders. For example, Bushmen or San in southern Africa are extraordinarily resilient and have perfected ways of living in the Kalahari desert, but are persecuted for hunting sustainably, and many have been evicted from their ancestral lands.

As Felipe Tuxá, an Indigenous anthropologist from Brazil, says: "We keep talking about the importance of cultural diversity, but nobody talks about territorial demarcation and nobody solves it, even though it is a central problem for the existence of Indigenous peoples in Brazil today. This creates a narrative that everything is fine as long as you have policies that promote cultural diversity, but these policies don't resolve the indigenous territorial issue".

Recognising land rights takes not only political will, and administrative commitment, but also financing. Governments and foundations should prioritise direct funding for grassroots, Indigenous-led initiatives which promote land rights and self-determination, territorial demarcation, land defence and land management and Indigenous knowledge. A report by the Rainforest Foundation found that less than 1% of funds from international donors for climate aid between 2011 and 2022 was given to Indigenous peoples' forest conservation. This needs to be massively increased, and the funds must go to securing land rights first, so that Indigenous-led conservation can follow.

In the absence of the state, many Indigenous communities are mapping out their lands to secure them. Some have produced land management plans and encyclopaedias of medicinal plants in positive collaborations with non-Indigenous scientists and specialists. Many are devising protocols for consulting with their communities. Others have formed groups of "Forest Guardians" or environmental defenders risking their lives on the frontline to protect their territories from violent invaders and land grabbers. Many have been murdered defending their land and communities. They need tools and technology for these initiatives: drones, GPS, satellite imagery, video cameras, mobile phones, and two-way radios. One study found that communities supplied with satellite data via smartphones saw 52% less forest loss than similar communities that did not adopt the technology, in the first year alone.

Another critical area for funding is recording and revitalisation of Indigenous languages, many of which are endangered or have already disappeared – today about 200 known Indigenous languages have fewer than 10 native speakers. Knowledge is embedded in language and there is a strong correlation between biodiversity and linguistic diversity – research suggests that biodiversity hotspots contain great linguistic diversity – about 70% of all languages.

Biodiversity and species are also preserved due to Indigenous histories and myths, which give immense value to sacred spaces and certain plants, animals, birds and insects, and thereby ensure their protection.

Concerted lobbying of governments and institutions which fund fortress conservation has seen some progress. For example, following concerns raised by the Baka people and Survival, the UN Development Programme (UNDP) carried out its own investigation which found that rangers supported by WWF beat up and intimidated hundreds of Baka in Messok Dja in the Congo Republic, where WWF is pushing for the creation of a park on Baka land. UNDP decided to scrap its funding for the project because of the violation of Baka rights.

Survival met with the European Commission team in charge of the Messok Dja project in February 2020, and stressed that it had never had the consent of the Baka and other local people. As a result, the European Commission announced in May 2020 that it was suspending its funding of Messok Dja. It is currently working to set up a framework for human rights compliance in the conservation projects its funds and has supported a consultation process for the creation of Messok Dja, carried out by the Congolese government. It's the first time that this kind of process has been attempted for a Protected Area in the Congo. Nevertheless, the consultation process does not mean that the Baka have given their FPIC for the Protected Area: several villages rejected the project and many community representatives reported that they felt pressured and intimidated into "agreeing" to it.

4. Conclusion

We know that keeping forests healthy it critical for our future. We will only achieve this with a radically different model to the current one, that is, one that has Indigenous peoples and their skills and wisdom – and rights –

at the centre. Their collective living based on sharing and reciprocity is increasingly seen as the most intelligent and best response to living within our means.

We must ensure that Indigenous and tribal peoples not only survive but thrive for the well-being of humanity. This can only happen by recognising the land is theirs by right, and by dint of having lived there for generations, caring for and nurturing it. Despite these deep roots and spiritual connections to their land, many will not survive as peoples unless the violence, invasion, and dispossession are stopped. Time is not on our side and governments must act now before it is too late.

Finally, we must heed Indigenous voices who warned about climate change years ago. Yanomami shaman Davi Kopenawa said: "What the xapiri [shamanic spirits] teach us has far more weight and strength than all the white people's money... I would like the white people to hear our words and dream about all they say: if the shamans' songs stop being heard in the forest, white people will not be spared any more than we will".

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The Maasai Response to the Climate Crisis – A Global Outlook on Indigenous Peoples The Nashulai Maasai Conservancy Story – We Co-Exist!

Nelson Ole Reiyia
CEO/Co-Founder, Nashulai Maasai Conservancy, Nairobi

For many of you who like to watch wildlife documentaries, you may have seen where I live on the border of Kenya and Tanzania where the Maasai Mara and Serengeti meet, where elephants roam, towers of giraffes stand proud, and wildebeest follow the timeless roots of the great migration.

This majestic homeland which we Maasai people share with wildlife is even the birthplace of our own species, it is the Rift Valley, the cradle of mankind!

We have to recognize the huge asymmetry in terms of climate impacts where the bottom 50% of the poorest people in countries contribute just about 10% of the carbon emissions but suffer 75% of the economic hardship.

Despite the ecological empathy the Maasai have living symbiotically with Mother Earth, they face a crisis.

Climate change is the cause of prolonged and unpredictable droughts; of the drying up of water tables; of the depletion and degradation of the lands upon which our livestock depend – the very same lands upon which wildlife depends; upon which our ways of life and our future depend.

The Maasai are turning into Climate Change warriors, by drawing the strength they in the past used to hunt lions.

Connected to that endeavor is the Story of community-led conservancy called Nashulai Maasai Conservancy, in Maasai Mara, Kenya.

As a boy, I grew up in the rich Savannah grasslands on the edge of the famed Maasai Mara National Reserve.

My boyhood land nourished both the teeming wildlife and our cattle and, in turn, provided food security to our communities.

But 30 years later, the land, which was once accessible to people, livestock, and wildlife, was affected by government policies and was subdivided into group ranches.

Due to poverty, many families, in turn, sold the land. We call such transactions 'selling wealth to buy poverty'!

We knew we had to do something to save our land.

In 2016, we came together under the guidance of our Elders to create what we call a "an indigenous-led conservancy."

Nashulai Maasai Conservancy was the very first Maasai-governed and directed Conservancy out of the 24 other conservancies in the Greater Mara Ecosystem.

Nashulai means a place of harmony where community and wildlife live in balance and mutual benefit.

We put in place a plan that follows the age-old practice of rotational grazing, opened up ancient wildlife corridors, removed fences and, in no time, nature recovered before our own eyes! Grassland regenerated, wildlife voted with their feet and returned in record numbers, moving again through the newly opened migratory corridors and ancient Elephant birthing nurseries.

Our conservancy demonstrates that local communities have the leadership and capacity to provide innovative solutions to preserve our threatened biodiversity.

When the world was reeling under COVID, and when other larger, wealthier conservancies with outside leadership closed up, leaving their communities with nothing, against all odds, Nashulai provided food to over 1.1 million people from not just Nashulai but neighbouring conservancies as well, between May 2020 and March 2021. In doing so, not only did we stave off hunger and make it through the pandemic, as one, perhaps more importantly Nashulai won the trust and loyalty of Maasai communities all across the Maasai Mara region.

What I'm trying to tell you is that what is growing in the hearts of my people right now is not despair and not complacency and not even anger, but rather a collective will to rise together, to find solutions, to help one another, to draw on our ancestral knowledge. To use all of our wisdom and all of our courage and all of our experience coexisting with wildlife and mother nature in one of the world's most precious places in order to find a way to sustain life on the land.

We are the proud winners of the UNDP/Equator Initiative Award in 2020 for leading in Innovative Nature-based Solutions.

And today, as I stand before you, Nashulai's vision, inclusive land-use approach, and success, has captured the hearts and minds of fellow Maasai all across the Great Rift Valley. Maasai communities across southern Kenya, from the Maasai Mara all the way to the foot of Mt. Kilimanjaro, an area of over 2 million acres, are rallying together to create history. To create perhaps the world's largest equitable, indigenous conservation corridor that will also sequester carbon, and sustain Maasai on their land. That is how we are responding to the climate loss by providing nature-based solutions through the stewardship of our ancestral lands.

We are doing this for the future of our children, countless wild beings, and that of the planet.

The world cannot afford to turn indigenous people into conservation refugees. Our indigenous knowledge is crucial for biodiversity, health and food security.

What is needed is enough trust and belief that communities like Nashulai are mobilizing for economic and social well-being.

The Maasai continue getting marginalized by tourism and conservation, for example in the misadventure of moving the Maasai in Tanzania out of the Ngorongoro area.

In Kenya the Maasai are facing a new threat in the form of climate colonialism.

A change of narrative and solutions are needed urgently to sustain the Maasai on their land.

The only missing piece is capital. Any seed capital that is entrusted to us will go a long way in mitigating our climate crisis while allowing our peoples to continue living on their ancestral lands with dignity and improved quality of life, and in harmony with nature.

The millions of dollars that goes to our part of the world goes to foreign conservation NGOs and not directly to indigenous people and local communities to create co-existence models like the Nashulai one. The funding systems that support fortress conservation and move out the Maasai from their ancestral land should stop.

Climate optimism cannot be the solution. What matters is what happens on community lands. Indigenous groups like the Maasai and others should have access to financial capital that helps them lead and guide the way forward in the climate crisis. Financial Capital should be disintermediated and de-colonized by putting it directly in the community's hands.

The Maasai and other indigenous communities are simply calling for inclusion at the conservation table and not exclusion.

Thank you!

5. BRAIDING SCIENCE AND INDIGENOUS KNOWLEDGE AND EDUCATION

Braiding Indigenous Knowledges and Western Science: Remembering Who We Are and Reclaiming Our Sacred Responsibility to Mother Earth

Ora Marek-Martinez

Northern Arizona University – Office of Native American Initiatives / Anthropology Department, Associate Vice President / Assistant Professor;
Center for Braiding Indigenous Knowledges and Science, Co-Principal Investigator

1. Indigenous Lifeworlds and Knowledge as a Critical Strand of Braiding

I would like to thank the session organizers and those who contributed to the unseen work that went into organizing such an amazing opportunity to bring us together to braid knowledge to address climate change – a phenomenon that none of us can evade without working together as *Nihóokáa Diné'é Bilá Ashdla'ii* – as Human Beings. I am both humbled and grateful to share some of the ancestral knowledge that has been generationally shared with me for a larger purpose – to combine our awareness with action to address climate change. I am here today to share this information to overcome the differences that separate us before *Nahasdzáán* or Mother Earth is destroyed. As human beings, each of has a Sacred Responsibility for stewarding our resources and lands in an Indigenous way – planning for the success of seven generations into the future.

In recognition of my Ancestors that have traveled to this place with me, as well as all your Ancestors, I would like to introduce myself in *Diné Bizaad* – Navajo language – because what I am sharing with you today is coming from my heart and from my lived experiences as an Indigenous woman and trained archaeologist. *Shí éí Dził tłahnii nishłí dóó Nimíipuu éí baashishchiin. Kis'áanii éí dashicheii dóó Bilágáana éí dashinalí. Ákot'éego éí asdzáání nishłí. Lapwai, Idahodę́ę́ íyísii náasháa, aadóó Kinłanídí náasháagóó*. All the women in my family, including my daughter and myself, come from a long line of Diné Mountain Cove clan women who go all the way back to our creation. My Father's people are the ancient Nimípuu or Nez Perce from Northern Idaho in the US. My maternal grandfather was Hopi from Orayvi on Third Mesa, and my paternal grandfather was Czech and Italian. Because of my family and kinship, I am a Navajo and Nez Perce woman, and my pronouns are she/*asdzáá*/*ayat*. I was born and raised on the Nez Perce reservation, but I currently live in Flagstaff, Arizona, USA, under the watch of *Dook'ó'oosłííd* or the sacred San Francisco Peaks.

The information that I shared with you is Diné protocol; it is also my first call to combining awareness with action to establish kinship. Through this extended kinship network, I have relied on family and culture to guide my research and teaching, as well as a profound respect for the power that is inherent in these systems. Because I am of the land – everything that we have been gifted by *Diyin Diné'é* our deities, such as our homelands, our language, the intergenerational knowledge, and my medicine come from the land. I ground myself in my homelands. In my *tamina*, my heart, I know I was put on this Earth to fulfill my Sacred Responsibility to help my People thrive and survive, to protect our homelands and our sacred places in a way that braids – not combines – my Indigenous Knowledge and my western academic training and education.

The Diné or Navajo People based in what is now the United States of America's southwestern states of Arizona, New Mexico, and Utah understand themselves as being *nishłí* or 'of and from their homelands'. They have an ancient understanding of themselves and their connection to their homelands and all creation that provides a way of life that is conceptualized through four kinds of laws based on an ancient covenant through our Foundational Diné Laws, including our Traditional Laws, our Customary Laws, our Natural Laws, and our Common Laws. These laws, taken together as *Diné Bi Beenahaz'áanii*, guide our understanding of the place we hold within the environment, creating an intimate knowledge of how to live in *hózhó* or in a complementary, loving, and supportive way with and within their homelands.

My second call to combining awareness with action is to learn from Indigenous practices and Knowledge Holders in order to braid knowledges. Indigenous Knowledge is embodied knowledge based on an understanding and knowledge that has been honed over thousands of years of observation, trial and error, process, and evaluation, or what western science refers to as 'knowledge' or a body of knowledge and the process used to gain that knowledge. Indigenous Knowledges are localized and are a blueprint to survivance for our communities and for future generations; this is also the space to create common ground with non-Diné who wish to help. Diné knowledge has also provided the Diné people with a four-step "scientific method" that is based within our ceremonial knowledge and provides us with a way to hypothesize, plan, engage or act, evaluate and reflect on our experiences throughout the overall process and make changes as needed. This method is also aligned with our directionality and phase of life cultural teachings; each direction and "step" of the Diné scientific method is bundled with traditional knowledge regarding prayers, colors, protocol, and teachings. Taken together, this method provides the Diné with a unique understanding and connection with their Ancestors and their homelands.

Unfortunately, through the insidious process of settler-colonization, Indigenous knowledge has been relegated to myth or superstition and is considered outside of being usable or acceptable in scientific practice. This treatment of Indigenous knowledge from western academia has excluded the intellectual and practical contributions and knowledge of the Diné and many other Indigenous Peoples from climate change and environmental justice issues that were created all around them through extractive resource practices by industry, US, and foreign governments.

This 200-year relationship has resulted in some of the largest environmental disasters on Navajo reservation lands that continue to impact Navajo and other Indigenous Tribal Nations in the Southwest. For instance, there are over 1200 Super Fund Sites located throughout Navajo Tribal Lands; of note, is the largest release of radioactive materials in US history when in 1979 a uranium tailings disposal pond was breached on Navajo Tribal Lands at Church Rock in New Mexico, contaminating Navajo Nation waterways and lands. This spill contaminated and killed livestock, plant medicines, and Navajo Tribal Members who used resources that were contaminated from this spill. Unfortunately, this spill also contaminated precious groundwater and rendered a local river unusable. Several Navajo families who lived near the waterway were also contaminated via ingesting meat from cattle, crops, and contaminated water, as well as playing in contaminated water. As such, this area has seen disease rates at 2 to 8 times the national averages for kidney disease and diabetes (Shuey, deLemos, and George 2007).

This story is a shared experience for other Indigenous Peoples (n.b. the term "Indigenous" is based in a larger global context and is really an acknowledgement of the settler-colonial history of different countries with the Indigenous peoples; the UN created a definition of Indigenous that acknowledges the historically excluded status of Indigenous people throughout the world, and these groups are unique in that they maintain, practice, and perpetuate their cultural and ancestral practices and knowledge to younger generations), and the destruction, exploitation, and degradation of

Indigenous lands, waters, and bodies has been and continues to be fueled by settler-colonial land claims for resource extraction and the belief grounded in colonization that Indigenous Peoples are extinct. We know that isn't true – our languages and our cultures are alive. Our prayers, offerings, and songs connect us to our ancestors and to our pasts, they keep us grounded in the current moment and remind us to keep working for the benefit of future generations. This is what sustains us and is the motivation for continuing this work, because it is for ALL OF US – we are all *Nihóokáa Diné'é Bilá Ashdla'ii* – Five Finger Earth Surface People, or human beings.

