THE CONTRIBUTION OF TRADITIONAL KNOWLEDGE AND TECHNOLOGY TO CLIMATE SOLUTIONS

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CIF CLIMATE INVESTMENT FUNDS

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Acronyms

ANDES	Association for Sustainable Communities (Peru)
BAIF	Bhartiya Agro Industries Foundation
CBD	Convention on Biological Diversity
CIF	Climate Investment Funds
CBMIS	Community-based Monitoring and Information Systems
COP	Conference of Parties
COP 21	The Twenty-first Session of the Conference of the Parties in Paris, 2015
CTF	Climate Technology Fund
DGM	Dedicated Grant Mechanism
FIP	Forest Investment Program
GCF	Governors' Climate and Forest Task Force
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GPS	Global Positioning System
IBHA	Indigenous Biocultural Heritage Area
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
INDC	Intended Nationally Determined Contribution
IPLC	Indigenous Peoples and Local Communities
IPR	Intellectual Property Rights
MDB	Multi-lateral Development Bank
MRVA	Mackenzie Valley Resource Management Act
NABARD	National Bank for Agriculture and Rural Development (India)
NAPA	National Adaptation Programme of Action (Bangladesh)
NDC	Nationally Determined Contribution
NGO	Non-governmental Organization
NWP	Nairobi World Program
PPRC	Pilot Program for Climate Resilience
RMI	Republic of the Marshall Islands
SDG	Sustainable Development Goal
SIDS	Small Island Developing State
SREP	Scaling Up Renewable Energy in Low Income Countries Program
STI	Science, Technology, and Innovation
TBS	Tarun Bharat Sangh
TEK	Traditional Ecological Knowledge
TKT	Traditional Knowledge and Technology
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WBG	World Bank Group
WIPO	World Intellectual Property Organization

Use of Terminology

Use of Terminology

Though described differently in various lexicons, the words *conventional*, *scientific*, *western*, and *modern* are used interchangeably in this report for colloquial reasons (http://uis.unesco.org/en/news/global-consultation-how-define-scientific-and-technological-services).

The terms are used in this report to bring out their contrast with TKT, although there are no strict dichotomy between convention/scientific/western/modern and TKT. In preparing this report, the authors have been cautious not to draw dichotomous representation of traditional and conventional scientific knowledge systems as such strict delineation tends to have limitations.

Suffice to say that there is a spectrum of both indigenous and scientific means of acquiring knowledge with many areas of overlap that should be considered, including the following:

- Traditional knowledge systems were developed by trial and error over long periods, while conventional technologies are largely rooted in science and engineering.
- Changes in traditional knowledge are intergenerational in scope as they have evolved slowly, whereas conventional knowledge is generational as it changes rapidly.
- Traditional knowledge is mainly tacit in nature and tends to be relatively localized, while conventional knowledge is more conducive to codification and transmission by modern means, making it universally available.
- In traditional systems, there are no clearly defined innovation systems, whereas conventional innovation systems are more clearly identifiable and defined.

Executive Summary

1. This study, led by the Climate Investment Funds (CIF) Stakeholder Engagement team, assesses the role of traditional knowledge and technology (TKT) in climate solutions. Through analyses, case studies, and an overview of challenges, this report addresses the path forward for integrating TKT into climate solutions and demonstrates the CIF's inclusive approaches to tackling climate risks using innovative and proven solutions. It builds on the premise that Indigenous Peoples and local communities (IPLCs), whose livelihoods, identities, and cultural survival depend on their natural environment are especially vulnerable to change-induced risks and disasters. The study also builds on the premise that these same IPLCs may have highly specialized, tested TKT that has been shown to be beneficial in conservation and climate contexts at all scales. The report aims to provide policymakers, practitioners, and other stakeholders with the insights needed to understand TKT's value added to climate action.

2. The report outlines case studies from across Bank regions highlighting the key features where TKT systems have proven to be replicable and cost-effective solutions to addressing climate risks. The report confirms that given the right policies, partnerships and resources, TKT can effectively complement modern technologies by providing tested, tailored approaches for building community resilience to the vagaries of climate risks and disasters. The report stresses a strong rationale for complementing traditional knowledge with modern science to address climate change and discusses the path forward for the climate change community and the World Bank Group (WBG) to integrate TKT in climate action. The report is organized into five chapters and various annexes.

3. Chapter 1 introduces the reader to TKT and Paragraph 136 of the Paris Agreement Decision. It provides an overview of TKT in the climate solution context. This chapter also issues a call to action for the international development community and the WBG in particular.

4. Chapter 2 builds on the TKT overview and highlights the fundamental differences between traditional and modern/conventional knowledge systems. It covers the implications for the development of policies that can help scale, mainstream, and/or preserve TKT.

5. Chapter 3 illustrates how TKT is being used to address climate challenges through a series of case studies from different parts of the world:

6. The case studies identify key elements of TKT as summarized below:

   a. TKT in the context of early warning systems can add value to the development of sustainable climate change mitigation and adaptation strategies. The case study from the African Sahel discusses how indigenous knowledge systems have been applied to limit greenhouse gas (GHG) emissions.

   b. Land management is the main focus of a case study that features the use of floating gardens in Bangladesh. This traditional practice of cultivation has quite a few associated social, economic, agricultural, and ecological benefits.

   c. In addressing rising sea level, the Marshallese have developed numerous disaster reduction strategies due to their long-term rapport with the sea. Traditional housing patterns and

architecture, food systems, navigational and resource charts, taro pits, water harvesting techniques, and land extension processes are invaluable forms of TKT. These TKT practices can be scaled-up locally and introduced in other small island developing states (SIDS) facing similar risks associated with climate change.

d. Two case studies from India demonstrate how communities have adopted sustainable water harvesting technologies that are in use year-round including the successful recharging of five major rivers in the semi-arid region of India using traditional ground water management techniques.

e. In Latin America's mountainous region, water and soil management, proven traditional agricultural practices for conserving natural crop diversity and overall biodiversity have been key to adapting to climate change.

f. In Nepal and Ghana, case studies show the value of blending traditional with scientific knowledge in strategies for coping with climate change. A similar case study from Río Lagartos on the Yucatán Peninsula focuses on the diversification of resources as a means to reduce vulnerability.

g. Partnership between governments and the IPLCs is a key aspect to controlling climate change. The Governor's Task Force, comprised of governors from states and provinces across the globe, highlights innovative partnerships between subnational governments and IPLCs and efforts to protect forests while enhancing rural livelihoods using jurisdictional programs.

h. A case done study on the effects of climate change for land tenure and land policy assesses the implications of ongoing anthropogenic climate change resulting from GHG emissions for land tenure and the role that land policy can play in climate change adaptation planning in the developing world.

i. Community-based monitoring and information systems (CBMIS) have helped communities cope with floods in Nepal. IPLCs in Nepal use information generated from CBMIS to inform collective analyses and decisions on their lands, territories, and resource to further their communities' development.

7. Chapter 4 covers the challenges, limitations, and opportunities for accessing and scaling-up TKT with case studies related to intellectual property rights (IPRs) and land rights at the local, national, and global levels. An analysis of the Pauktuutit Inuit Women's Association of Canada highlights the lack of international consensus about how IPs can protect their TKT.

8. The land rights issue is further discussed in a case study on the Batwa in the Bwindi Impenetrable Forests of Uganda. The study outlines the issue of protected areas where the interest of game animals is supposedly given priority over the interests of the native Batwa people.

9. This chapter makes the case that the use of traditional knowledge should not be viewed strictly through the prism of IPLCs as it can have greater and wider impact. Greater involvement and ownership in decision making by indigenous peoples is important for the success of programs involving the use of TKT. A study about the Potato Park in Peru argues that successful biodiversity and ecosystem management depends largely on local, regional, and global

cooperation in technology, the recognition of intellectual and property rights, the dynamics of landscapes, and the critical role of TKT.

10. Chapter 5 concludes the report by stressing the strong rationale for complementing traditional knowledge with modern science to address climate change and discusses the path forward for the climate change community and the WBG to integrate TKT into climate solutions.

11. Research for this report was conducted through an interdisciplinary desk review of the latest literature on indigenous knowledge, traditional ecological knowledge, technology, and climate change in order to clearly define and distinguish TKT. This material was complemented by interviews with a wide network of indigenous peoples, scholars, government officials, development practitioners, and entrepreneurs conducted over the phone, in person, and in conjunction with various conferences including the 17th and 18th forums of the Permanent Forum on Indigenous Issues at the UN Headquarters in New York in 2018 and 2019 and in the margins of the World Bank/IMF International Forum for Indigenous Peoples in April 2019.

Chapter 1. Introduction

1.1. Context

1. **The overriding lesson of scientific reports on climate change such as the 2014 World Bank Group report "*Turn Down the Heat: Confronting the New Climate Normal*" is that nobody will be immune to its impacts. However, the costs are going to fall inequitably on the poor, marginalized, and underprivileged, including IPLCs, whose livelihoods, identities, and cultural survival depend on their natural environments.** While IPLCs[1] are particularly vulnerable to environmental degradation, climate change, and improper conservation, they also have highly specialized TKT rooted in local ecosystems that has been shown to be beneficial in the conservation and climate contexts at all scales. Broadly, TKT encompasses three elements: knowledge about the environment, knowledge about the use and management of the environment, and values about the environment. Research has shown that incorporating TKT into climate change policies can lead to the development of effective mitigation and adaptation strategies that are cost-efficient, participatory, and sustainable. (Hunn 1993; Robinson and Herbert 2001) Incorporating TKT into climate change policy can complement modern science, technology, and innovation (STI) to benefit both people and nature, particularly in communities that are responsible for overseeing or stewarding lands and resources in climate mitigation and adaptation projects.

2. **Although a relatively new development, TKT in the context of climate change has begun to receive more attention.** Several high-profile cases of traditional knowledge complementing and supplementing modern innovations have caught the attention of policymakers. For example, research on ancient herbal medicines won the Nobel Prize in Physiology.[2] A ground-breaking partnership between the University of California, Berkeley and the Samoan government explored the role of Samoan traditional knowledge in identifying key essential chemicals for AIDS and cancer treatments.[3] Finally, India's attempts to use traditional water harvesting techniques to combat droughts have garnered considerable attention.

3. **There is a need to gather more information on the contributions of TKT to climate solutions, to increase the availability of this new research, and to incorporate this research into existing climate science frameworks.** This is especially important if we are to achieve the promise of the Paris Agreement. In order for the Paris Agreement to keep the warming of the planet below the 1.5-degree Celsius target, governments must commit to reducing CO_2 emissions "in accordance with the best available science." (UNFCCC, 2015)

4. **Paragraph 136[4] of the Paris Agreement "*Recognizes* the need to strengthen knowledge, technologies, practices and efforts of local communities and Indigenous Peoples related to addressing and responding to climate change and *establishes* a platform for the exchange of experiences and sharing of best practices on mitigation and adaptation in a holistic and integrated manner."** There is also an increasing recognition of the value of TKT and the role of IPLCs as effective conservation stewards as many IPLCs have maintained a balance with their surrounding landscapes for millennia, sustaining many of the planet's biologically important

[1] Indigenous Peoples (IPs) and IPLCs used interchangeably
[2] http://www.pbs.org/newshour/rundown/chinese-herbal-therapy-malaria-wins-part-nobel-prize-medicine/
[3] http://newscenter.lbl.gov/2004/11/05/samoas-gift-to-the-world/
[4] https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

ecosystems. Research has already shown that TKT is a valuable source of information for meteorological observations, early warning systems, water harvesting techniques, healthcare, landscape management, and more.