In my research, I have found that the sociological concept of "Life-worlds" is a critical framing of Indigenous embodied experiences that has been sufficient at explaining the way Indigenous epistemologies, ontologies, axiologies, pedagogies, and the colonial oppression that surrounds the world and experiences of Indigenous Peoples creates a very different understanding and engagement with the world. For the Diné People their lifeworld is interdependent with their homelands; for example, there is no distinction between the 'natural' and the 'cultural' world. The way that we understand the world dictates our relationship with the environment: we see much more than separate and disparate parts. This ancestral knowledge provides the Diné People with the ability to "experiment". Additionally, in many Indigenous cultures, the interpretation of lived experiences with the past recognizes animate and inanimate relations, as well as the intangible aspects of cultural heritage. This information helps to tell the larger story of Indigenous connections to lands that are embedded with cultural stories and knowledge. For example, our kinship system extends to the environment: there is a relationality that exists within Indigenous knowledge systems. The Diné or Navajo have a holistic view of the environment they inhabit: thousands of years of lived experience contribute to our knowledge systems and our way of life provide us with tribally specific research approaches with which to investigate our environment; this is how we steward and care for the land.

Being raised in a very tight-knit community that emphasized keeping our Sacred Responsibility of serving the community and making it stronger for the next generation guides me in determining what kinds of research and service work to complete with and by Indigenous peoples. This is a critical aspect of Indigenizing research praxis, which can be enacted through reciprocity, which is the third call of combining awareness with action. Within this research framework, the research is co-designed to benefit or help Indigenous and/or local communities as it already benefits the researcher, and so it will be adapted to work that supports Indigenous Nation-building, community-expressed concerns, and needs, and building capacity as requested from communities. This has been a critical approach to Indigenize research for me as a *Diné asdzáán* (Navajo woman), a mother, and as an Indigenous scholar. My culture nurtured, guided, and supported me throughout my life, and I have come to rely on my cultural knowledge and education in all facets of my life to honor my ancestors and my communities. This knowledge and the relationships established and maintained through acts of reciprocity are components of relationality that are culturally important to the community you're assisting. By engaging in reciprocity with community members, you are building trust and establishing long-term relationships.

2. Settler-Colonization in the USA and its impact on Indigenous Peoples and Lands

The impact of settler-colonization on the relationships connecting Indigenous Peoples to their homelands in North America, particularly in the United States, has been devastating. The impact of broken treaties with federally recognized Tribal Nations has resulted in the fractionization of Tribal Lands and the removal of Indigenous Peoples – the traditional land stewards – from their usual and accustomed homelands, and consequently the destruction of waterways and food systems that support all people for commercial or natural resources extraction.

Reflecting from a cultural level, Indigenous Peoples have faced generational impacts of this abuse and removal, which are believed to be manifested in the number of social ills disproportionally affecting US Tribal Nations, such as the epidemic of Missing and Murdered Indigenous Relatives (MMIR) connected to extractive environmental industries such as mining, and the extremely high rates of Indigenous youth suicide – almost 2.5 times higher than the general US population (Pappas 2023). The overall desecration of Indigenous homelands – those lands that are the usual and accustomed homelands of the United States' Indigenous Peoples, i.e. America – is reflective of mainstream societies' negative historical narratives and contemporary perspectives, understanding, and treatment of Indigenous Peoples characterized as extractive and genocidal.

To change the way that Indigenous Knowledges are regarded in academic scientific spaces, and to begin exploring how to utilize Indigenous

Knowledges, the fourth call to combining awareness with action is to confront and interrogate misconceptions about Indigenous peoples and Indigenous knowledge, resulting from colonial-based research. Within archaeology, there has been historical rejection of Indigenous knowledge in site interpretations and in creating archaeological narratives that become factualized and have displaced Indigenous peoples as experts of their own cultures; this practice can be seen in many other STEM fields. However, we are seeing a resurgence in the application of Indigenous ancestral knowledge in all fields – but we have particularly witnessed the power of traditional ecological knowledge in the fire management knowledge systems of Australian aboriginal peoples and California Indigenous peoples, for example.

Within archaeology, confronting and interrogating misconceptions about Indigenous knowledge has shifted to the act of Indigenizing archaeological-based research, which centers the act of reconnecting Indigenous narratives to ancestral and cultural homelands. Our histories, identities, and presence have been designed, created, and classified by anthropologists and archaeologists for over 200 years. This is why Indigenous archaeology is so important for me, as it has provided a pathway for Indigenous communities to engage sovereignty in cultural heritage work in culturally-based ways that protect tribal lands, protect the tangible and intangible aspects of heritage, protect tribal sovereignty, and prepare future generations to continue this important work (Marek-Martinez 2016, 2021). Most importantly, however, is that Indigenous peoples are the experts, the authorities over their own pasts, presents, and futures – there should be nothing about us without us.

The act of interrogating and subverting unequal power balances that exist between Indigenous Peoples and scientists creates opportunities to learn from Indigenous knowledges in decision-making over stewardship of the environment, supporting Indigenous peoples in leadership positions, requesting co-management opportunities for tribal nations and federal agencies, and the implementation of Indigenous citizen-scientist programs for conservation, environmental, and climate change work. Once scientists begin to interrogate the source of patronizing language and attitudes about Indigenous Knowledges, and collaborate with Indigenous scientists, we will undoubtedly begin to see advances in the way we are able to innovate braided approaches to address climate change.

As a guiding framework to overcoming the impacts of colonial-based research, scientists can learn from the Land Back movement, which can be described as the return of Indigenous lands to Indigenous Peoples. Within my research focus of Indigenous archaeology, this looks like the protection of sacred places, reclamation of stewardship and protection of the environment back to Indigenous people, including the reclamation of Indigenous decision-making, acknowledgement and valuing Indigenous ancestral knowledge. But this movement is changing the landscape of environmental and social justice issues and leadership to provide spaces for Indigenous peoples to educate, share, and reclaim these spaces. The Land Back movement has contributed to creating pathways to healthy, safe futures for Indigenous peoples. This is an example of an Indigenous framework that can be applied to any environmental or social issue. For example, if we look at extractive mining industries and how this enterprise impacts Indigenous communities, we see that if we as Indigenous peoples are able to reclaim this landscape and work to protect lands, waters, and our peoples, which are critical parts of Indigenous knowledge, then we are able stop the destruction of our sacred places, our homelands, and our relatives, as we know that extractive industries create "man camps" that are well known to target Indigenous women, which contributes to the high rates of MMIR (Stern 2021).

3. Braiding Indigenous Knowledge and Science as Decolonization

Decolonization is a two-step process that involves both Settlers and Indigenous peoples. It is the process of deconstructing colonial ideologies about the superiority and privilege of Western thought and investigative research approaches to overcome systems of oppression that disproportionately impact Indigenous Peoples. For example, words have power and are often weaponized against Indigenous Peoples in ways that undermine their connections to their lands and render them invisible in land stewardship and climate efforts. The use of words like "discovery" when referring to the New World, or even "discoveries", creates a separation of Indigenous peoples from land stewardship and management. To Indigenous peoples, the ancestral knowledge that has been passed down for generations has told us about where we come from and how we got to our current homelands, thereby placing us as stewards and caretakers of homelands. This knowledge is beginning to be verified through archaeology, especially in the cultural affiliation of the Ancient One or Kennewick Man with the Confederated Tribes of the Colville Reservation, something thought impossible by many archaeologists because he was dated to 9,600 C.E., or the discovery of an ancient (16,000-year-old) fishing village known as "Cooper's Ferry" but known to the Nez Perce tribe as Nipehe. These sites have pushed the antiquity of the "New world" even further back than allowed by American archaeology. Based on this deconstruction we begin dismantling structures and systems that perpetuate the status quo (and the use of antiquated words that sever the ties Indigenous peoples maintain with their deep pasts), and we begin addressing unbalanced power dynamics born because of violent colonial processes.

The second part of the Decolonization process is valuing and revitalizing Indigenous knowledges and investigative approaches, making way for a shift from a western based research approach to approaches that include the spaces for alternative knowledges. This also includes weeding out settler biases or assumptions that impact Indigenous ways of being and Indigenous peoples in contemporary society. We can see this for example in the choice of words used to describe Indigenous peoples and their knowledges, histories, and cultures which negatively impacts learning and potentially perpetuates negative stereotypes of Indigenous people and the ability to "use" Indigenous Knowledges to address issues such as climate change. I do not want to place blame, but I do want to bring attention to the ways that words can be weaponized to dehumanize and diminish the connections that Indigenous people maintain with the landscape and the ability of Indigenous Knowledges to provide innovative solutions to the impacts of climate change. The active destruction of Indigenous lifeways via a "vanishing Indian" narrative has created a sense in mainstream American society that "American Indians" or "Native Americans" are extinct or that we are assimilated into American society so that we no longer engage in our cultural practices, and it becomes easy to think of our ancestral places as "ruins" or even Indigenous cultures becoming "extinct cultures".

Efforts to integrate Indigenous Knowledge and Western Science in research have demonstrated that compatibilities exist between the two knowledge frameworks. At the same time, we also must recognize that trying to integrate or combine these knowledge systems creates a competitive environment wherein one knowledge system is given authority and priority, and the other becomes a tool or even worse – a colloquial anecdote for the "real science". This is because these knowledge systems are based on different ways of knowing (epistemologies), being (ontologies), and doing (axiologies). For example, Indigenous Knowledge is place based and localized, while Western Science aims to universalize. Indigenous Knowledge has long studied the world through an interconnected and interdependent framework of relationality, viewing humans as intimately part of natural systems, and land, water, and animals as relatives. Western Science has taken a reductionist approach that divides natural and cultural realms and rigorously isolates objects of study from their context (CBIKS 2023). Most U.S. scientists lack training, skills, and experience to conduct research in this framework, and are often hesitant or even resistant to conceptualize what "braiding" may look like in their own research.

4. Braiding (not Combining) Indigenous Knowledge Systems and Science

For decades, Indigenous Knowledge systems were ignored or marginalized as many scientists failed to recognize the contributions that Indigenous Knowledge systems bring to the practice, process, and methodologies of scientific research and the scientific information and data carried within these systems (Nelson 2014). Drawing on a growing body of evidence accumulated over the past 2-3 decades, natural and social scientists from multiple disciplines are coming to recognize that Indigenous Knowledge systems carry important scientific data and observations (Bonta et al. 2017, Donovan and Puri 2004, Eckert et al. 2018, Fernandez-Llamazares et al. 2021, Forest Peoples Programme et al. 2020, IPCC 2014, Jessen et al. 2022, Lee et al. 2018, Pierotti and Wildcat 2000, Parlee et al. 2014, Polfus et al. 2014, Service CN et al. 2014) and that Indigenous Knowledge systems can be braided together with Western Science to provide research methodologies that have the potential to produce new knowledge that contributes significantly to our scientific understandings of the world.

Research that braids these knowledge systems can provide more robust and complete understandings on climate change, protection of archaeological sites and cultural places, and changing food systems (Bala and Gheverghese 2007, Hopkins et al. 2019, Huambachano 2018, IPCC 2019, King and Goff 2010, Makondo and Thomas 2018, McAnany and Rowe 2015, Ubisi, Kolanisi, and Jiri 2019), all critical issues to scientists and to many Indigenous communities. As such, my final call to combining awareness with action is to learn how to braid Indigenous Knowledge systems and Western Science systems to enhance our understanding of our natural systems, and to strengthen and innovate our responses to climate change. Our goal then is to learn how to braid these knowledge systems. We do this through conducting transdisciplinary research in specific places to develop generalizable methodologies that matter to both scientists and Indigenous communities, which are focused on the urgent concerns of climate change, destruction of cultural places, and protection and cultivation of foodways.

Effective and appropriate braided methodologies require that research be carried out with, rather than on, Indigenous communities and involve "plural coexistence" of both knowledge systems (McGregor 2008, Reid et al. 2022). This is in distinct contrast to attempts to blend or integrate one into the other, which have resulted in erasure, reproduction of extractive colonial practices, and further marginalization of IK (Liboiron 2021, McGregor 2009, Sidik 2022). Indigenous cultures have plural coexistence frameworks, several of which use metaphors of braiding or weaving (Atalay 2012; Hopkins et al. 2019, Kimmerer 2013, 2015). The verb-based metaphor of braiding indicates the importance of action, of utilizing Indigenous Knowledges and Western Science in research that addresses a shared problem for mutual benefit. Just as with strands in a braid, this approach allows both knowledge systems to retain their integrity and they become stronger braided together.

Acknowledgements

Ahé'héé' Shíałchíní, thank you to my children for your love and support, I do this work for your futures! I would like to thank both President Joachim von Braun and President Prof. Sr Helen Alford for the kind invitation to share knowledge with an amazing group of scholars who are dedicated to making this world stronger and viable for seven generations forward. I would also like to thank Prof. Sonya Atalay and Director Addie Rose Holland of the Center for Braiding Indigenous Knowledges and Science for the encouragement and support to travel and participate in a critical workshop. Finally, I would like to acknowledge the support from Vice President Ann Marie Chischilly and President José Luis Cruz Rivera of Northern Arizona University for their direction and support of these important opportunities.

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The Importance of Indigenous Peoples for Climate, Biodiversity, Food, and Nutrition Agendas, and Building Bridges Between Indigenous Knowledge and Sciences

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Background

Indigenous sciences and their epistemologies are often questioned and disregarded as primitive and invalid. Indigenous Peoples have always been the object of scientific-social sciences research but not the co-creators of knowledge. Many scientists rely on Indigenous Peoples to guide their work by helping them to find wildlife, navigate rugged terrains or to understand weather trends (Sidik, 2022) but these relationships feel colonial, extractive, and unequal. Researchers drop into our communities with similar intentions as a mining company. They gather data and leave – never contacting the individuals of the communities involved in the research and excluding them from the publication process (Sidik, 2022). Similarly, Indigenous-led research also faces well-documented institutional barriers that limit full participation and visibility of Indigenous worldviews (Artelle, 2024).

Although the value of bridging Indigenous science with Western science has been recognized to provide solutions for mutual thriving of lands and cultures, we have only begun to scratch the surface of its benefits (Popp, 2018). Hence, this *conference on Indigenous Peoples' Knowledge and Sciences – combining traditional knowledge and science on innovations for resilience to address climate change, biodiversity loss, food security, and health* is a step towards epistemic justice and an acknowledgement that we need other ways of knowing to illuminate a different way forward when we are faced with wicked challenges of a rapidly changing environment. The efforts from the Pontifical Academy of Sciences and Social Sciences in partnership with Indigenous Peoples will hopefully take a concrete step to replace the present-day monoculture of Western scientific thinking that attempts to homogenize valid knowledge with an ecology of knowledge.

Why Indigenous Peoples are indispensable partners?

> *Davi Kopenawa, a Yanomami shaman, recounts how the Yanomami legend Omama, the creator and the father of Yanomami, hung in the sky. Initially, he propped the sky up on a single rock, but that was not firm enough, and the sky fell, killing many. So, he hung it up again, but this time propped more rocks, so it would hold steady. The Yanomami believe that the sky will fall again only when there are no more Yanomami Peoples to keep the earth and sky in balance*
> (Krenak, 2020)

Hence, Kopenawa's story speaks volumes about the knowledge systems of Indigenous Peoples around the world and how Indigenous Peoples and their knowledge systems are extremely important to the resilience of our socio-ecological systems. World Bank research in 2016 showed that indigenous peoples make up 5% of the world's population but safeguard 80% of the world's biodiversity.[1] This resilience is based on centuries of interaction with, and adaptation to, environmental change and the Indigenous Peoples' capacities to assess interrelated ecosystem functions (IWGIA, 2022). Indigenous perspectives are holistic and founded upon interconnectedness, reciprocity, and the utmost respect for nature and can complement Western science and vice-versa. Consequently, Indigenous Peoples' knowledge systems are associated with better management, conservation, and sustainability of biodiversity and therefore fundamental to the well-being of the planetary health.

Indigenous Peoples are the oldest living memory of what it means to subsist on this planet. Indigenous Peoples and their institutions are like an old-growth forest that is mature, stable, and able to regenerate if there is a disturbance (Kimmerer, 2020). Indigenous Peoples' culture and our knowledge systems did not come about overnight, it is thousands of years of work. Kimmerer (2020) also asserts that Indigenous Peoples' old-growth cultures, like the old-growth forests, still exist that could serve humanity in solving the issues of climate change, biodiversity loss, green transition, and transformation of our food systems. Western science and research institutions must incorporate the knowledge and ingenuity of Indigenous Peoples in their work as equal partners. Hence, Indigenous Peoples are indispensable partners for climate solutions, protecting biodiversity conservation, and improving our food systems. Indigenous territories that cover a quarter of Earth's surface and overlap with a third of intact forests often have reduced deforestation, degradation, and carbon emissions, compared with non-protected areas and protected areas (Jocelyne S. Sze, 2022).

[1] https://ifnotusthenwho.me/about/demands/

The national parks, conversation areas, and wildlife reserves of today were Indigenous territories that our ancestors had protected and lived in harmony with nature. However, the national parks, conversation areas, and reserves are guided by a fortress conservation model that ignores the worldviews of Indigenous Peoples and their reciprocal relationships to nature. This model that assumes that protected areas should be created and governed by States and the goal of protected areas should be strict nature preservation with emphasis on biodiversity conservation and protected area management required protected areas to be uninhabited and without human use of natural resources.

If Indigenous Peoples have a share in management and conservation, there is an incentive to ensure sustainability, given that the ecosystem is inextricably bound up with their identity, spirituality, livelihood, and long-term survival (Amnesty International, 2022). However, state policies, laws and practices governing national parks, protected areas, and wildlife reserves have disenfranchised Indigenous Peoples around the world. Indigenous Peoples are criminalized when they demand their inherent rights to self-govern and their collective rights to their land's territories and forests. We can investigate West Papua, Myanmar, Chittagong Hill Tracks of Bangladesh, and India where the Indigenous territories are extremely militarized.

Indigenous Peoples' Food systems

Traditional food systems of Indigenous Peoples touch the full spectrum of life in ways that modern food systems do not. Agricultural technological developments in the six decades of FAO's existence have led to great disconnections between people and their food. Globalization and homogenization have replaced local food cultures; high-yield crops and monoculture agriculture have taken the place of biodiversity; industrial and high-input farming methods have degraded ecosystems and harmed agro-ecological zones; and modern food industries have led to diet related chronic diseases and other forms of malnutrition
(Harriet V. Kuhnlein, 2009)

Indigenous Peoples' food systems are diverse and unique, comprising a wide variety of wild, semi-domesticated, and domesticated plants and animals that are rich in nutritional value. These systems pay special attention to the relationships between different elements within ecosystems, unlike modern agri-food systems. Indigenous Peoples' food systems have endured for centuries, surviving climate variations, periods of colonization, and displacements. They adapt their food generation and production to the seasonality and natural cycles observed in their surrounding ecosystems.

Consequently, Indigenous Peoples' food systems are multifunctional and holistic, producing food, medicines, shelters, and energy, while also supporting cultural and spiritual practices. Additionally, the concept of food waste is unknown in these systems. Hence, Indigenous Peoples' food pathways are crucial knowledge that western science must collaborate with for the sustainable future of our food systems.

For the Tharu Peoples of Nepal, everything begins with the monsoon rains. These rains dictate their ecosystems, food systems, knowledge systems, social institutions, and worldviews. With the arrival of the monsoon, rice seedlings are planted. As the water drains from the rice fields, fish are trapped and dried, providing sustenance throughout the year. Tharu diets are highly diverse because we not only cultivate crops but also gather a variety of foods and medicines from the forests and riverine areas. They harvest only what they need, leaving the rest for the future.

Similarly, to ensure that the Tharu Peoples have healthy diets and food throughout the year, we dry and store food while maintaining its nutritional value. The Tharu are experts in diverse food storage systems, but the pressure from Western development models, modernization, land privatization, and the commodification of food poses a serious threat to our culture, identity, and knowledge systems. Consequently, Indigenous food systems and the associated biocultural knowledge are now under threat. We are no longer saving seeds, trapping, or gathering from the forests. Do you know why? Agrochemicals were introduced in the 1980s when Nepal signed the structural adjustment policies. This has taken a lot from us and undermined our collective vision for the future.

Longevity of Indigenous Peoples' Knowledge systems

Indigenous Peoples transmit their knowledge systems to the next generations orally and they have been quite successful in transmitting their knowledge. However, Indigenous youth are migrating to the urban centres for opportunities and education at an alarming rate. Additionally, the education provided by the governments is not culturally adapted to the worldviews of Indigenous Peoples. To keep the Indigenous Peoples' knowledge thriving and transmitted to the new generations, our land and traditional territories are important. The health of Indigenous Peoples territories is interlinked with the well-being of Indigenous Peoples and their knowledge systems. We need our land, forests, mountains, and rivers because they are our schools, pharmacies, grocery stores, and spiritual sites – if we are removed from our territories, and our social institutions, our gift economy starts to degrade. Still today, in Asia where two-thirds of Indigenous Peoples live they are fighting for the legal recognition of their identity and access to their territories and are fighting legal battles with their national governments to amend their national park laws. Our national laws do not align with our laws, there is often tension and I see this everywhere around the world. We need to work together in reforming the existing constitution or laws that work for Indigenous Peoples and their realities as well.

Recommendations

Indigenous Peoples are indispensable partners for climate, biodiversity, food, and nutritional agenda. Hence, their knowledge systems are instrumental. Their knowledge systems can immensely complement western science. Research institutions must move away from conducting research on Indigenous Peoples to conducting research with Indigenous Peoples as equal partners when it comes to issues like climate change, biodiversity loss, food systems, and nutrition agenda. Indigenous Peoples' leadership and their ingenuity must be recognized, and their leadership is important in complementing western science. Research institutions must abide the principle of free, prior, and informed consent when working with Indigenous Peoples.

Western science and western institutions must decolonize the way they gather their information and should move away from creating a monoculture of mind. In their work, they must incorporate other forms of knowledge including Indigenous Peoples' worldviews and their knowledge systems to ensure epistemic justice. As a result, Indigenous-led research must be supported, and we must remove institutional barriers Indigenous Peoples face. What we need is Indigenous leadership in decision-making to restore the harm that colonialism, and neo-liberalism policies and their institutions have done to Mother Earth and Indigenous Peoples.

Indigenous Peoples' knowledge systems and their leadership are the future. Western institutions, including universities, states, and UN bodies must adapt and include Indigenous Peoples at all levels of decision-making because they were not created for Indigenous Peoples and their worldviews and their livelihoods. They must adapt their working principles as outlined by UN Declaration on the rights of Indigenous Peoples (UNDRIP). We have many foundations here today and representatives of UN bodies that know this very well, yet there are still doubts in your minds about our leadership, organizational capacities, and scientific knowledge. We all need to unlearn and relearn to engage meaningfully with Indigenous Peoples. Learn our songs, learn our languages as we have learned yours. The funding that is pledged to support Indigenous Peoples for climate change and biodiversity conservation must go to Indigenous Peoples directly.

Finding new innovative ways to understand and reimagine our relationship to the natural world is an important step towards bridging science and Indigenous Peoples' traditional knowledge. How are we preparing the new generations of Indigenous leaders to tackle the issues of climate change, biodiversity loss, cultural revival, and intergenerational knowledge exchange? We all must ponder on this question and work on infrastructures needed to bridge the gap between Indigenous elders and youths as youths are migrating at an alarming rate.

We need to change the way we are selling the idea of sustainability and transition into a green economy. We need to change the way development is planned and implemented. We need to move away from the production paradigm and move into the holistic way and regenerative paradigm that Indigenous Peoples have championed for generations. We need to drive away that spirit of *Daliddar*[2] through our songs. My mother signs even today to chase such spirit out of us. *Daliddar* is the greedy side in us. *Daliddar's* energy and spirit also drive the agribusiness, mining industries, and multinational corporations. We also need to think about the degrowth paradigm because perpetual growth is not compatible with natural law. Hence, we must incorporate Indigenous knowledge systems in policies that decide the future of our planet.

We all are looking for low-hanging fruit. But let's nurture long-term reciprocal relationships with Indigenous Peoples. My mother tracks and maintains relationships with individuals and families that go beyond 15 generations. We need to go beyond the project life cycle. I invite you all to work like the mountains, Himalayas, forests, winds, rivers, winds, and the ocean that brings monsoon to my land that sustains all forms of life and beings. Through kindness and deep respect, I hope we will continue this conversation as there is a lot of work to do in bridging western science and Indigenous worldviews together.

[2] *Daliddar* is a Tharu word for a spirit that is full of greed and thinks of acquiring more and more without giving consideration to others.

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The United States Federal Government Recognizes the Importance of Indigenous Knowledge with New Policies and Actions

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Abstract

The Biden-Harris Administration made historic progress in delivering on President Biden's commitment to support Tribal Nations and Indigenous Peoples, including strengthening understanding and respect for Tribal sovereignty and Native history and elevating Indigenous Knowledge through formal White House Guidance to federal departments and agencies. Through this Guidance, the Administration formally recognized Indigenous Knowledge as one of the many important bodies of knowledge that contributes to the scientific, technical, social, and economic advancements of the United States and our collective understanding of the natural world.

1. Introduction

Indigenous Peoples in the United States include members of the 574 federally recognized Native American Tribes and Alaska Native entities, Native Hawaiians and other Pacific Islanders, and other Indigenous peoples.

During his first week in office, President Biden pledged[3] to support Tribal Nations and Indigenous Peoples, strengthen understanding and respect

[1] Lubchenco served as Deputy Director for Climate and Environment at the White House Office of Science and Technology Policy from February 16, 2021 to January 10, 2025, on loan to the White House from Oregon State University.

[2] As of January 13, 2025, Lubchenco resumed her positions as Distinguished University Professor of Integrative Biology and Valley Professor of Marine Biology at Oregon State University.

[3] U.S. Federal Register Notice 2021-02075 (86 FR 7491) Tribal Consultation and Strengthening Nation-to-Nation Relationships, Memorandum from President Joe Biden to the Heads of Executive Departments and Agencies. January 26, 2021 Federal Register :: Tribal Consultation and Strengthening Nation-to- Nation Relationships

for Tribal sovereignty and Native history, and address long-standing issues of importance to the Tribes and Indigenous Peoples. To assist in achieving that commitment, President Biden reactivated the White House Council on Native American Affairs (hereafter, the Council), initially established by President Barack Obama "to improve the coordination of federal programs and use of available federal resources for the benefit of Tribes and Tribal communities". Composed of the heads of federal departments and agencies and White House offices, the Council focused on a wide range of issues, including Tribal-centric topics (Tribal treaty rights, Tribal homelands, sacred sites, and Native language) as well as Tribal perspectives on a broad range of other topics (climate change, health, education, economic development, energy, infrastructure, safety and justice).

The Office of Science and Technology Policy (OSTP) is one of the White House Offices that compose the Council. Recognizing the importance of Indigenous Knowledge (IK) to the work of the Council and to a broad array of federal department and agency decisions, OSTP proposed the development of formal IK guidelines for departments and agencies.

The fact that the Office of Science and Technology Policy initiated and co-led the process is relevant to this Pontifical Academy of Sciences and Pontifical Academy of Social Sciences workshop. So, too, is the underlying premise of the U.S. work that IK is vitally important and relevant and should help inform government actions, alongside science and other forms of evidence, while respecting its origins and keepers.

In 2021, at the first White House Tribal Nations Summit of his Administration, President Biden announced a new IK Initiative. This announcement launched an IK working group, led by OSTP and another White House Office, the Council on Environmental Quality (CEQ), and composed of representatives from more than 25 federal agencies. The working group was charged with consulting widely and producing a new policy on IK. The President's announcement complemented the Administration's commitment to scientific integrity and knowledge- and evidence-based policymaking.

The working group consulted widely with agencies, Tribal Nations and other Indigenous Peoples, knowledge experts, and the public. Engagement included formal Nation-to-Nation Consultation, meetings, and input from

https://www.federalregister.gov/documents/2021/01/29/2021-02075/tribal-consultation-and-strengthening-nation-to--nation-relationships more than 100 federally recognized Tribes. The working group also held public listening sessions, convened Roundtables with Native Hawaiian and Pacific Islanders and with Native and Indigenous Youth, and held dozens of individual meetings with people with experience and expertise on IK. Finally, the working group released a draft of the guidance to Tribal Nations for consultation prior to finalizing the guidelines.

The resulting White House Guidance on IK[4] was released by OSTP and CEQ at the 2022 White House Tribal Nations Summit. The Guidance defines IK, directs U.S. departments and agencies to consider and where relevant apply IK in federal research, policies, and decision making, and encourages ongoing respectful engagement with Indigenous Knowledge-holders – as described in the next sections.

2. What is Indigenous Knowledge?

Indigenous communities within the United States use a variety of terms including "Indigenous Knowledge", "Traditional Knowledge", and "Traditional Ecological Knowledge". After extensive consultation with Tribes, Indigenous Peoples and experts, the working group decided to use "Indigenous Knowledge" to encompass all of these terms.

The Guidance defines IK as follows: "Indigenous Knowledge is a body of observations, oral and written knowledge, innovations, practices, and beliefs developed by Tribes and Indigenous Peoples through interaction and experience with the environment."

The Guidance further clarifies that "IK is applied to phenomena across biological, physical, social, cultural, and spiritual systems. It can be developed over millennia, continues to develop, and includes understanding based on evidence acquired through direct contact with the environment and long-term experiences, as well as extensive observations, lessons, and skills passed from generation to generation."

[4] 2022 November 30. White House Guidance on IK: Memorandum for Heads of Federal Departments and Agencies: Guidance For Federal Departments and Agencies on Indigenous Knowledge, from Arati Prabhakar, Assistant to the President and Director of the Office of Science and Technology Policy and Brenda Mallory, Chair, Council on Environmental Quality https://www.whitehouse.gov/wp-content/uploads/2022/12/OSTP-CEQ-IK-Guidance.pdf

3. What is the White House Guidance on Indigenous Knowledge?

Federal departments and agencies were already required by President Biden's directive and by the Evidence Act of 2018 to use science, data, and evidence in their federal decision-making. The new IK Guidance directs them to also consider and, where appropriate, apply IK in their research, policy, and management decisions. And it assists agencies in (1) understanding IK and why it is relevant, (2) growing and maintaining the mutually beneficial relationships with Tribal Nations and Indigenous Peoples needed to appropriately understand and include IK, and (3) implementing the directive to consider and apply IK in their decision making.

The Guidance emphasizes that agencies should obtain consent from Tribal Nations and Indigenous Peoples prior to including IK in federal policy, research, or decision-making. The guidance makes clear that the U.S. government understands that Tribes and Indigenous Peoples may possess IK that is sensitive, sacred, or belongs to certain families or clans.

The Guidance formally recognizes Indigenous Knowledge as "one of the many important bodies of knowledge that contributes to the scientific, technical, social, and economic advancements of the United States and our collective understanding of the natural world". An underlying assumption is that "use of multiple ways of knowing or lines of evidence can make for better-informed decision making".

The Guidance also identifies promising practices, based on agency experience and Tribal and Indigenous input, for (1) collaborating with Tribal Nations and Indigenous peoples, (2) considering and applying IK in implementing statutory and regulatory requirements, and (3) respecting the decisions of Tribal Nations and Indigenous peoples on whether and how to engage in Federal processes.

In addition to the Guidance, OSTP and CEQ also released an Implementation Memorandum[5] which tasked agencies with reporting on progress within 180 days, and announced the formation of a new standing interagency group under the White House OSTP National Science and Technology Council that will assist in coordination and implementation of the new guidance across agencies.

[5] 2022 November 30. White House Implementation of Guidance for Federal Departments and Agencies on Indigenous Knowledge https://www.whitehouse.gov/wp-content/uploads/2022/12/IK-Guidance-Implementation-Memo.pdf

4. What has been the result of this new IK Guidance?

Prior to the Guidance, some federal agencies were already applying IK in their work, although how they were doing so varied considerably from agency to agency; many others were not considering IK at all. After the Guidance was issued, departments and agencies reviewed their practices, began to harmonize their approaches to IK, and started interacting more with each other, especially through the new IK Subcommittee.