5. **Further scientific assessments are critical to understand the potential beneficial outcomes that can result in the successful integration of modern and traditional knowledge systems.** While conventional knowledge systems are aimed at the division of labor in research, experimental design, scale-up, and technological investments as well as at adherence to standards and proper marketing, traditional knowledge systems are diffuse with no clear systems of execution and business networking. To tackle the effects of climate change, traditional societies must transform their infrastructures into better organized and more efficient approaches that incorporate scientific methodologies. If we can find ways to bridge the gap between the philosophies and insights of both systems, countries will be better able to build relevant innovation systems enabling them to become more confident, resilient, and proactive in tackling climate change.

6. **This report provides policymakers and other stakeholders with the insights needed to understand issues related to TKT and climate change**. These issues are explored as they relate to the interaction between the impact of climate change on IPs, the role of IPs in climate change mitigation and adaptation efforts, and the conventional knowledge systems needed to expand these traditional mitigation and adaptation efforts.

7. **By and large, systematic efforts to mainstream TKT or attempts to scale up TKT have been very limited.** The Climate Investment Funds (CIF), including the Forest Investment Program (FIP) and its Dedicated Grant Mechanism (DGM), the Clean Technology Fund (CTF), Pilot Program for Climate Resilience (PPCR), and the Scaling-up Renewable Energy in Low Income Countries Program (SREP) are uniquely positioned to place more value on TKT as an integral component of their climate change solutions. This study uses the CIFs' position to build on other bodies of work such as the United Nations Framework Convention on Climate Change's (UNFCCC's) compilation of examples (discussed in Annex 1) while distinguishing the study from earlier works on the topic.

1.2. Objective of the report

8. Specific objectives of this report are:

   A. **To trigger dialog on the need to strengthen the evidence base of the role of TKT in climate solutions by enhancing the understanding of TKT as an effective tool to address the detrimental effects of climate change.** The report fosters the enhanced use of TKT in the implementation of climate change programs at the local, national, and global levels through recognition of the potential contribution of TKT as a knowledge base alongside modern STI.

   B. **To identify the key factors that make it feasible to connect TKT with more conventional scientific practice and knowledge.** Conventional technologies are generally codified, transferrable, and amenable to systematic adjustments and adaptations. In contrast, traditional techniques remain mostly tacit, informally held knowledge dependent on the experience of individuals and their abilities to pass their know-how on to other

individuals within their communities. By fostering an understanding of good practices in TKT, this report addresses gaps in available information on TKT's contribution to climate solutions and proposes measures to create and sustain an enabling environment that recognizes the contributions of TKT as a knowledge base. This report provides evidence to support TKT's contribution to meet Article 7, Section 5 of the Paris Agreement.

C. **To foster discussion on the need to improve the understanding of key limitations, challenges, and opportunities for accessing and scaling-up TKT.** Conventional knowledge represents only one system of inquiry. Recognizing traditional knowledge as a legitimate and complementary system leads to the reconsideration of many fundamental notions about development, biocultural diversity conservation, climate change, access to information, education, and intellectual and land rights. Traditional knowledge is regulated by customary norms and is embedded in a web of relationships that are often unique, often have specific rules of practice, and often have specific ownership codes. These considerations create significant challenges when TKT is transferred outside community boundaries. In any effort to access, document, or scale up TKT, due consideration should be given to IPRs. Documenting TKT itself does not protect TKT, but it is a necessary first step.[5] Thus far, documentation of TKT has been extremely poor, and even the efforts at documenting have not attempted to understand how the TKT works. This report strives to identify applicable and informed case studies. However, given that the mandate of the study does not include field visits or a deep dive, the authors have highlighted case studies and call for deeper methodical analysis of TKT.

1.3. Methodology

9. This data collection and analyses for this report included:

A. An interdisciplinary desk review of the latest literature and case studies on indigenous knowledge, traditional ecological knowledge, technology, and climate. The analytical work follows and builds upon the Paris Agreement as well as upon the Marrakech and Bonn Conferences of Parties (COPs). Various case studies that are representative of particular geographies, climates, peoples, knowledge, or technology were collected. The report documents case studies that show how IPLCs have been able to use TKT in a broader geographic and intercultural context while at the same time protecting their intellectual property and avoiding collateral, unintended harm to their communities, livelihoods, or survival. The desk review covered the latest literature on indigenous knowledge, traditional ecological knowledge, technology, and climate change in order to clearly define and distinguish TKT. This material was complemented by interviews with a wide network of indigenous peoples, scholars, government officials, development practitioners, and entrepreneurs conducted over the phone, in person, and in conjunction with various conferences including the seventeenth and 18th Permanent Forum on Indigenous Issues at the UN Headquarters in New York in 2018 and 2019 and in the margins of the World Bank/IMF International Forum for Indigenous Peoples held in Washington, DC in in April 2019.

[5] **World Intellectual Property Organization** (**WIPO) Documenting Traditional Knowledge – A Toolkit** presents a range of easy-to-use checklists and other resources to help ensure that anyone considering a documentation project can address intellectual property issues effectively. http://www.wipo.int/publications/en/details.jsp?id=4235.

B. The team was comprised of a working group of stakeholders and IPs that worked closely with an IPLC platform. Consultation with IPs included the creation of interview groups to solicit their opinions, perspectives, and ideas, their inclusion in co-design and co-analyses, and their secured buy-in. The multi-disciplinary working group consisted of representatives of influential IPs who were able to speak for the wider community. The terms of reference for the working group were discussed and agreed upon during wider consultations. The working group operated both virtually and in-person to integrate the results of the consultations, literature review, focus groups, and interviews into a comprehensive report.