This new IK Subcommittee became a productive community of practice that fostered meaningful collaboration, enabled identification of best practices and shared learning, and promoted problem-solving to address cross-cutting agency challenges. The Subcommittee also incentivized meaningful progress.

Several departments and agencies such as the Department of the Interior, the National Oceanic and Atmospheric Administration, and the Advisory Council on Historic Preservation have announced their own Indigenous Knowledge guidance that translates the more generic guidance of the White House policy into more granular direction tailored to the agency's specific mission. The requirement for all departments and agencies to deliver a progress report stimulated considerable, productive discussions and exchanges within the Subcommittee and within the agencies.

Examples of the incorporation of IK into agency practices are emerging. For example, the Native American Tribal practice of routinely burning small patches of landscape to maintain culturally important plants and prevent large wildfires is now beginning to be incorporated into agency wildfire management practices.

A key to the success of this effort has been leadership from scientists and Indigenous experts across the interagency, but especially two scientists and the six Indigenous members of the Climate and Environment team at OSTP between 2021 and 2024. The latter included Native Americans, Alaska Natives, and a Native Hawaiian, all of whom brought deep expertise and lived experiences that greatly enriched and strengthened the work. Recognizing the benefits of Indigenous expertise, OSTP created a position dedicated to 'Indigenous Engagement and Native American Affairs.' This person was OSTP's lead on the interagency IK Subcommittee and coordinated closely with the White House Council on Native American Affairs.

In summary, this new formal White House Guidance on IK and associated White House and agency positions were intended to make decisions made by agencies and the White House more robust, durable, and effective. It is too early to evaluate the full impacts of this work, but the initial progress is encouraging. Especially when confronting global challenges like climate change and loss of biodiversity which have significant consequences to human health, national security, and the economy, more pathways for inclusion of IK and Indigenous Peoples are urgently needed.

The Critical Role of Indigenous Peoples in Addressing the Twin Crises of Climate Change and Loss of Nature: How Powerful New Partnerships Between Indigenous Peoples, Faith Communities and Science to Protect Forests Can Turn the Tide

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Abstract

This paper argues that Indigenous Peoples' knowledge, culture, ways of life and spirituality provide essential contributions to addressing the twin crises of climate change and biodiversity loss and it reviews how global support for Indigenous Peoples' issues has grown dramatically over the past 30 years through United Nations processes, with support from NGOs, the scientific community, philanthropies, government, etc. This new movement is among the most significant and encouraging developments to date in the fight to protect our climate and nature. One recent and significant development – strongly advanced by His Holiness Pope Francis – is the way religious leaders and faith-based organizations are joining this global movement to rally support for Indigenous Peoples, their rights and knowledge. An important expression of this trend is the Interfaith Rainforest Initiative (IRI), working in major rainforest countries to give greater voice and power to Indigenous Peoples – in spite of the 500-year-old torn relationship between Western religions and Indigenous Peoples. Examples are provided of how IRI's work is advancing the collaboration between Indigenous knowledge and science in Brazil, Colombia, Democratic Republic of Congo, Indonesia and Peru. This effective model and methodology of interfaith cooperation can be applied to other issues and geographies to make further progress on combatting climate change and sustaining nature.

Introduction

It is well established that we are facing a twin crisis of climate change and loss of nature that is now threatening all life on the planet.

I argue here that another historically significant change is also underway – only this one is positive and life-affirming – the growing understanding of, and support for, Indigenous Peoples in our world.

This trend is very good news because of the rapidly expanding body of evidence that Indigenous Peoples' culture, ways of life and spirituality have a powerful and far-reaching impact in addressing those twin crises through their traditional knowledge and stewardship of their lands.

I also argue that Indigenous knowledge and links to modern science – the focus of this conference – is vitally important – but the securing of rights to indigenous lands and resources is a critical 'enabler', without which indigenous knowledge and culture are not sustained.

The increasing support for Indigenous Peoples is thanks to the concerted efforts over decades of many indigenous leaders here in this conference – Vicky Tauli Corpuz, Myrna Cunningham, Hindou Oumarou Ibrahim, Jen Rubis, Elifuraha Laltaika, Stanley Kimaren and countless others.

I explore here key events, programs and processes that have led to this increased power and influence of Indigenous Peoples from the perspective of my 32 years in the United Nations – starting with my first UN assignment, the 1992 Rio Earth Summit.

Recently, and significantly – advanced by His Holiness Pope Francis – many religious leaders and faith communities have also joined this movement to support Indigenous Peoples. For example, His Holiness provided inspiration for the creation of the Interfaith Rainforest Initiative (IRI) – an effort that I have devoted the past 6 years of my career to build – and which has mobilized religious communities to protect rainforests and Indigenous Peoples' rights and knowledge, as I explain below.

Thirty-Year Trend of Growing Support for Indigenous Peoples Rights and Knowledge

Over the past 30 years since the Rio Earth Summit, Indigenous Peoples have skillfully contributed to, and influenced, key international environmental bodies and initiatives, including the Rio Conventions and their associated Conferences of the Parties (COPs). As a result, we are now seeing the world's most powerful institutions – public and private – begin to align behind Indigenous Peoples' efforts to be incorporated into decision-making to secure their rights and help combat climate change and protect biodiversity. (See here Vicky Tauli-Corpuz' account of Indigenous Peoples' struggles for access to international processes during an even earlier period: 1970 to 1999).[1]

Indigenous Peoples' territories cover about 20% of land worldwide, and yet contain 80% of the world's remaining biodiversity[2][3] and there is a wealth of other evidence that Indigenous Peoples have been far more effective than other land uses in maintaining intact tropical forests that store and protect immense amounts of carbon, biodiversity and critical water circulation. In other words, Indigenous Peoples across the world are doing what other groups have not succeeded in doing: retaining the forests standing with the carbon and wildlife intact too.[4]

And formal recognition of indigenous territories is crucial to enable these benefits of reducing deforestation, maintaining a stable regional climate, mitigating climate change, preserving biodiversity, and sustaining local livelihoods.[5][6][7] Securing self-determination and the rights of Indigenous Peoples to their lands is also a matter of both social justice and climate justice.

How did this understanding and support for Indigenous Peoples evolve over these past three decades since the 1992 Rio Earth Summit?

[1] Tauli-Corpuz, V. (1999). "Thirty years of lobbying and advocacy by Indigenous Peoples in the international arena". *Indigenous Affairs* 1, 4-11.

[2] Kamal, B. (2017, Feb. 9). "Indigenous Peoples Lands Guard 80 Per Cent of World's Biodiversity", Inter Press Service News Agency https://www.ipsnews.net/2017/02/indigenous-peoples-lands-guard-80-per-cent-of-worlds-biodiversity/

[3] CBD News Headline (2022, July 20) "Indigenous Communities Protect 80% of All Biodiversity", https://www.cbd.int/kb/record/newsHeadlines/135368?FreeText=protected%20areas

[4] Kruid, S. Madedo, M. et al., (2021, July 27), "Beyond Deforestation: Carbon Emissions from Land Grabbing and Forest Degradation in the Brazilian Amazon, Front. For Glob. Change, Sec. Tropical Forests, Vol. 4 – 3021, https://doi.org/10.3389/ffgc.2021.645"282

[5] Soares-Filho, B., Moutinho, P., et al., (2010, May 26), "Role of Brazilian Amazon protected areas in climate change mitigation", Proceedings of the National Academy of Sciences (PNAS), 107 (24) 10821-10826 https://doi.org/10.1073/pnas.0913048107

[6] Nolte, C., Agrawal, A. et al., (2013, Mar 11). "Governance regime and location influence avoided deforestation success of protected areas in the Brazilian Amazon", Proceedings of the National Academy of Sciences (PNAS), 110 (13) 4956-4961, https://doi.org/10.1073/pnas.1214786110

[7] Walker, W.S., et al. (2020). "The role of forest conversion, degradation, and disturbance in the carbon dynamics of Amazon indigenous territories and protected areas". Proc. Natl. Acad. Sci. U.S.A. 117, 3015–3025. doi: 10.1073/pnas.1913321117

For the 1992 UN Convention on Biological Diversity (CBD), Indigenous Peoples have been influential since the beginning because they succeeded in being formally recognized in the Convention itself, especially in Article 8(j), where Parties agree to respect, preserve, and maintain the knowledge, innovations, and practices of Indigenous Peoples which are essential to reach the Convention's objectives.

However, Indigenous Peoples' access to the 1992 UN Framework Convention on Climate Change (UNFCCC) processes occurred much later, with no significant recognition of Indigenous Peoples issues in its decisions until 2001 when they were recognized as a constituency in the UNFCCC.

When the Global Environment Facility (GEF) became the implementing mechanism for the three Rio Conventions in 1992, Indigenous Peoples had little voice or impact on GEF priorities or decision making. However, through their own efforts, supported by many of us in UNDP and others, Indigenous Peoples have earned an enhanced role over the years, including through the establishment of the UNDP GEF Small Grants Programme (SGP) which celebrated its 30th anniversary last year and has allocated over \$725 million to more than 25,000 community-based projects since Rio. GEF now consults Indigenous Peoples in a serious and organized way so there has been an enormous growth in influence of Indigenous Peoples in the world's largest environmental granting body.

The establishment of the UN Permanent Forum on Indigenous Issues (UNPFII) under the UN Economic and Social Council (ECOSOC) in 2001 was another important milestone towards giving voice and influence to Indigenous Peoples at the highest levels of the UN.

The "Local and Indigenous Knowledge Systems" (LINKS) program in UNESCO has also played a valuable role since it was established in 2001 in facilitating exchanges between the holders of Indigenous and local knowledge with science policy processes, among other contributions.

In 2002, during the World Summit on Sustainable Development (WSSD) in Johannesburg, the Equator Initiative[8] – and the Equator Prize – were launched by my colleagues at UNDP and I to identify and honor thousands of successful indigenous and community projects from tropical countries to be resourced, scaled up and to foster south-south exchange of experience among communities. The Equator Initiative is still active, 22 years later – and represented here in this conference.

[8] Equator Initiative. www.equatorinitiative.org

After nearly 30 years of intense negotiations, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) was adopted by the UN General Assembly in 2007 – signifying since then a strong global commitment to rectify historical injustices and promote indigenous rights around the world.

In 2008 the International Indigenous Peoples Forum on Climate Change (IIPFCC) was established as the caucus for Indigenous Peoples participating in UNFCCC deliberations. They have continued to expand their interventions and influence in UNFCC COP processes since then.

The introduction of the Forest agenda into UNFCCC at COP11 in 2005 in Montreal and COP13 in 2007 in Bali brought renewed attention to the importance of Indigenous Peoples.

Significantly, Indigenous Peoples and Civil Society Organizations (CSOs) were given full seats on the governing body of the first phase of the UN-REDD Program in 2009, with equal authority to the other members representing governments and UN agencies, enabling them to have strong influence over how the REDD instrument operated and evolved. Prior to this, despite their outsized role in combatting climate change through forest conservation, Indigenous Peoples did not have official seats at the table or decision-making power for climate negotiations. The international community can surely do more to help secure land rights and decision-making power for Indigenous Peoples through more formal recognition of their contribution to, and leadership on, combatting climate change and biodiversity loss.

In 2010, Indigenous Peoples' efforts played a pivotal role in the adoption by the UNFCCC of the Cancun Safeguards, which recognize the need to ensure respect for the knowledge and rights of Indigenous Peoples.

The Forest issue was given prominence in the UN Secretary General's Climate Summit in September 2014 as one of its main themes and Indigenous Peoples' rights and knowledge were strongly featured in the New York Declaration on Forests (NYDF) which emerged from that Summit.

In the run-up to the Paris Climate Conference (UNFCCC COP21) in 2015, my colleagues at UNDP and I, supported by Norway, worked with the International Indigenous Peoples Forum on Climate Change (IIPFCC) – including by bringing more than 200 Indigenous leaders from all 7 indigenous regions to the COP – to formulate positions and strategies on climate, which were then coalesced into a common position for COP21. They had significant influence over the COP decisions related to their rights and traditional knowledge. The Local Communities and Indigenous Peoples' Platform (LCIPP) was also established at COP21 to strengthen Indigenous Peoples voices in UNFCCC processes.

Hindou Oumarou Ibrahim and the other IIPFCC leaders created an "Indigenous Pavilion" at the Paris COP, with support from UNDP and Norway – as a powerful platform for indigenous innovations, practices, positions and advocacy to greatly strengthen their presence and impact at Climate COPs, and these influential pavilions have been sustained through the subsequent COPs, including COP28 in Dubai.

In preparation for the Paris COP, the IIPFCC, UNDP and a range of NGOs and philanthropies began the serious exploration of ways to create an Indigenous-Managed Global Fund to support indigenous priorities directly – not through intermediaries as has historically been the case. In spite of their critical role in protecting the climate and biodiversity, Indigenous Peoples receive a very small proportion of financial resources provided by donors.[9] Concerted work is now underway to create viable platform(s) to channel resources directly to Indigenous Peoples.

The Glasgow Leaders' Declaration on Forests and Land Use at COP26 in 2021 brought together 145 committed governments, Indigenous Peoples groups, major philanthropies, NGOs and UN agencies to embed Indigenous Peoples rights in government declarations along with an allocation of \$1.7 billion to directly benefit Indigenous Peoples. This represents a serious move from advocacy to real investment in Indigenous Peoples.[10]

A wide range of local, regional, national and global funds and organizations to deliver funds at these various levels are being established or strengthened around the world and are reviewed in Hindou Oumarou Ibrahim's report to the UN Permanent Forum on Indigenous Issue (UNPFII) meeting on 15-26 April 2024.[11]

[9] Rainforest Foundation Norway, (2021). "Indigenous People Receive Little Climate Funding", https://www.regnskog.no/en/

[10] Ford Foundation (2021, Nov 1). "Governments and private funders announce historic US\$1.7 billion pledge at COP26 in support of indigenous peoples and local communities", www.fordfoundation.org

[11] Oumarou Ibrahim, H, (2024, Jan 26). "Financing the future: the financial needs of Indigenous Peoples to support their actions for biodiversity, climate and the protection of Mother Earth", UN Permanent Forum on Indigenous Issues; www.un.org

Hundreds of NGOs are now supporting Indigenous Peoples causes, including international NGOs with a focus on indigenous issues like Amazon Watch, Amazon Conservation Team (ACT), Indigenous Environmental Network (IEN), FERN, Forest Peoples Programme (FPP), International Work Group for Indigenous Affairs (IWGIA), Indigenous Peoples' Rights International (IPRI), Pachamama Alliance, Rainforest Foundation Norway, U.S. and UK, Rights and Resources Initiative (RRI), Tebtebba Foundation, Tenure Facility, World Resources Institute, etc.; as well as the major conservation organizations such as: Conservation International, IUCN, The Nature Conservancy, Wildlife Conservation Society, WWF, etc. Also, major foundations like: the Bezos Earth Fund, Climate & Land Use Alliance (CLUA), Ford Foundation, Christensen Fund, Good Energies, Kellogg Foundation, Hewlett Foundation, Moore Foundation, Nia Tero, Open Society Foundations, Packard Foundation, Porticus, etc. are also investing seriously. For more than 15 years, the Meridian Institute has offered invaluable support to the UN (UNDP, UNEP, FAO) and the UN-REDD Programme, and many other organizations, to advance the forest protection and indigenous peoples' rights agendas. The government of Norway has shown extraordinary commitment to the protection of tropical forests and Indigenous Peoples over the past several decades through programs of the Norwegian International Climate & Forest Initiative (NICFI) and the Norwegian Agency for Development Cooperation (NORAD).

Indigenous Peoples groups at the local level are becoming stronger and so are regional and global indigenous organizations including: AFPAT, Asia Indigenous Peoples Pact (AIPP), African Indigenous Women Organization (AIWO), AMAN, AMPB, Asian Pacific Indigenous Youth Network (APIYN), Coordinator of the Indigenous Organizations of the Amazon Basin (COICA), Global Territorial Alliance of Territorial Communities (GATC), ILEPA, Indigenous Peoples of Africa Coordinating Committee (IPACC), IIPFCC, REPALEAC, etc.