C. Consultations with IPs. To enhance the participatory approach of the study, the working group held many rounds of consultations with IPs. The working group also researched how WBG financing, analytics, and convening power can support the promotion of TKT in international climate discourse to support policies and operations. The working group examined mechanisms to obtain consent, to protect intellectual property, and to adopt good practices. Finally, the working group constructed an inclusive process with IPs and set out an approach which allowed those involved to agree on an appropriate engagement strategy. Annex 3: Methodology provides details on the various consultation activities.

1.4. Overview of conventional innovation and TKT

10. **It is important to note that TKT can stimulate ideas and innovation and, on occasion, also benefit from utilising conventional knowledge systems and engineering**. The fundamental differences between traditional and conventional knowledge systems have to be recognized and measures must be taken to integrate them. Historically, all civilizations and cultures emerge from traditional knowledge systems, which evolve slowly over long periods of time in specific localities to become ingrained in cultural norms. Conventional knowledge systems arose as the direct result of the use of scientific methods to understand and improve upon traditional knowledge. Scientific methods, based on deductive and inductive reasoning, provided the means to determine cause and effect and enabled the systematic replication of TKT practices. Conventional, scientific methodologies offer the most reliable tools to solve complex problem such as climate change through advanced data collection and analyses. The advent of electronic, real-time data collections allows the conventional, scientific approach more power to assemble and analyze continuously growing datasets to solve the critical problems emanating from climate change.

11. **Analysts should be cautious about the dichotomous representations of traditional and conventional scientific knowledge systems as such a strict delineation has limitations. There is a spectrum of both indigenous and scientific means of acquiring knowledge with many areas of overlap that should be considered, including the following.**
    - Traditional knowledge systems were developed by trial and error over long periods, while conventional technologies are largely rooted in science and engineering.
    - Changes in traditional knowledge are intergenerational in scope as they have evolved slowly, whereas conventional knowledge is generational as it changes rapidly.
    - Traditional knowledge is mainly tacit in nature and therefore highly localised, while conventional knowledge is more conducive to codification and transmission by modern means, making it universally available.
    - In traditional systems, there are no clearly defined innovation systems, whereas conventional

innovation systems are more clearly identifiable and defined.

12. **To tackle the effects of climate change, traditional societies may, in some cases, have to transform some of their infrastructure components into more organised and efficient approaches and systems that are able to incorporate scientific methodologies.** As it stands, traditional systems have evolved using management approaches based on belief and cultural norms that are in sync with changes in nature. These approaches and structures render them almost incompatible with conventional philosophies that try to dictate and dominate nature. The examples set by New Zealand and India speak to the importance of bridging the gap with traditional systems. In early 2017, these countries bestowed legal human rights on the Whanganui River and the Ganges and Yamuna rivers based upon the indigenous belief that the rivers are one with the local population and are therefore sacred. Annex 5 provides more details that compare and contrast conventional innovation and TKT.

1.5. TKT in the context of climate change

13. **Atmospheric scientists, including Nobel Prize-winning chemist Paul Crutzen, argue that since industrialization the planet has entered a new geologic age known as the Anthropocene.** Anthropocene means that humans are fundamentally impacting Earth's natural processes through the rise levels of GHG emissions from human activities that result in the warming of the Earth's surface. Initial efforts to deal with the problem of global warming focused on mitigation to reduce and stabilize GHG concentrations in the atmosphere. However, GHG emissions have continued to rise, causing increasing temperatures and more frequent incidences of severe climate events. Even if stabilization is achieved, global warming and sea level rise will continue for centuries because of inertia and knock-on effects. Given this harsh reality, adaptation has become a crucial component in reducing the vulnerability associated with climate change. Global and national policies must therefore include ambitious mitigation and adaptive strategies that optimize knowledge and technology to confront the challenges ahead.

14. **Communities in remote and exposed coastal, mountain, and desert regions are most vulnerable. In those settings, IPLCs are adjusting to new weather realities using what remains of their TKT and, increasingly, conventional STI**. IPLCs depend upon local resources for subsistence, livelihoods, spiritual, and cultural survival as well as for the transmission of their knowledge, histories, and languages, and identities. By resources, we are not only referring to physical resources, but also to their encompassing knowledge system. For example, in the high-altitude regions of the Himalayas, rural communities depend on the seasonal flow of water from melting glaciers. Increased temperatures have caused rapid melting and floods in the short term. In the long run, as glaciers and snow cover shrink, water will become scarce for millions of people who depend upon the glacial melts for their water supply. Climate change exacerbates challenges already faced by rural communities, including political and economic marginalization, loss of land and resources, human rights violations, discrimination, and unemployment. Rising temperatures, dune expansion, increased wind speeds, and loss of vegetation are negatively impacting the traditional cattle and goat farming practices of IPs in Africa's Kalahari Basin, who must now live around government-drilled bores to access water and who depend upon government support for their survival. Similar patterns of desertification are being reported from Australian aboriginal populations, communities in Central and South Asia, as well as parts of the American Southwest, South America, the Middle East, and

elsewhere. Wildfires are predicted to rise more than 60 percent in some medium and high latitudes. (Mathiesen 2015; Yue et al. 2015)

15. **Societies with more advanced technological capabilities or resources can better adapt or respond to climate-change related extremes. However, the impact of these advanced adaptation methods can affect IPLCs detrimentally.** IPs who are forced to migrate away from their traditional lands often face double discrimination as both migrants and IPs. IPs may also be more vulnerable to trafficking and smuggling owing to sudden displacement by a climactic event, limited legal migration options, and limited opportunities to make informed choices. Deforestation, particularly in developing countries, is pushing indigenous families to migrate to cities for economic reasons, where they often end up in urban slums. In many cases, IPs may be dislocated from their countries. If climate change results in stateless peoples, these peoples must be given special rights to migrate to safe countries where they can enjoy state protection as their predicament in many instances is a consequence of the emissions of developed nations. Annex 6 provides more details on impact of climate change on IPs.

Chapter 2. Protecting and Promoting TKT for Climate Change: Systems and Policy Issues

2.1. Differences between traditional and modern knowledge

16. **Fundamental differences exist between traditional and modern knowledge systems and the functioning of the respective economies in which they exist.**

    A. Traditional knowledge systems arose as man's inquisitiveness to explore and use natural phenomena developed through trial and error over long periods in circumscribed circumstances.

    B. Innovations are filtered throughout communities as a consequence of verbal communication and are seldom documented, except in instances of ritual and religious rites.

    C. Conventional technologies evolved as the scientific method was introduced to illuminate natural phenomena and traditional technologies.

    D. The changes that occurred from the application of scientific principles were more rapid, often occurring within a generation, instead of gradually over many generations as is typical of traditional practices.

    E. Conventional technologies are generally codified and are amenable to systematic adjustments and adaptations making them universally available, transferrable, and subject to adaptation giving rise to innovations. In contrast, traditional techniques remain mostly tacit knowledge dependant on the experience of a few individuals and their abilities to pass the know-how to other individuals within their communities. As a result, traditional knowledge and the technologies they spawn are highly localized.

17. **Because of their origins, traditional communities often have a profound respect for and admiration of nature alongside an understanding of its contribution to peace, tranquillity, and sustenance.** These societies and their survival methods are often less invasive and threatening to the natural equilibria than many of those created using conventional technologies. In modern societies, the view that man can manipulate and, in some ways, conquer nature has grown because of the understanding and utility of science to solve problems and to open up ever increasing economic opportunities. With this success has come less sensitivity to the delicate balance of the natural environment resulting in a dysfunctional ecosystem exemplified by the evidence of climate change. Conventional technologies have contributed so much to this imbalance that it is now commonly acknowledged that man has contributed significantly to climate change. Caution is therefore necessary when contemplating the scale-up of traditional practices by the introduction of conventional methods as the resulting innovations should result in climate solutions that have less dissonance with the environment.

18. **The users of traditional technologies offer a worldview that respects the environment and promotes the notion of communal ownership and responsibility for its maintenance and transfer to subsequent generations**. This is in contrast to the prevailing reality of individual and corporate ownership that dominates societies built around conventional technologies. Further examination of this dichotomy needs to be pursued by the social, psychological, and behavioral

sciences to resolve the tensions between the two viewpoints of communal versus individual ownership. Coordination between both systems of knowledge to tackle climate change should be underpinned by a clear recognition of the cultural and communal norms and practices that are likely to be negatively impacted, which may result in resistance by the communities to expected changes in behavior. It must therefore be acknowledged that the contributions of the social sciences in understanding the dynamics of traditional and modern communities are as important as those of the physical sciences in reaching sustainable climate solutions that are applicable, acceptable, and sustainable to stakeholders.

19. **There are exciting instances of synergies between traditional knowledge and practices with conventional sciences as exemplified by the work being done by Emory University and the Dalai Lama under the Emory-Tibet partnership, which has as its tagline "bridging two worlds for one common humanity."** The aim of this initiative is to promote "the convergence of science and spirituality" by teaching science to Tibetan monks to form a bridge "between two complementary forms of knowledge."[6] Monks are being equipped with scientific principles to deepen their understanding of the world and educators are learning Buddhist methodologies for the relief of suffering, an improved understanding of the mind and human emotions, and integrated approaches to health and well-being.

20. **There are empowered traditional communities that have taken steps to solicit support for bold interventions to protect, conserve, and expand their rights over their ecosystems**. In March 2017, the Maori of New Zealand secured legal human rights for the Whanganui River, the stewardship of which is now overseen by two guardians, one each from government and the Maori tribe. This landmark decision was closely followed by India, which granted similar rights to IPLCs of the Ganges River and its tributary, the Yamuna. Marriage of the two systems has given rise to a unique interpretation of the law that enables traditional and conventional norms to be integrated for the protection of fragile ecosystems.

2.2. Implications for policy development

21. **Innovations to adapt to climate change have occurred in traditional knowledge systems, but they are highly nuanced and site specific and have to be pursued with diligence to be clearly identified and assessed**. Innovation frameworks can evolve out of the close interaction between operatives of traditional and the conventional systems if properly resourced and established in an atmosphere of mutual respect and understanding. By their very nature, the effects of climate change are site specific. Consequently, parameters for policy will have to take specification into consideration. A policy framework should accept the differences between the two systems and arrive at a common understanding that enables innovations to be recognised and new indicators of success to be elaborated upon using appropriate methods as the current conventional, science-based indicators do not accurately reflect all the needs and aspirations of traditional societies. This involves recognizing the importance of the utility of technologies fitting in with traditional environmental, cultural, social, and survival imperatives.

22. **There are oftentimes no organized technological retention and management systems for TKT as part of national development policies**. As conventional technologies become accepted and verifiable, it will become possible to develop levels of individual intellectual property

[6] http://dalailama.emory.edu/about/ETP.html

protection and ownership for TKT. This is currently not the case with traditional technologies that remain communal property without clearly defined ownership and with less possibility for commercial exploitation in an equitable manner. At present, only a few countries such as Brazil and India have given traditional methods due prominence and support in national policies. The efforts of these innovative countries should be examined and, if applicable, adapted and replicated.

23. **The intellectual property objectives of conventional systems are based on unique and individual discoveries that are of commercial merit, whereas traditional intellectual property systems that have evolved over generations are considered communal property and not given to unique, incremental, and discrete characteristics**. Nevertheless, the proven traditional methods are new to conventional systems and require investigation into how best to incorporate them into commercial systems without loss to traditional communities.