As a result, we are seeing increasing coverage of Indigenous Peoples issues in mainstream media and social media, including by Mongabay, the Guardian and countless others, thereby shaping and directing global public opinion to support indigenous issues.

And modern science is taking note and recognizing Traditional Knowledge in new ways as well, evidenced by recent reports of the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), as discussed in this conference.

IPBES embodies "one of the most ambitious attempts to date to bridge the divide between scientific and indigenous and local knowledge"[12] by establishing a task force on Indigenous and local knowledge systems, methodologies and an approach to recognize and work with Indigenous and local knowledge across all its assessments. Work on this ambitious and challenging agenda continues.

The 2019 report by IPBES adds further urgency to this growing movement to recognize and respect Indigenous rights because the authors conclude that without this recognition, the ability of Indigenous Peoples to continue to protect life on Earth through their lifestyles will be compromised.[13]

As I explain in the next section, through the Interfaith Rainforest Initiative (IRI) and other faith initiatives, religious leaders have also joined this multi-sectoral movement to support Indigenous Peoples' rights, traditions, knowledge and ways of life. And Pope Francis has been leading and supporting this encouraging development in important ways.

It has taken more than 30 years for Indigenous Peoples to embed their rich and long-lasting traditional knowledge and worldviews in the international arena in such a substantial way and all of this adds up to a massive and encouraging global movement of support for Indigenous Peoples. I believe this is among the most positive and significant developments in today's world towards addressing the climate and biodiversity crises.

However, many policies and laws at national and global levels still fail to provide appropriate and explicit recognition and support to Indigenous Peoples in the formalization of rights to lands and resources. With the rapid evolution of multiple threats to Indigenous Peoples and their lands, we can acknowledge the tremendous successes of the past 30 years but let us remain vigilant and committed to even more progress on this critical agenda going forward.

The Interfaith Rainforest Initiative (Iri)

His Holiness Pope Francis' visionary leadership on nature, climate and Indigenous Peoples issues has inspired many important efforts around the world, including the Interfaith Rainforest Initiative (IRI).

[12] Lofmarck, E & Lidskog, R, (2017). "Bumping against the boundary: IPBES and the knowledge divide", Environmental Science & Policy, vol. 69, issue C, 22-28. https://econpapers.repec.org/article/eeeenscpo/

[13] Brondizio, E.S. et al., eds. (2019). "Global Assessment Report on Biodiversity and Ecosystem Services" (Bonn, IPBES Secretariat).

IRI is based on the fact that tropical deforestation is a major driver of the global climate and biodiversity crises that undermine the lives and livelihoods of Indigenous Peoples, and deprives us all of water, food and jobs.

A number of the speakers in this conference have supported IRI since their participation in the IRI launch event in 2017 at the Nobel Peace Centre in Oslo, notably Bishop Marcelo Sanchez Sorondo, HE Sonia Guajajara, Vicky Tauli Corpuz, Nigel Crawhall and others.

The government of Norway has generously provided funding for IRI's pilot phases and the following prominent interfaith organizations oversee its work: GreenFaith, Parliament of the World's Religions, Religions for Peace, World Council of Churches and Yale Forum on Religion & Ecology – along with the Rainforest Foundation Norway and UNEP. Joseph Corcoran serves as the Program Manager of IRI. The Meridian Institute supported the launch and establishment of IRI.

IRI works in the 5 countries that hold 70% of the world's remaining tropical forests – Brazil, Colombia, Democratic Republic of Congo (DRC), Indonesia and Peru – and provides a platform for religious leaders to work hand-in-hand with Indigenous Peoples, scientists, civil society and governments on actions that protect rainforests and safeguard the rights and knowledge of the Indigenous Peoples that serve as their guardians.

One of the most encouraging impacts of IRI that we have seen so far is the beginning of a healing of the historically broken relationship since colonization between major Western religions and Indigenous Peoples.

Pope Francis has contributed enormously to this healing in the world through his recognizing and honoring Indigenous Peoples and their spirituality on many occasions, including through this conference.

To share one anecdote, I was personally deeply inspired to participate in His Holiness' meetings with thousands of Indigenous Peoples from throughout the Amazon who gathered in Puerto Maldonado, Peru in January 2018. There in the Amazon, Pope Francis expressed his profound respect for, and solidarity with, Indigenous Peoples, their culture, knowledge and spirituality – and thereby sent a powerful message of reconciliation around the world.

I will now give examples of how IRI programs are contributing to Indigenous Knowledge on the ground in the Amazon, the Congo Basin and Indonesia.

All of the 5 IRI programs work in the following four areas, among other areas: (1) Developing training materials and training thousands of religious leaders of all faiths on forests, climate and Indigenous Peoples knowledge and rights. (2) Establishing and supporting local chapters to impact local laws and policies where deforestation and threats to Indigenous Peoples are greatest. (3) Undertaking aligned, coordinated interfaith interventions on national legislation and policy on forests, climate and Indigenous Peoples rights. (4) Carrying out effective communication campaigns on these issues through radio and television, print media and social media and leading highly visible public campaigns.

How Indigenous Knowledge and Science are Coming Together Through the Interfaith Rainforest Initiative (Iri)

Brazil: 'Scientific Immersion Training' for Religious Leaders & Public Mobilization Through a Virtual Reality Experience of the Amazon

IRI Brazil is managing two major innovative programs to educate millions of Brazilians on the climate crisis and indigenous knowledge – and in particular, I thank HE Minister Sonia Guajajara for her extremely strong support of IRI and IRI Brazil since the beginning, and I acknowledge Mr. Carlos Vicente, IRI Brazil National Facilitator for his capable leadership of IRI Brazil.

'Scientific Immersion Trainings' are rigorous two-day training courses for Brazil's most influential religious and political leaders held in Brazil's top scientific institutions – CEMADEN (National Center for Monitoring and Alerting of Natural Disasters) and INPE (National Institute for Space Research). The focus is on the most current science on the causes and prevention of climate disasters and on alternative "bioeconomy" development models for the Amazon.

This training combines the science of forest preservation with understanding of the importance of Indigenous Peoples to overcome these crises, both through the preservation of existing forests on Indigenous lands, and also through their vast knowledge of the conservation, restoration and sustainable use of nature.

The "Immersion Training" activates religious leaders in their own institutions to educate their constituencies and encourage political authorities to enact laws and policies that protect forests and respect the rights of Indigenous Peoples.

This work is vitally important because the Brazilian public generally does not understand the connection between the climate disasters that are occurring in their cities with the destruction of forests in remote Amazon regions. This disconnect is now being resolved through IRI's educational work with and through religious leaders.

We are seeing many encouraging cases of how – after this "Immersion Training" – the hundreds of prominent Brazilian religious leaders from all faiths with millions of followers are using their own educational systems and social media to powerfully educate their followers about the scientific facts and indigenous knowledge related to the climate and biodiversity crises – and thereby reorienting their choices as voters and consumers.

The challenge remains serious because now – more than five centuries after the colonization of America by Europeans, when the violation of Indigenous Peoples' rights began – Indigenous Peoples still face powerful economic interests that deny their constitutional rights in the governments and courts and they also face prejudice from large portions of the population, including religious practitioners.

The "Amazônia Viva Virtual Reality Film" is a dazzling, award winning 3-dimensional film – based on indigenous knowledge – that offers a 10-minute immersive experience of actually being inside the Amazon rainforest.

The Amazon is unknown to the vast majority of Brazilians, especially the younger generations, and the film is guided and narrated by Chief Raquel Tupinambás, a dynamic young woman Indigenous leader from the State of Pará.

The film's message combines the traditional knowledge of Indigenous Peoples with modern scientific knowledge.

The narrator, Raquel tells us that "it rains in the Amazon because there is a forest" and not "there is a forest because there is rain" as science previously understood. In other words, it is the forest that causes the rain, not the rain that causes the forest, and if we destroy the forest then we lose the water to sustain food production and other needs of life. This is an example of ancestral indigenous knowledge from the Amazon.

The film is a powerful tool for raising awareness, education and mobilization and just last year (2023), more than 50,000 people personally experienced it. A rigorous study of the impact of the film shows that the number of people who donated money to conservation after seeing the film increased by 50% and people's perception of the importance of Indigenous Peoples and their knowledge for the preservation of the Amazon forest increased greatly too.

The film is now being distributed by many religious educational institutions and prominent museums throughout Brazil with constituencies of millions of people.

IRI Brazil also coordinates religious leaders to support the specific mobilizations and campaigns of Indigenous Peoples in defense of their rights. To this end, it carries out advocacy actions aimed at governments, parliamentarians and judges, contributes to the public debate by publishing opinion articles and promotes inter-religious dialogues and dialogues with indigenous leaders.

Colombia: 42 Local Iri Platforms for Indigenous, Science and Religious Cooperation

The IRI Colombia program also provides an excellent example of how indigenous knowledge and science can be brought together to address the climate and biodiversity crises in local municipalities in the Amazon.

In 2018, Ms. Blanca Echeverry, IRI Colombia National Facilitator and her team, set out to improve both national-level and local-level development policies to make them more protective of standing forests and Indigenous Peoples' rights and knowledge. First, they lobbied members of Congress to have two major Articles on halting deforestation introduced into the National Development Plan of Colombia.

With this national-level commitment in place, IRI Colombia mapped the regions of the country with the highest rates of deforestation and most violations of Indigenous Peoples' rights and then launched "local chapters" of faith-based action coalitions in those areas.

With the intention to use local municipal and state-wide elections to further their goals, IRI Colombia brought candidates for Mayor and Governor together throughout the country in public debates that were broadcast widely on TV and radio – and where each candidate signed a commitment statement that — if elected — they would actively promote rainforest protection and stand for Indigenous Peoples' rights and knowledge.

After the elections, IRI Colombia leaders came back to the newly elected Mayors and Governors and reached agreement on having IRI representatives serve on local and state-wide Planning Councils to monitor forest and land use planning to ensure the commitments made by the elected officials are implemented.

By the end of 2023, 42 local IRI chapters had been launched across the country to enable leaders from Indigenous Peoples, the scientific community and all the religions of the country to work powerfully together to protect nature and indigenous knowledge.

Democratic Republic of Congo and Historic Indigenous Peoples' Legislation

In the Democratic Republic of the Congo (DRC), religious leaders contributed significantly to indigenous issues by bringing their considerable moral authority and political influence to bear in support of a decade long campaign by Indigenous Networks in DRC and to successfully lobby government to adopt a new law in November 2022 on the "Promotion and Protection of the Rights of the Indigenous Peoples".

This historic law is the country's first ever legislation to formally recognize and safeguard the rights, land tenure and knowledge of Indigenous Peoples and is another high impact example of how multifaith action can make a difference on the ground for Indigenous Peoples. The Reverend Matthieu Yela Bonketo serves as IRI DRC National Facilitator.

Indonesia: Fatwas to Combat Climate Change

In Indonesia, on 23 February 2024, religious leaders through IRI Indonesia, together with partners and led by the Ulama Council of Indonesia (MUI), the highest authority on Islamic law in the country, issued a 'fatwa' against actions that cause climate change. (Fatwa MUI Number 86/2023 on The Law for Controlling Global Climate Change.) A 'fatwa' cites the Koran and carries significant moral weight with the majority Muslim population.

Several important MUI fatwas have preceded this one, including: (1) in 2011, forbidding destructive mining operations; (2) in 2014, forbidding activities which threaten endangered species; and (3) in 2016, forbidding "the burning of forests and land that can cause damage, pollution, harm to other persons, adverse health effects".

Importantly, the MUI is now considering work on a fatwa regarding the protection of Indigenous Knowledge. Dr. Hayu Prabowo serves as IRI Indonesia National Facilitator.

Peru: National Legislation to Protect Environmental Defenders

Peru provides another example of how religious leaders are helping to protect indigenous knowledge and rights in cooperation with NGOs and government.

In early 2021, the Interfaith Rainforest Initiative (IRI) in Peru, in partnership with the NGO, ProPurús Association, alerted the Minister of Justice and Human Rights and other senior government leaders to the alarming increase in threats and violence to indigenous leaders and environmental defenders in the Amazon, especially in the areas of Ucayali and Pucallpa.

Senior religious leaders including Cardinal Pedro Barreto, indigenous leaders from the region, the Minister of Justice, Minister of Culture and many other important religious and NGO leaders participated in a series of meetings which resulted in the adoption on 21 April 2021 of the Supreme Court Decree N° 004-2021-JUS "Intersectoral Mechanism for the Protection of Human Rights Defenders", coordinating the work of eight government Ministries to protect environmental defenders.

IRI Peru has been actively supporting this new mechanism that focuses on effective prevention, rapid protection and access to justice and has already shown it can help protect indigenous and other local environmental defenders against violations of their rights across Peru.

IRI Peru Advisory Council member, Cardinal Barreto published an editorial on the topic in an influential Peruvian newspaper on 27 May 2021.[14]

These recent examples demonstrate the profound impact of powerful new partnerships between religious leaders and Indigenous Peoples around the world and how this collaboration is providing vitally important and effective support to Indigenous Peoples' struggles for their rights, livelihoods and ways of life.

Conclusions

To conclude, I summarize the 6 main points proposed in this article as follows:

1. Indigenous knowledge, culture, ways of life and spirituality are key to avoiding cataclysmic outcomes from the twin climate and biodiversity crises and the evidence base for this is growing each year.
2. Securing Indigenous Peoples' rights to their lands and resources is essential for indigenous knowledge to be sustained.
3. This understanding – along with the allocation of increasing support and resources to Indigenous Peoples – has been growing strongly over the past 3 decades since the Rio Earth Summit – along with powerful new partnerships among Indigenous Peoples, scientists, the United Nations, NGOs, philanthropies and governments – and most recently: with religious leaders and faith communities.

[14] Barreto, P, (2021, May 27). "Peace and Dignity for the Amazon", El Comercio Newspaper, Peru, https://elcomercio.pe/opinion/colaboradores/paz-y-dignidad-para-la-amazonia-por-pedro-barreto-sj-tala-de-arboles-cardenal-noticia/#google_vignette

4. I argue that this constitutes one of the most hopeful and "game changing" movements to generate effective action on climate and biodiversity in today's world.
5. One such partnership, the Interfaith Rainforest Initiative – inspired by Pope Francis – is demonstrating how faith communities and Indigenous Peoples, scientists and other sectors have formed influential coalitions in key countries to stop tropical deforestation and protect Indigenous Peoples' rights and knowledge.
6. The Interfaith Rainforest Initiatives' methodology and experience in tropical forested regions of the Amazon, Congo Basin and Southeast Asia can inform and serve as a model for multifaith efforts on indigenous rights and other aspects of the climate and biodiversity crises and in other geographies to help us build a viable future for all.

Climate Change Education Facing Traditional Cultures

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Education needs educators capable of developing an ethics of ecology, and helping people, through effective pedagogy, to grow in solidarity, responsibility and compassionate care.
Pope Francis, *Laudato Si'*, in Chap. 6.
Ecological education and Spirituality

1. Introduction

From the creation of the United Nations Framework Convention on Climate Change (UNFCCC, Rio Summit 1992) to the publication of the Encyclical Letter *Laudato Si'* (2015) and during the following decade until today, the preoccupation for education in climate change has steadily grown in international and national bodies, as being one of the complex but efficient tools to act on the threats of climate change (for a detailed analysis, see Borde et al 2024).

In 2015 at the Conference of Parties (COP21), the Paris Agreement, today being quasi-unanimously ratified by 192 nations, provided a solid basis for action of the governments. Its Art. 12 reads: "*Parties shall cooperate in taking measures, as appropriate, to enhance climate change education […], recognizing the importance of these steps with respect to enhancing actions under this Agreement*". Then, up to the last COP28 in Dubai, prescribed progresses were slow but noticeable, education concerns slowly being considered in COPs and by governments, as evidenced by the hosting by the UAE of the first ever education pavilion at COP28.