24. **Scientific assessment to ascertain the benefits of TKT are critical to the successful integration of modern and traditional knowledge systems.** Despite having evolved over long periods of time, certain TKT practices can have detrimental effects that must be studied. Indeed, the burning of wood in enclosed structures for cooking and heating has led to serious lung diseases and general ill-health among many traditional communities. A system that is capable of assessing, verifying, codifying, and estimating the potential impacts of TKT practices, both beneficial and detrimental, should be developed to enable traditional societies to evaluate their methods of survival.

25. **Some key points to inform the development of policy are:**

A. IPs are an important subset of traditional populations and some have the makings of formal mechanisms to record and analyse many of their traditional practices.

B. The inadequacy of conventional systems to address communal property rights is further complicated when a system based on the integration of conventional and traditional technologies and practices is being contemplated, particularly when dealing with complex and multifaceted phenomena such as climate change.

C. Two-way systems of knowledge transfer, integration, and outcomes aimed at mitigating the impacts of climate change should be developed to benefit both constituencies and should contribute to the development of relevant impact indicators.

D. Policy development should solicit the active participation of traditional knowledge holders in drafting and implementation.

E. Traditional knowledge alone may be insufficient to address climate change even in regions where it has proven effective. It may need to be coupled with modern systems. For instance, traditional rain water harvesting methods can become far more effective when assisted by global position systems (GPS), global information systems (GIS), and terrain mapping technologies.

2.3. Key elements

26. **Any synergies or collaboration between traditional and modern knowledge systems will**

largely be site specific. However, the following important parameters may be considered:

A. A group representing both traditional and conventional functionaries that can lead the policy planning process should be convened with representation from the Ministry of Finance or a similar body to ensure that the process is adequately funded.

B. Policy makers should establish a process to identify and understand the factors that underpin each TKT so that the collaboration between the two systems is effective.

C. Policy makers should establish a clear process to identify the relevant traditional insights and techniques that have the potential to contribute to the mitigation of the consequences of climate change.

D. Policy makers should establish a process to evaluate the most meaningful methods and processes for the collaboration between the systems.

E. Once a traditional technique is selected for integration into the conventional system, a pilot project must be undertaken to impress the success and the need to scale the model worldwide.

F. Scale-up in a conventional system is a challenging task even in the best resourced systems. Special efforts should be made to assemble the necessary scientific and technical skills, funds, infrastructure, and other resources necessary to ensure the usefulness of the innovation in the efforts to mitigate or prevent the adverse effects of climate change.

G. Policy makers should establish a program to ensure the participation of all stakeholders, including the private sector and civil society, to work in tandem with the research and development process.

H. Policy makers should define a clear process of ownership by developing laws and regulations to ensure the protection of both conventional and traditional participants in an equitable manner.

Chapter 3. TKT in Climate Change Adaptation and Mitigation

27. **The key to addressing climate change is the development of sustainable mitigation and adaptation strategies that are rich in local content and planned in conjunction with local communities.** Indigenous communities have accumulated sufficient knowledge of the ways in which the adverse impacts of climate change may be reduced through both mitigation and adaptation. Indigenous knowledge has been directly applied in many communities in climate change mitigation through emission reduction, carbon sequestration, and carbon substitution. However, these practices are often not applied as effectively as possible and should be refined through proper policies that solicit and utilize local community input. In the area of adaptation, indigenous knowledge systems have been applied in weather forecasting, vulnerability assessment, and implementation of adaptation strategies.

28. **This section analyzes several specific impacts of climate change on IPLCs and the TKT used to mitigate and adapt to climate change through a review of case studies**. These case studies illustrate successful examples that address multiple dimensions across the climate change mitigation and adaptation spectrum including carbon sequestration, early warning systems, landscape management, rising sea levels, rainwater harvesting, land usage and agriculture, government/IPLC partnerships for sustainability, and community-based monitoring and information systems.

29. **The sample of case studies come from across the globe and address a wide variety of ecosystems including SIDS, arid zones, tropical forests, deltas and water-based ecosystems, and mountainous landscapes.** These case studies help understand gaps in available information on TKT to create a knowledge base alongside modern STI that can enable effective climate solutions. The insights from these studies can contribute to more effective policy.

30. **The scope of work for this report did not permit the working group to conduct deep analytical research on these case studies**. Hence, in Chapter 5, the working group recommends the need for a more comprehensive program to investigate the case studies in more depth. Further insights can inform whether the practices expounded upon in these case studies can be replicated in other geographies.

3.1. Carbon sequestration

31. **It is widely recognized that forests and soil[7] play an important role in the global carbon cycle by sequestering and storing carbon.** The importance of forests has been recognized by traditional institutions to the extent that communal forest reserves remain very common in traditional societies. Besides the fact that these well-managed forests provide food and timber resources to their communities, they also serve as carbon sinks. It was the recognition of the role of forests in climate change that influenced participants of the Kyoto Protocol to allow countries to include carbon sequestered in forests in their emission requirements. (Nyong et al. 2007) Agricultural practices can help mitigate climate change by reducing emissions from agriculture and other sources and by storing carbon in plant biomass and soils

Case study: Zero Tilling in African Sahel

[7] http://www.fao.org/soils-portal/soil-management/soil-carbon-sequestration/en/

32. **Agriculture and land use changes are two main sources of GHGs in Africa, and indigenous knowledge systems have been applied to mitigate the effects of these two activities in relation to climate change.** Local farmers in the Sahel have been known to conserve carbon in soils through the use of zero tilling practices in mulching, cultivation, and other soil management techniques. Natural mulch moderates soil temperatures and extremes suppresses diseases and harmful pests, and conserves soil moisture. Before the advent of chemical fertilizers, local farmers largely depended on organic farming, which is also capable of reducing GHG emissions. Further, local farmers are known to have practiced the fallow system of cultivation, which encouraged the development of forests. With the growth in population, lengths of fallow have been reduced to the extent that the practice no longer exists in certain areas. Measures to revise and strengthen these traditional practices can have a twofold impact – one through carbon sequestration by the no-till methods and a second by inducing greater forest cover.

3.2. Early warning systems

33. **On December 26, 2004, a tsunami devastated many communities in the Indian Ocean. However, the Moken people, an indigenous community in the epicenter of the destruction, suffered few casualties.** Island environments have a heightened sensitivity to the rapid environmental change caused by tsunamis, droughts, earthquakes, hurricanes, and related events. (Nakashima et al. 2012) Pacific Islanders exhibit complex response systems to facilitate survival after these natural catastrophes. These include a wide range of traditional forecasting techniques such as those exhibited by the Moken People. Moken folklore includes stories of the "hungry seas" where the winds would shift, the tides would change, and the insects and other animals would move away from the sea. According to this folklore, these events precede the onset of a *laboon*. A *laboon* is a "wave that eats people" and cleanses the land. Because of this ancient narrative, likely the result of accounts of previous tsunamis that occurred in pre-history, the Moken people knew to migrate to higher ground when they began to observe the harbingers from their oral histories. Similar incidents of survival attributed to oral histories have been documented in the Andaman and Nicobar Islands. (Bishop et al. 2005; Dybas 2005) Villagers on the volcanic island of Ambae, Vanuatu use signs such as pervasive gas smells, the death of trees, unusually active bubbling within the lake surrounding the volcano, rumbling and booming from the crater, and the rapid rotting of taro roots in the ground as early warning signals that the volcano may soon become active.

34. **Since the Indian Ocean tsunami of 2004, there has been a surge of interest in developing early warning systems for all countries and all hazards. Early warnings can take several forms ranging from the knowledge that an event could occur through to qualitative assessments that the event is becoming more likely all the way to a forecast of its timing**. There has already been steady progress in the use of hazard mapping and risk assessments, the involvement of communities, the recognition of indigenous warning knowledge, and increased support for decentralized community-based response systems. For several rapid-onset natural hazards such as hurricanes and tsunamis, sophisticated early warning systems are already in place. For some slower-onset hazards such as drought and malaria outbreaks, forecasting knowledge and technology are in their infancies.

Case study: Early Adaptation and Food Security on the African Sahel

35. **The African Sahel is characterized by recurrent droughts that have increased in magnitude and intensity over the last one hundred years. IPLCs in this region have developed and implemented extensive mitigation and adaptation strategies that have enabled them to reduce their vulnerability to this climate variability.** However, this knowledge is rarely taken into consideration in the design and implementation of modern mitigation and adaptation strategies. This case study highlights indigenous mitigation and adaptation strategies that have been practiced in the Sahel and the benefits of integrating TKT into formal climate change mitigation and adaptation efforts.

36. **The Sahel refers to the semi-arid and arid regions of Africa and constitutes significant portions of Senegal, Gambia Mauritania, Mali, Burkina Faso, Niger, Chad, and the Sudan.** According to some definitions, the Sahel covers a wider area that extends into parts of the Ivory Coast, Ghana, Benin, Togo, Nigeria, Cameroon, and Ethiopia. Drought has been a recurrent feature in this region, with early records dating back to the 1680s. The most prominent drought was in the early 1970s when hundreds of thousands of people and millions of animals died. (Mortimore 1998) The Sahel has a high population growth rate (about 3.1%) and a rapid rate of urbanization. (Nyong 2007) With a population of about 50 million inhabitants, population density is often higher than in sub-humid and humid climates. There is a visible north-south stratification of the livelihood systems. The northern cultures tend towards pastoralism, while the southern cultures largely practice sedentary, arable, rain-fed farming. (Nyong 2007) Agriculture is the predominant livelihood system, employing more than half of the working population and contributing nearly 40% to the gross domestic product. Rain-fed agriculture is the dominant practice and is only possible in areas where the length of the growing season allows for crop maturation. Irrigated agriculture is only possible around the flood plains of the few perennial rivers. The lack of water, in association with high temperatures (up to 45 ^{o}C at certain periods of the year), is the most limiting factor for agricultural productivity. Millet, sorghum, cowpeas, and maize are the dominant food crops. Sorghum predominates in the heavier soils, and millet (Panicum) in the sandy soils. The main cash crops are cotton (Gossypium) and groundnut. Farmers are predominantly smallholders using traditional farming systems that mix food and cash crops.

37. **Seldom-consumed plants are often used as alternative, emergency food by IPLCs in the Sahel during periods of famine**. Changes in climate are closely related to changes in vegetation, animal (ants, birds, rats, snakes, etc.) and human behavior, the color of clouds, their location, and the intensity and frequency of rainfall. These changes can lead to the proliferated production and consumption of less traditional, plant-based food. An uptake in consumption of these crops can serve an indicator of the extent to which a region may be suffering silent famine. Rural desert communities perceive drought as a multi-dimensional phenomenon across meteorological, biophysical, and socio-religious aspects.

38. **The inhabitants of the Sahel have adapted to climatic extremes that exceed those predicted by some models.** They have accumulated sufficient knowledge of the ways in which the adverse impacts of droughts may be reduced through both mitigation and adaptation, but that knowledge is not being applied in an effective manner through development channels. Recently, new adaptation strategies that build on existing knowledge and expertise about water, agriculture, and livestock management have been introduced by local non-governmental organizations (NGOs). These include growing new crops such as vegetables, increasing fodder and higher value medicinal crops for commercial sale, the use of environmentally sound fertilizers, improved

storage for fodder and food grains, and improved water conservation and harvesting techniques through the digging and deepening of ponds and wells.