The same year 2015, the United Nations adopted the seventeen Sustainable Development Goals (SDGs), as part of the Agenda 2030. These 17 SDGs are very broad and cover all the aspects of an ideal ecological transition, from science to economy and finance, as shows their more detailed declination in 169 sub-goals. Therefore, introducing sustainable development as an objective for education is virtuous but often too general to become operational and efficient (Léna 2020). On the other hand, the focused and science-embedded themes of climate change and biodiversity can more easily impact on curricula and teachers' practice, as discussed here. Both themes are closely related, but we focus here on climate change education.

Developing it in indigenous cultures, most often marked with poverty, faces special challenges, but cannot be done independently of an effort dealing with education in all countries, since climate issues are essentially global ones. We present below some actions carried out in this context by the *Office for Climate Education*, a structure we created in France in 2018, to help teachers in primary and secondary schools, worldwide, to cope with education on climate change. Broadly speaking, this includes: the need to prepare the youth for a threatening future; a challenge to make teachers able to convey a proper message, based on scientific knowledge, while developing a critical mind as well as a hopeful heart; a transformation of curricula decided by governments.

2. The Office for Climate Education and indigenous cultures

Since 1995, the French Academy of sciences had developed a model named *La main à la pâte* for improving science education in primary, then middle schools (Léna 2012, Fondation La main à la pâte 2024). In collaboration with science academies in a number of countries, and with the InterAcademy Partnership (InterAcademy Partnership 2024), this model of active science education was implemented in over 50 countries, sometimes on a local and experimental basis, sometimes on a broad scale. It often had to work with indigenous cultures, where the scientific concepts carried by modern science needed adaptation and a specific pedagogy. Today, science education has to consider not only the beauty of science for itself and the natural curiosity of children, but also the societal issues which often bring science and its applications to the forefront of the public debate (Alberts 2024).

This is why, after the COP21 and the Paris Agreement in 2015, an offspring of this Foundation was created, keeping its spirit and pedagogy of active science education, but focusing explicitly on climate education. Today, the Office of Climate Education (OCE), based in Paris, employs 15 full-time persons and proposes various pedagogical tools for teachers of primary and secondary schools (Office for Climate Education 2024). The OCE adapts for teachers the Reports for Policy Makers which accompany each IPCC Report. These adaptations are published in the series *The Climate in our Hands*, covering today the 1.5°C Report, Ocean and Cryosphere, Climate change and Land, and the 6th IPCC Assessment Report. It then publishes a variety of pedagogical resources to help teachers in the class room on these topics, trying to refer to subjects already present in the prescribed, existing curricula. In the process of creating these guides, great care is taken to involve education actors which would represent and respect a diversity of cultures (currently Chile, India, Indonesia, Mauritius, Mexico…). OCE has fostered a specific program in Latin America (ALEC 2024), which has numerous interactions with indigenous cultures in Colombia and Mexico, now expanding in partnerships with Argentina, Chile, Costa-Rica, Guatemala, Honduras, Panama, Peru. A similar program in Africa, initially in Senegal, Kenya and Mauritius, is set to start in 2024 and is likely to encounter even more the question of children from indigenous backgrounds having to face climate change.

In Colombia, developing a partnership with the Academia Colombiana de Ciencias, the University of Rosario and the NGO Fondo Acción, eight regional dialogues have been undertaken with nearly a thousand teachers, attempting to remain as close as possible to their local conditions (mountain, rural areas). In Mexico, in cooperation with the remarkable NGO Innovec (Innovec 2024), a contextualized module, *Introduction to Climate Change*, has been implemented with primary school teachers of five local communities, including the Mazahua and Otomi, located in the Central Plateau of the country. In Southern Chile, a thorough work is undertaken for Mapuche and Araucarian areas by the Pontificia Universidad Villarica collaborating with the Siemens Stiftung and its Experimento program (Bascope & Canihuan 2016, Bascope et al. 2021).

The first lesson from these still limited attempts is the constant observation that the curiosity of children for natural facts and explanations is universal, no matter their cultural background. But indeed, the approach to climate education in developed countries builds up on abstraction, lack of deep contact with nature, consumerism and belief in the power of technology. On the other hand, in indigenous communities, there exists a deep experience with senses and a knowledge of nature, a rich descriptive language of phenomena, plants and animals, a sense of fragility of humans facing the natural phenomena. On such basis, a long way has to be undertaken to enter the scientific explanations of climate change, the rational motivations to act and protect present and future humans, and to foster climate justice in a global system. But there is no doubt, on the basis of ALEC project's experience, that teachers in these indigenous communities are more receptive to teaching climate issues to their students than teachers in France.

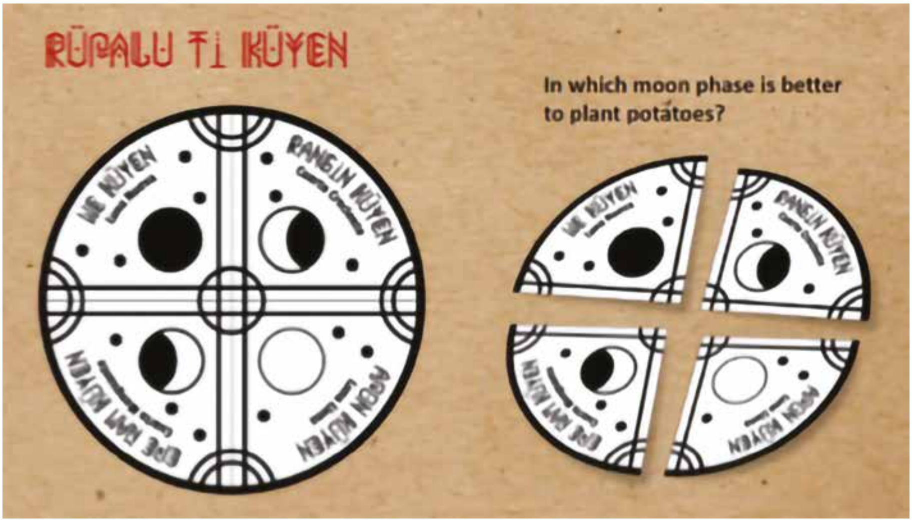

Figure 1. Interfacing with Mapuche culture in Chile (Bascope & Canihuan 2016).

Let us conclude this with a quotation of the Fondo Acción analysis in Colombia:

> These dialogues sought to gather knowledge, wisdom, languages and experiences from the different regions of the country on environmental education and climate education. Little by little we are getting ready for these days of dialogue, with our hearts filled with joy for having the opportunity to be invited to talk, to share experiences, to validate knowledge and to imagine our future. With a pause to observe the environment, to feel the humidity of the moor, the sea breeze or the freshness of the river, always allowing ourselves to be enveloped by the wonders of nature, but with the awareness that environmental problems and the risks of climate change are happening right now and are part of our lives and that, with a positive and proactive outlook, we can act and transform situations now (Fondo Acción 2024).

3. UNESCO, poverty and climate change education

Analyzing the evolution of poverty with the various IPCC transition scenarios shows that, in 2050, global poverty could be reduced from today's 3 billion humans to 1.3 billion, if scenario SSP2 (Shared Socioeconomics Path, in IPCC Sixth Assessment Report) can be achieved (Soergel et al 2021). The world map in 2050 shows a high correlation of intense poverty with areas of indigenous cultures, especially in Africa, Asia and South America.

Recently, UNESCO has initiated a number of detailed studies on the status of climate change education. Exploring curricula in 100 countries, it found that half of these have no mention of climate change (UNESCO 2021). When 95% of teachers agree that teaching climate change is necessary, barely a third of them consider they could do it properly. Among the students, 70% cannot explain what is climate change. There is clearly an immense gap to fulfill. Since 2023, following a UN decision, UNESCO has established a Greening Education Partnership (UNESCO 2024a) with a four-folded set of goals (Fig. 2).

UNESCO is indeed an essential UN body, which carries the interface of climate change education with the scientific community on one hand, with ministries of education and schools on the other. The Office for Climate Education is a co-coordinator of the ambitious scheme and has contributed to the writing of the Greening Education Guidance (UNESCO 2024). The goal here is to serve "as the basis for a review of existing curriculum and the integration of climate change across all subjects including the social sciences, natural sciences, humanities, and technical education". As a support of

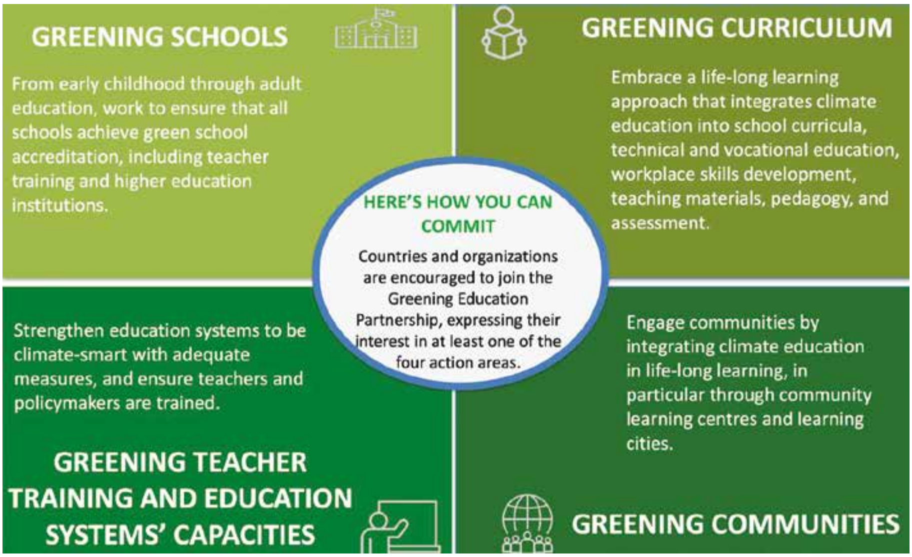

Figure 2. Details of the UNESCO Greening Education Partnership.

this UNESCO action in 2023, OCE held 94 teacher training and conferences in 21 countries, outside the specific ALEC project in Latin America. Many of these countries have indigenous communities with whom dialog is crucial for inclusive education curricula.

As the yearly UNFCCC Conference of Parties (COP) offers a worldwide rendez-vous on climate issues, OCE inaugurated at COP26 (Glasgow in 2021) a Teacher's COP which repeats yearly. In 2023 in Dubai, co-organised with UNESCO, the Teachers' COP had gathered 400 submissions from 71 countries. Ten teachers, some representing indigenous communities in Mexico, presented their projects during a hybrid event which gathered 1500 teachers and policy-makers (Fig. 3). Planning for such event in future COPs will ensure that voices of teachers are listened to, and cultural diversity accounted for in implementing climate change education.

Figure 3. Teachers participating in the Teachers' COP at Dubai in November 2023. (Source OCE)

4. Conclusion

This short presentation just gives a hint of the wealth of possibilities offered when introducing climate change education in indigenous communities, and of the progress made in the last few years in this direction. The hope is that, through dialog at local, national, regional and international level, the intense perception of nature and human fragility in indigenous communities will progressively inspire the curricula and the practices of schools everywhere in the world.

Acknowledgments

The authors have benefited from the OCE experience gathered in Latin America, with special thanks to its director David Wilgenbus, to Claudia Robles (Mexico) and Martin Bascope (Chile). The constant support of climatologist V. Ramanathan (Scripps Institution, California) for implementing climate education has been invaluable since 2014, as well as the support of Bruce Alberts (San Francisco) in fostering science education worldwide in the last decades.

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Science Education as a Perspective for Young Minorities in General

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The intelligent heart acquires knowledge,
the ear of the wise seeks knowledge
(Proverbs 18,15)

Introduction

The need for scientific education is general and regardless of the geographic location where we live and in what conditions we live. Everyone takes advantage of technological advances, and everyone wants to preserve their deepest customs. The globalization of practically everything on the planet makes it impossible for any community to live exclusively based on ancient traditions. It is necessary to preserve tradition and prepare everyone for proper use that helps to preserve traditions. Climate change, diseases in general, and pollution affect everyone whether they live in isolation or not. The world is now one big community where everyone is affected by the irresponsibility of somebody else, and everyone can benefit from the technological advances that humanity are developing. Educating children scientifically is not breaking traditions; on the contrary, it is preparing them to enjoy the knowledge that will allow them to maintain their traditions and preserve their own people, while still enjoying technological benefits. The question is how to do this, since many communities live in conditions that do not contain traditional forms of education or resist acquiring it? Educational kits or theater performances are appropriate ways of bringing scientific knowledge almost anywhere. In addition to these aspects, there is a fact of extreme importance for different communities, including indigenous communities: teaching science is a way of preparing everyone to better understand nature and, consequently, develop ways of preserving it, even when it is necessary to explore it to obtain basic survival supplies. In this chapter we will describe some of our experience in teaching science to different types of communities and the results achieved. Almost all described activities are taking place in Brazil and it is par to the science diffusion activity of the University of São Paulo in São Carlos.

Educational kits: adventures in science

During the last few decades, there has been a great effort to establish quality university level education. Little or no effort is being put to improve basic education in general. Not even the best schools teach science to their students, when we refer to children's basic education. As a result, great talents are lost or wasted when compared with the real needs. Many programs have been launched with the aim of promoting scientific education and motivation around the world: "Hands on" in France and "Os grandes cientistas" in Brazil, among others, are examples. Our experience began with a proof of concept, which was carried out with the support of CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior), and was composed of the launch of a set of kits, with the purpose of teaching science in a non-school environment, with the character of a Pilot Project, in order to evaluate the content, adaptability, educational complementarity, ease of use, clarity of instructions, etc. For this proof of concept we used the Basic Education Programs of Capes – Pibid – Institutional Teaching Initiation Scholarship Program and Parfor – In-person – National Training Plan for Basic Education Teachers. We first developed the kits with mem-

Figure 1. The first group of kits and the group of scientists responsible.

Figure 2. Examples of kits: optics and geophysics.

bers of the Brazilian Academy of Science. Around 6000 kits, distributed across five themes, were inserted into these programs and tested. Distribution was carried out in public high schools and basic schools located in different regions of the country. Assessments were collected and analyzed, creating input for a second corrected version of the five themes involved. Some of the kits in this proof-of-concept phase were the following: *Adventures with light rays* – Introduces basic laws of geometric optics, allowing you to verify them, visualizing and recording the path of light rays, and understanding how optical instruments work, including the telescope and other instruments. *Exploring the skies* – Using the Galileoscope, designed for the International Year of Astronomy, it allows to observe all the astronomical objects discovered by Galileo. The fact that the students had to assemble the device allows them to explore how it works and the power of optical instruments. *The certainties of chance* – Introduces the basic ideas of calculating probabilities, illustrating them with experiments involving throwing dice in different ways, drawing lots and applying them to genetics. *Discovering the world of chemistry* – It is a mini chemical laboratory, using small bottles of small volume and minimum doses of reagents, without risks for users. Various aspects of chemistry, physical chemistry and electrochemistry are practiced with this kit. *The microscopic world* – Uses a low-cost microscope but of sufficient quality to allow you to observe plant and human cells and other microscopic organisms. The group of scientists that developed the kits is shown in Figure 1.

Today, the collection of these kits contains 12 topics, including the *Geophysics* Kit, where students can experiment with natural effects that occur on the planet, such as the greenhouse effect, thermal zones, climatic seasons, etc. A *Thermodynamics* kit, a topic considered taboo for high school, where the student can understand the concept of temperature, fundamental to all sciences, deducing the gas laws, etc. The ARDUINO kit teaches hardware principles to students of all levels. The *wonders of colors* explores how the human vision works related to colors and how the brain makes interpretations. The exploration of optical illusions and stereoscopic image place students in contact with modern technology and its use. Over a period of 12 months, the initially designed kits were produced and distributed to schools, universities and groups of independent young students. We tried to evaluate all the positive and negative points of these kits.

The website www.aventurasnaciencia.com.br was created. It contains the program presentation, instructions for use, contact address, and evaluation forms. In addition, printed forms were distributed to all participants in this proof of concept.

The analysis of thousands of complete questionnaires leads to the following results: (i) the idea of the kits is excellent; (ii) their content is appropriate; (iii) they complement very well the practical teaching of science in schools; (iv) they have an appropriate level for students; (v) they will certainly have a good effect on the training of students. In addition to a large list of positive aspects, some points were highlighted that deserve to be improved. Among them are the way of presenting the program on the "Home Page", which created problems with some parts of the instructions, time to carry out the experiments, necessary previous concepts, difficulty

Figure 3. Demonstrations with the kit: colors and vision.

of parts of the practices, learning effectiveness on the part of the student, arrangement of parts, ease of assembly, and several other aspects. One of the most important lessons learned in the pilot project was that the teachers have to be involved from the very beginning and mostly be trained to be able to answer the students' questions.

Even though it is an extracurricular activity, students get so engaged that they take the topic and their experience to the classroom. To have positive results, teachers must also be prepared with the material. Special training of teachers is now organized. Today the program is greatly successful and the number of students engaged with the kits and their scientific interest is growing. The problem is that the government should get involved in the initiative to make it a part of the education activity, but that is not happening. Science clubs in many schools and neighborhoods were initiated with kits.

Visits and theater in more isolated communities

In many situations, the infrastructure is inadequate for scientific practice, for example with kits, which are true laboratories, requiring another type of activity. Our experience involves forming a mobile unit that visits schools and communities, demonstrating science as a topic of interest. We chose the theme "water" and through it we propose teaching in different areas: mathematics through proportions, chemistry through the constitution of water and the occurrence of mixtures and solutions, as well as methods of purifying water. The phases of water and how it flows and the consequences of the gaseous, liquid and solid phases in our lives are explained. Physics is introduced through the topic of energy and the use of water to generate electricity. Inside the mobile unit, we have a micro hydroelectric plant to show how energy is generated. Biology is introduced through microorganisms that live in water, whether they cause disease or not. Biology

Figure 4. Bus as a science exhibition: 150,000 students/year reached with this unit.

is also taught showing how water can feed the different parts of the plant and carry nutrients, etc. The mobile unit, mounted on a bus, normally goes to communities and remains there for over two days, giving everyone the chance to interact with the exhibition.

Equivalent to the bus are the Planetariums, domed theaters that project images of the starry sky and countless spectacular objects we find in our universe, creating educational experiences that teach astronomy and related sciences. The star projectors that show the night sky itself are among the most durable, versatile, and cost-effective educational tools.

At a time when quality science education is more important than ever, a scientifically literate public is an essential part of the progress of any country. Planetariums around the world both inspire and educate people of all ages about our surroundings – the Earth itself and our place in the Universe – and they are often a place in which young people become enthused to follow a scientific career.

Figure 5. The roving planetarium.

During the last few years, we have taken the Planetarium to numerous schools and public exhibitions. The Planetarium mainly featured the movie entitled *The Birth of the Solar System*, which brings the story traced from the Big Bang to the present day, through the existence and extinction of dinosaurs. The film's projection is of the highest quality and the activity attracts people of all ages.

Another program to reach the young kids in school is called *USP goes to your school*, and it is one more possibility to complement the scientific education of students in underserving communities. In this case, an Itinerant Science Museum was built, through interactive panels. The panels were made in partnership with the Center for Human Genome Studies, collaborators of this project. Two main themes have been prioritized: optics and cells. During the exhibitions, the school's own instructors, trained at USP, explained the panels to students, staff and teachers at their schools.

Figure 6. The planetarium.

Figure 7. Exhibition in schools in the *USP goes to your school* program.

Exhibitions and Public Places: Fantastic Sciences

The Circus of Science, held in public squares, aims to awaken, especially in young people, the taste for science. The event, which attracts many young and senior people in the communities where it is established, is part of the Brazilian National Science and Technology Week. During the exhibition, the thousands of children and adults who visited the exhibition were able to interact with the various educational equipment and panels, as well as numerous experiments, which demonstrated the work that is carried out in present research to understand the nature of atoms and molecules, their importance in producing new pharmaceuticals, as well the concepts of transforming science into products for society.

Figure 8. Circus of Science: more than 20 cities visited.

TV Channel Dedicated to Educational Complementation in Sciences

In general, people spend more than eight hours per week in front of a TV set. Even high school students in Brazil spend more time watching TV than on the internet. In view of this situation, TV is an excellent mechanism to disseminate science in general. The goal of this project is to diffuse science and technology to the general public, including students, using the TV channel run by the Optics and Photonics Research Center. We have six people fully dedicated to the activities of the TV. Our scientific TV channel broadcasts 24 hours a day, bringing lectures, classes, interviews and documentaries from various fields of science, entrepreneurship and innovation.

Several scientific programs are recorded and edited monthly, either inside or outside the studio. Journalists and reporters also produce radio programs, newspaper columns, and classes on the internet, where scientific, technological, and innovation content is aired continuously. Article columns are maintained in two local newspapers (both online and print), on a weekly basis, resulting in several science outreach articles. Appearances in the local radio news and interviews have also been promoted regularly, reaching thousands of people per action. The content for the TV channel includes interviews, speeches, event broadcasts, science shows developed by the Optics and Photonic Research Center team and associated partners from other institutions. Programs are produced in our studio for the YouTube channel, and others. Today the YouTube channel has more than one million followers, mostly young people. Within the last year, dozens of programs were produced especially for the YouTube channel, currently with more than 183 thousand subscribers, released on a daily basis, for a total of 285 new videos released between June 2021 and May 2022. The 61 YouTube playlists collect varied content, including science news, events, live broadcasts, and interviews, along with productions aimed at fostering interest in science, technology, and innovation. These programs are also broadcast on the TV channel, in addition to the already produced material, resulting in a 24-hour broadcast of scientific and cultural content. Among the activities developed during the last 12 months, the TV and YouTube channels received new episodes of successful programs such as *Chemical Elements* (*Elementos Químicos*), exploring basic aspects of the Periodic Table elements, *Science Workshop* (*Oficiência*) where Prof. Luiz Antonio Nunes explores fun aspects of physics in homemade experiments, *Educational Kits* (*Kits Educacionais*) where a program started from a collaboration of professors from some of the main universities of the country created educational science kits that allow students to explore phenomena by themselves and has now been turned into a national educational program. New programs were also introduced, such as *Biphotonics in Entrance Exams* (*Biofotônica no Vestibular*), where questions present in university entrance exams exploring Biophotonics are discussed and resolved, *Science is News* (*Ciência é Notícia*), where new advances and current discussions on science are explored in an accessible language, and *Fun and Fantastic Math* (*Matematica Divertida e Fantástica*), which explores fun situations where mathematical logic can help solve problems or deal with real-life situations.

Main TV and Internet Programs Available in the Collection:

Basic Science courses (417 videos):

Physics (362 videos): Basic Course on Mechanics, Basic Course on Electricity and Magnetism, Radiation-Matter Interaction, Basic Course on Modern Physics, Introduction to Atomic Physics, University-class Basic Physics (two modules), Structure of Matter, Introduction to Atomic and Molecular Physics, Physics for Engineering, Fundamentals and Biomedical Applications of Quantum Science, Optics Spectroscopy, Computational Electromagnetism, Computational Classical Mechanics, Introduction to the History of Physical Sciences; **Mathematics (13 videos):** Mathematics, Mathematics Review – *USP waits for you* program; **Chemistry (42 videos)**: Chemical Elements; **Science Fostering Events (291 videos):**

- **Events:** International Day of Light, Optics Weeks, seminars, workshops, science fair and awards, local Science Museum activities, among others

* Science Fostering Productions (343 videos):

- **Science News (31 videos):** Science means News, FAPESP Scientific News
- **Science Fostering Shows (210 videos):** *Biphotonic on Entrance Exams, Educational Kits, Fun and Fantastic Math, Education for All, Science for All, Science Workshop, Life and Science Tips, Science Tips, On the Path of Scientists, Science in the Cathedral, Light*. All this material is fully available at *http://cepof.ifsc.usp.br*

How Astronomers Explore the World and What They Have Learned – And Not Yet

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Abstract

What are stars and planets? How did the Universe begin? Is there a connection between our Earth and the sky? These and other similar fundamental questions have tormented the curiosity of mankind since the birth of our species. These questions have started to be addressed with the development of modern astronomy, which began in 1610 when Galileo Galilei first put his eye to the telescope. Despite four centuries of discoveries, however, many of these fundamental questions remain unaddressed, and are still the subject of active research. I present here a succinct and simplified view of some of the major accomplishments of modern astronomy, as well as the fundamental questions that are still open, concerning the existence of life on other planets and the nature, birth and fate of the Universe as a whole.

I conclude mentioning how the recent development of mega-constellations of low orbit satellites threaten future observations of the sky from the Earth.

Introduction

Along with medicine and botany, astronomy is arguably one of the oldest human sciences. It stems from the inevitable curiosity about the nature of the objects that we see in the sky and of their complex motion: the daily setting of the Sun and the Moon, the apparent erratic movements of the planets, the yearly motion of the fixed stars. For thousands of years, mankind – not overshined by artificial lights – has stared at the sky and argued about its role and origin. All human cultures in every continent have developed their explanations about the birth and nature of the Sun, the Moon, and planets. In particular, the luminous stripe that crosses the summer sky (see Figure 1) has attracted human attention and given rise to a number of explanations about its birth, resulting in a variety of different names – "Milky Way" in the Western Culture, "River Ganga in the Sky" in Sanskrit, "Silver River" in Chinese, "River of Heaven" in Japanese, "Straw Way" in a number of Asian cultures, "Fish jumping in shadows" in some

Figure 1. The Milky Way. An image of the Milky Way as viewed from the Utah desert. Author unknown.

Hawaiian cultures, "The Heavens River" in some Berber languages, just to mention a few.

Ancient astronomers mastered the motion of objects in the sky and used this knowledge to predict the change of seasons and take informed decisions about harvesting, migrations and other human activities.

Since its origin, astronomy has therefore been linked to the human quest of the origin and ultimate nature of the world, has influenced the perception of mankind's position in the world and influenced its daily life.

Modern astronomers are the heirs of this tradition and are moved by the same ultimate goals. While we nowadays use powerful instruments to explore beyond what is visible using only the naked eye and utilize sophisticated mathematical analyses to decipher the rules that govern the laws of the Universe, they are driven by the same curiosity and fascination that moved every human being. The *sense of wonder* in discovering the secrets of the Universe and the desire to understand *how the Universe and the world around us were borne* are the same that motivated ancient astronomers and that attract all of us.

Galileo and Hubble: exploring the Universe

There is no better evidence of this motivation than the words used by the giants of modern astronomy to describe their discoveries.

Galileo Galilei founded modern astronomy by using for the first time an instrument – a small telescope that was used previously only for navigation purposes – to look at the sky. In his masterpiece *Sidereus Nuncius*, published in 1610, Galileo reports his discoveries about the surface of the Moon, the existence of satellites around Jupiter and the nature of the Milky Way. It is worth looking at his hand-drafted designs (Figure 2) and reading how he describes his discoveries:

In third place, I have observed the essence or substance of the Milky Way circle. By the aid of the telescope anyone may behold this in a manner which so distinctly appeals to the senses that all the disputes which have tormented philosophers through so many ages are exploded at once by the unquestionable evidence of our eyes. [...] *the Galaxy is nothing else but a mass of innumerable stars planted together in clusters. Upon whatever part of it you direct the telescope straightway a vast crowd of stars present itself to view; many of them are tolerably large and extremely bright, but the small number of small ones is quite beyond determination.*

In the first sentence, Galileo proudly announces the superiority of his new observations based on the power of new instruments and the undisputable evidence upon which scientific method is based. In the second sentence, the *sense of wonder* for his discovery clearly emerges. We can only imagine the astonishment that Galileo must have felt when he pointed his telescope toward the fuzzy luminosity of the Milky Way and discovered

Figure 2. Galileo's observations of the Milky Way. This is Galileo's hand-drawing of the stars that he observed looking for the first time through a telescope. Faint stars in the image were not visible by naked eye and were forming the apparent Milky Way stream. From [1].

that it was made of “a vast crowd of stars”: literally a new world emerged in front of his eyes.

With his discovery, Galileo proved for the first time that the Milky Way is a cloud of “innumerable” stars, and that the Sun in only one star in a vast island of stars. Over these 400 years from Galileo’s discovery, astronomers have proved that the Milky Way is made of approximately 100 billion stars (most smaller but some larger than the Sun), that it has the shape of a rotating spiral with a central spherical bulge, and that the Sun is located in an undistinguished position relatively far away from the galaxy center.

Three hundred years after Galileo, another astronomer revolutionized our understanding of the Universe: in 1921, Edwin Hubble discovered that our galaxy is only one among billions of other galaxies: the Milky Way is not the only “island of stars” in the Universe but – again – innumerable others galaxies exist. A few years later he also discovered that all external galaxies run away from our Milky Way, and those farther away are also faster – this has been the first evidence that the Universe is constantly expanding. Again, his words are worth reading [2]:

Telescopes have continued to develop until today we are exploring those outer regions. They are inhabited by stellar systems comparable with our own system of the Milky Way. Those other systems are the extragalactic nebulae (galaxies). We find them scattered thinly through space out as far as telescopes can reach. [...] *They are gigantic beacons, permitting us to survey and study a sample of the universe. Eventually, if the sample is fair, we will be able to infer the nature of the universe as a whole from the observed characteristics of the sample available for inspection. This possibility is the ultimate goal of the space exploration.*

The first sentence is incredibly akin to Galileo’s first sentence – it explains that discoveries are made possible by new instruments and conveys the sense of wonder for the discovery of galaxies “scattered thinly through space out as far as telescopes can reach”, exactly like Galileo’s discovery of stars in the Milky Way.

The last sentence clarifies that the ultimate goal of this effort is “to infer the nature of the universe”: the same desire and curiosity that arose in early astronomers is motivating their modern descendants.

In the last century, after Hubble’s discoveries, astronomers have continued to explore the Universe and tried to pin down the fundamental laws that govern it. In this process, we have expanded our view in an unprecedented way and discovered new fundamental properties of the Universe. As always in science, these discoveries have opened new questions and unveiled new mysteries that await explanation. In the following I will give a few examples of what we have discovered – and what not (yet).

Planets around other stars

Until less than 30 years ago, the only known planets were the eight orbiting the Sun, five of which are visible to the naked eye. In 1995, the first discovery of a planet orbiting another star was obtained [3]. This discovery was awarded a Nobel Prize in 2019, as one of the major breakthroughs in modern science. Since then, more than 5000 planets have been discovered around other stars among those close to the Sun, with a variety of techniques and instruments. These objects have been collectively called *exoplanets* to emphasize their location outside our Solar System. For most of these objects we have solid measurements of their fundamental characteristics like mass, radius or distance from the parent star. From these, we can infer their composition and their surface temperature. For a few of them we also have direct images

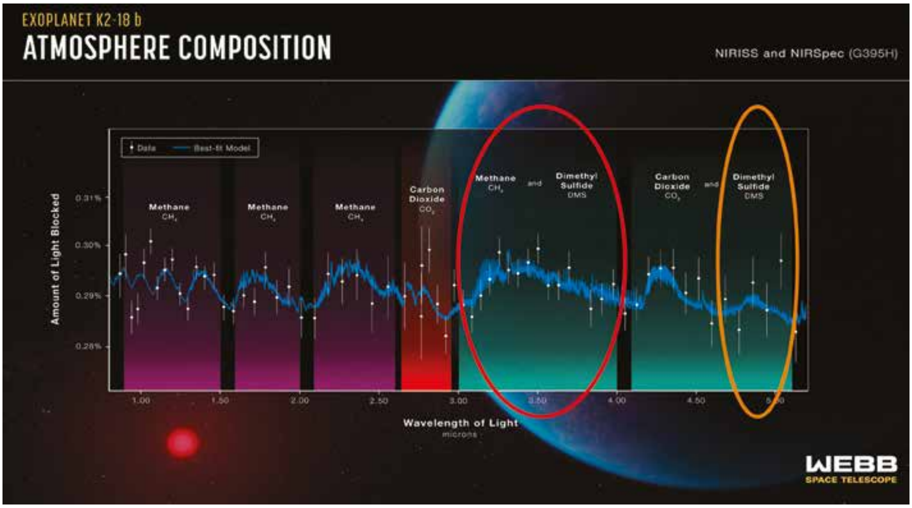

Figure 3. Searching for life on extrasolar planets. The background image is an artist's view of a planet, dubbed K2-18b, recently discovered around the star K2-18. Astronomical observations demonstrate that the planet is about three times larger than the Earth and is covered by a deep-water ocean. The data shows the absorption spectrum of the planet's atmosphere, as observed by the James Webb Space Telescope. The part of the spectrum enclosed in the red circle shows the signal due to the presence of methane in the atmosphere. The part under the orange circle shows the possible signal revealing the tentative detection of the DMS molecule, that on the Earth is due to plankton in the ocean. Adapted from [4] and [5]

or even measurements of the chemical composition of their atmosphere (see Figure 3 for an example). These observations have transformed our view regarding the existence and nature of planets around other stars.

It has now become clear that the formation of planet(s) is a very common process. To the point that we now believe that most – if not all – the stars in the Universe have planets orbiting around them. It is also very clear that planets come in a wide variety of sizes, shapes, and chemical compositions: we have hardly observed two planets that have similar characteristics. Some planets are larger than Jupiter and much hotter, others are smaller and closer to their star than Mercury. Some are rocky deserts, other are covered with water oceans, other are fluffy giants mostly made of gas. Some are covered by a thick layer of clouds, other have a bare surface with nearly no atmosphere.

We have also learned that planets can migrate in their system, i.e. they can get closer or farther from their parent stars while their solar system is forming. And we have also learned that planet formation is an event that occurs relatively quickly along with the formation of the star – likely within 50 million years, quite a brief time in comparison with the life of a star, which may easily be a billion years.

Despite these discoveries, there are many fundamental aspects that we have not yet understood.

First, we are not yet able to observe planets like the Earth orbiting other stars. In practice, if we were observing stars with our instrumentation in our solar system from another star, we would be unable to detect *any* planet in our solar system. The planets that we have observed so far are either much larger and/or closer to their sun than those in our solar system.

Due to the lack of information about earth-like planets, we have not (yet) understood how planets form around stars. Some theories predict that they form directly from the gas that also formed the central star, other from "pebbles" – namely big rocks that hit one other and eventually merge into a larger planet. Or, possibly, by some combination of these two avenues. Because of these two uncertainties, we cannot say today whether our solar system – composed of a combination of giant, gaseous and small, rocky planets – is typical or a rare exception.

More importantly, we cannot establish whether planets potentially hosting life are frequent or not. The vast majority of planets that we have detected so far are hostile to life, at least to the kind we are familiar with. Most of the 5,000 planets identified so far are either too hot or cold to host life, or lack any atmosphere. Only a few of them are likely covered by a

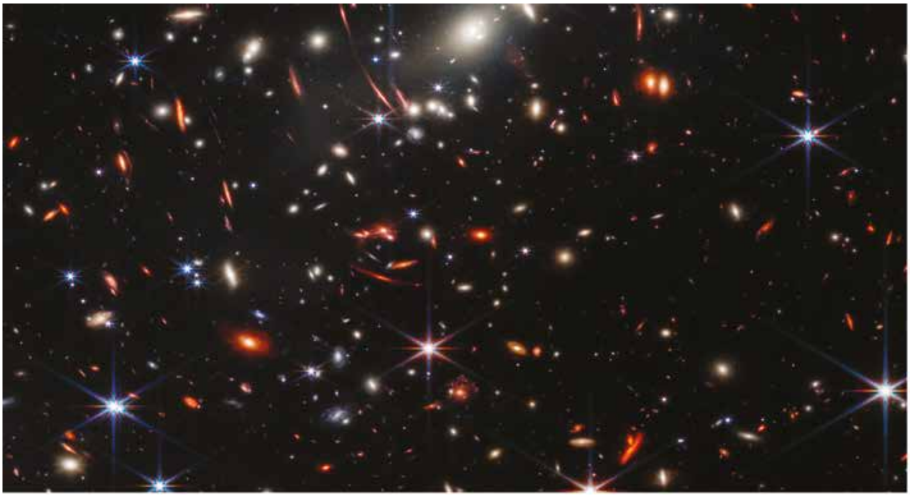

Figure 4. Distant galaxies. An image of very distant galaxies as observed by the James Webb Space Telescope [6]. Essentially all the objects shown in the image are galaxies located a billion light years from the earth. The smaller ones are typically the farthest galaxies. Each galaxy is seen as it was when the light was emitted, several billion years ago – hence every galaxy is a glimpse of the primitive Universe.

large ocean of water that may have the conditions to support life – despite some tantalizing results [5], there is no solid evidence of the existence of some form of life in these planets (see Figure 3).

While this picture is largely due to the limitations of our current telescopes, which cannot yet identify earth-like planets, we can nevertheless conclude that the Universe is largely *hostile to life*. While we cannot, of course, exclude that other inhabited planets exist, among the billions of billions of stars that fill the Universe, we can safely conclude that recent results support the belief that our planet is rare enough in the Universe – a further good reason to take care of our fragile planet, which is a rare gem of life in a hostile Universe.

The History of the Universe

The other central question that inevitably comes to mind is: "How did all the Universe start?" This question has "tormented philosophers", as Galileo wrote, since the beginning of mankind. Until the late 60s, astronomers have debated between two different ideas: *the static Universe,* built on the idea of an eternal Universe where small quantities of matter were forming spontaneously to keep creating new stars and planets; and the *Big Bang scenario,* stipulating that the Universe started a finite amount of time ago, and has kept expanding since then. According to this scenario, the Universe was initially filled only with primordial gas, from which stars and galaxies formed later and are still forming today. Again, the controversy between the two theories has been settled thanks to more powerful telescopes that have been used as *time machines,* literally *looking backward in time*. Indeed, the light that we observe from objects that are very distant from us has traveled for a long time before reaching our telescopes. For this reason, the light that we see today has been emitted a long time ago, and reveals how the object was at that time, not today. Modern telescopes can observe incredibly distant galaxies, even more than 13 *billion* light-years from now (see Figure 4). This way, our telescopes *reveal how these objects were when the light was emitted, not how they are today*. By looking at more and more distant galaxies, we have

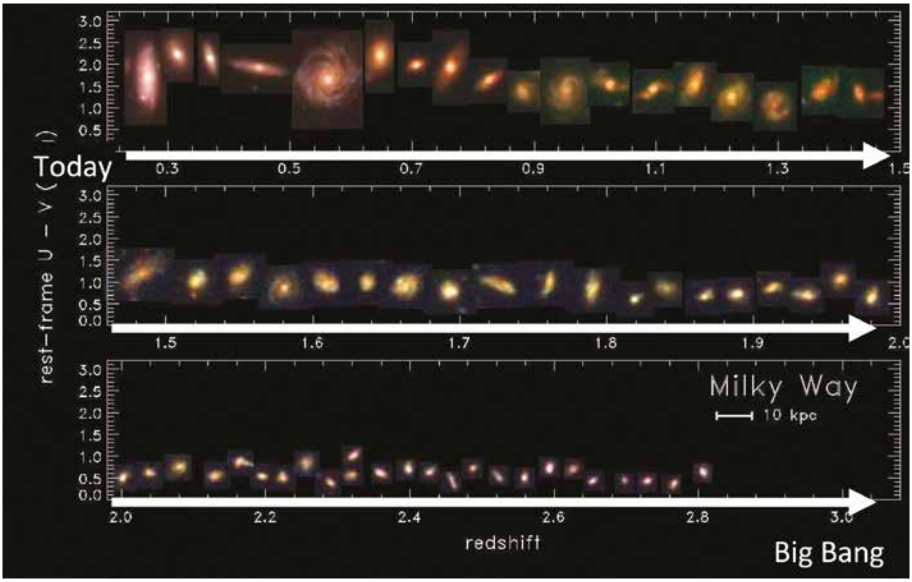

Figure 5. Observing the history of a galaxy. Images of galaxies observed at various distances from the Milky Way. Galaxies closer to the MW are shown in the upper left and progressively more distant toward right/bottom. The distance scale is measured in redshift, a unit adopted by astronomers, and covers a time of about 10 billion years from today. Galaxies toward the right/bottom are progressively closer to the Big Bang. All galaxies reported here are selected so that they describe how a typical galaxy like the Milky Way looks as it grows over cosmic time after the Big Bang. We emphasize that these are observed images of real objects, not simulated galaxies. Adapted from [7]

discovered that galaxies started to form about 13.5 billion years ago, as tiny clouds of stars thousands of times smaller than today, and that they have grown over time changing shape and size – pretty much like living species do. An example is shown in Figure 5. Other telescopes have stretched our vision even further, detecting the primordial gas that filled the Universe before the first stars were born. These and other crucial evidence demonstrate that *the Universe has an history*, which started about 13.7 billion years ago in an extremely dense phase that we call Big Bang, and has been expanding ever since. Thanks to these discoveries, the Big Bang scenario is not a controversial theory anymore, but an established fact that is considered one of the most important discoveries of modern science.

As undisputable as this evidence is today, it opens other fundamental questions that are still unanswered. What *really* was the Big Bang? Is there any creation event involved in this process, or does it stem from ordinary physical laws? Did anything exist *before* the Big Bang? Will the Universe continue expanding forever? What is the ultimate fate of the Universe and everything it contains?

This a realm where several theories have been formulated but no clear evidence has been established. Some of these theories even speculate that other Universes may have existed before or possibly in parallel with our Universe, maybe regulated by entirely different laws of physics. It is tempting to imagine that, after discovering that the Sun is a star among billions of stars, and the Milky Way is a galaxy among billions of galaxies, we will one day prove that the Universe itself is one among billions of Universes – but so far, this is just a speculation arising from the imagination and creativity of scientists.

What is the Universe made of?

One of the reasons why we are unable to understand the nature of the Big Bang is that the Universe seems to be made of more “ingredients” that we can naively imagine. We know that ordinary matter – that is, the same kind of atoms that we see in our Earth and Solar System – makes up stars and planets in the Universe.

However, we have good reasons to believe that something is missing in the picture. Indeed, we see that the expansion of the Universe and the motion of galaxies in the Universe seem to be driven by something much more powerful than the gravitational force, due to the matter that exists in the Universe. The simplest explanation is to postulate the existence of two new “ingredients”. One is a kind of matter that we have never seen on the Earth or in our laboratories. It must be a kind of matter (likely made of unknown particles) that is as much as six times more abundant in the Universe than normal matter, yet it does not interact in any measurable way with ordinary matter. For its elusive nature we call it *Dark Matter.*

In addition, we have proven not only that the Universe is expanding, but that it is expanding *faster and faster:* something seems to be pushing and inflating the Universe. We postulate the existence of an unknown form of energy that drives the expansion. As a whole, this energy must exceed by several times all other sources of energy in the Universe, summing up to at least ¾ of the total energy of the Universe. To express the scientist's dismay in front of this puzzling discovery, they have named it *Dark Energy*.[1] Other explanations exist, that postulate a modification to the fundamental laws that describe the nature and effect of the gravitational force but are apparently unable to describe all the observational evidence.

Whatever the explanation of our observations is, they demonstrate that we are still lacking a profound understanding of the ultimate nature of the Universe. Just when we thought we had grasped its ultimate composition, we must conclude that the Universe is still a mystery that exceeds our current comprehension.

Are observations of the Universe at risk?

To solve all these mysteries, and maybe discover others, scientists keep developing new telescopes and new techniques to observe the Universe farther and deeper. However, a fundamental challenge is emerging that could ultimately make this effort more difficult: the development of "mega-constellations" of low-orbit satellites for internet broadcasting (see Figure 6).

Over the last few years, flocks of low-cost, small-size satellites have been launched to provide internet coverage across the entire globe, especially on land and sea areas that cannot be reached by ordinary wire or cellular connection. The most effective company to develop this service (Space X) has become world famous and already provides users with global coverage employing only a few thousands of such satellites.

Future plans of Space X and other companies, based in several countries, foresee the development of dozens – and possibly hundreds – of these satellites in a few years.

[1] Some claim that this dull name more effectively proves the scientists' lack of fantasy, actually…

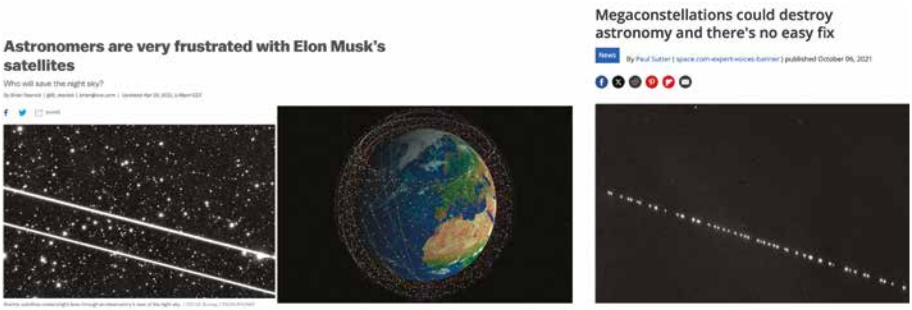

Figure 6 .The impact of mega-constellations on astronomy. Recent articles from the press reporting the thread that mega-constellations represent to astronomy. Center: a pictorial representation of the future distribution of telecom satellites. Right: the visible track of satellites a few hours after launch; Left: the stripes resulting from the passage of two satellites in the field of view of a satellite. Data taken along stripes are obviously lost.

The impact of these satellites on astronomical observations is potentially severe. In the optical light, where our eye and ordinary telescopes are sensitive, they inevitably reflect the Sun's light especially after sunset and before dawn, when they are high enough to be illuminated by the Sun even if on the Earth it is already dark. Being bright enough to be seen even with the naked eye, they are easily detected by modern telescopes and affect their observations substantially. In particular, observations of large patches of the sky at the beginning or at the end of the night, which are typical, for instance, of observations that target asteroids close to the Sun and the Earth, are the most severely endangered.

Radio telescopes, which observe in regions of the radio spectrum so far preserved for astronomy, are at even greater stake. These satellites are powerful sources of radio emission, which they use to broadcast internet signals. This signal can be so powerful as to saturate the entire signal detected by radio telescopes even at the radio frequencies preserved for astronomy.[2]

While astronomers acknowledge the economic and social importance of developing a distributed access to the internet across the globe, they are obviously concerned by the potential impact of these systems. Not only

[2] Future generation radio telescopes will be sensitive enough to detect the (incredibly faint) radar emission potentially originated by earth-like airports situated on planets distant up to 70 light-years from the Earth, if they exist. The effect of a powerful radio emitter flying only 500km above the telescope can easily be imagined.

they may affect multi-billion-euro projects for new telescopes which are in development, but they can eventually fundamentally limit our future capability of observing the sky from the Earth's surface.

For this reason, mitigation measures are being discussed with the satellite companies to alleviate their impact, but these are based on and limited by a best-effort, good-will approach on both sides, given the lack of international regulation on the matter. High-level discussions at the international level are ongoing. The International Astronomical Union and other agencies are actively promoting global awareness, in the context of the broader issue of the preservation of dark skies.

It is impossible, though, not to see the broader impact that these satellite constellations will have on many populations, for which the observation of the sky is an essential ingredient of their vision of life and a crucial input to take informed decisions on their activities. Should these constellations develop by orders of magnitude, as the current plans foresee, they will represent a substantial form of pollution of the last untouched environment: the deep sky.

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YOUTUBE PRESENTATIONS

Exploring Indigenous and Contemporary Science Through Hawai'i Astronomy

Doug Simons
Professor, Director, Institute for Astronomy University of Hawaii at Manoa

https://youtu.be/0H4j_9UM4nY?si=Pp4bIyDMS6Bt4OFn

Living within the Laws of Creation and Anishinaabe Journey on Mother Earth for the Next 7 Generations

Wendy Philips
Bald Eagle Clan, Canada

https://youtu.be/6WZlq0DswLw?si=n9-CDv_nesqbeBaH

Indigenous Peoples' Knowledge, Science and Technologies and the Role of this in Addressing the Global Environmental and Food Crises

Victoria Tauli-Corpuz
Indigenous Peoples' Rights International

https://youtu.be/R3ASPnyo2qQ?si=kbqUE0kv_xxJNFVO

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