39. **The Sahel case study confirms that TKT in the context of early warning systems can add value to the development of conventional sustainable climate change mitigation and adaptation strategies that adhere to local knowledge systems and landscape management techniques.** To be effective, early warning systems for natural hazards need to not only have a sound scientific and technical basis, but also a strong focus on the people exposed to risk and their TKT. New approaches must incorporate all of the relevant factors in that risk, whether they arise from natural hazards, social vulnerabilities, or short-term or long-term processes. Western science would benefit from the study of TKT and how TKT may be incorporated within disaster risk reduction strategies.

40. **There are significant challenges and limitations to scaling-up TKT-based systems, including early warning systems.** Local knowledge systems are situated in specific ecological and cultural contexts that maintain the integrity of landscapes. Hence, it is important to record, analyze, and integrate knowledge and early warning systems into climate solutions. Modern technologies represent important tools for the scalability of TKT within the context of early warning systems. Various studies have revealed that a proper communication system, coupled with traditional knowledge, can mitigate the effects of disasters and can be helpful in risk reduction.

41. **Policy makers and researchers should would be wise to adopt a "bottom-up" approach that identifies and elaborates upon indigenous TKT to inform conventional climate change mitigation and adaption policies.** Systematic documentation, quantification, and the subsequent integration of TKT into modern weather forecasting systems is recommended as one of the strategies to help improve the accuracy and reliability of early warning systems and seasonal forecasting information under a changing climate.

3.3. Landscape management

42. **Given the complexity of climate change and its interdisciplinary implications, a landscape approach is the most appropriate theoretical framework for understanding and building a bridge between IPLCs, TKT, and climate change in many cases.** Landscape incorporates the physical and biotic components of an area and their inter-relationships. However, anthropological approaches to landscape tend to focus on cultural perceptions and understanding while paying special attention to how local knowledge of landscape and ecology is imbued with individual and collective histories, symbols, myths, and memories. (Johnson and Hunn 2010:83) Carl Sauer, widely credited with developing a theory of landscape in geography that integrates physical and cultural dimensions, focused on the material basis of cultural life, especially agriculture and the domestication of plants and animals.

Deltas

43. **Deltas are some of the largest sedimentary deposits in the world and are widely recognized as highly vulnerable to the impacts of climate change, particularly to sea level rise, to changes in runoff, and to stresses imposed by human modification of landscapes.** Most deltas naturally undergo a gradual caving or sinking known as subsidence. This process is accelerated in deltas during climate change causing sea levels to rise above the global average.

Many deltas are also impacted by the effects of water extraction, diversion, and declining sediment input as a consequence of entrapment in dams. Adding to these challenges, delta plains, particularly those in Asia, are densely populated, threatening the security of millions as a result of terrestrial influences (river floods, sediment starvation) and/or marine influences (storm surges, erosion).

44. **Not only are these geographies vulnerable to the effects of climate change, they are also valuable sources of TKT that could be helpful for local, regional, and global communities faced with rising sea levels, food scarcity, forced migration, and other threatening events.** Nearly 300 million people inhabit a sample of 40 deltas globally, including all the mega deltas of the Changjiang [Yangtze], Pearl, Red, Mekong, Irrawaddy, Indus, and Ganges-Brahmaputra rivers. (Ericson et al. 2006) Average population density in these areas is 500 people/km^2, with the largest population in the Ganges-Brahmaputra Delta, and the highest density in the Nile Delta. (Parry et al. 2007) According to one calculation, more than 1 million people will be directly threatened by 2050 in the three mega deltas of the Ganges-Brahmaputra in Bangladesh, the Mekong in Vietnam, and the Nile in Egypt. (Parry et al. 2007) Many of these deltas and mega deltas are associated with significant and expanding megacities.

Case Study: Floating Gardens in Bangladesh

45. **Much of the geography of Bangladesh is dominated by the Ganges-Brahmaputra Delta. The Ganges flows out of India becoming the Padma River and it regularly experiences disasters such as tropical cyclones, storm surges, coastal erosion, floods, and droughts causing heavy losses of life and property.** Below its confluence with the Teesta River, the main channel of the Brahmaputra River is known as the Jamuna River. The climate is subtropical monsoonal with an average annual rainfall of approximately 4,000 mm. Over 80% of the rain falls during the monsoon season from June to October. The country already faces challenges such as high population density (120 million people living in an area of 144,000 km^2), shortages of land to accommodate the people, food insecurity, poor population health, illiteracy, etc. Natural disasters make these problems all the more complicated.

46. **Ethnic groups including the Garo, Hajong, Khasi and Koch developed several terms to differentiate between lakes, including *baor, haor, jheel,* and *beel*.** A *hao*r is a large back swamp or bowl-shaped depression located between the natural levees of rivers consisting of a number of depressions that retain water year-round. The *haor* basin is a remote area that is flooded every year during monsoon. People in this region are mostly very poor and are constrained by not having cropping space. In some cases, even when they do have access, the land is submerged under floodwater for 7 to 8 months, restricting its use for cultivation. An overview of floods since 1954 indicates that although there are no significant changes in the trend of normal floods in Bangladesh, scientists predict that extreme floods like those of 2007 will occur more frequently in the coming decades as a consequence of changing climate. The impoverished people of the *haor* basin could realize a number of socio-economic benefits in terms of food security, health, employment, and household income if they were to adopt floating gardening.

47. **Floating gardening is a traditional practice of cultivation in the southern floodplains of Bangladesh with quite a few associated social, economic, agricultural, and ecological benefits associated.** In this hydroponic system, plants such as water hyacinth (*Eichhornia crassipes*) are used to construct a floating platform or raft on which vegetables and other crops

are cultivated in the rainy season. The following winter, the platform is dismantled, and the residue is used to prepare beds on the soil for winter vegetable cultivation. This traditional cultivation technique is an environment-friendly means that utilizes the natural resources of wetlands to grow vegetables and other crops almost year-round.

48. **Floating gardens are a traditional practice confined to southern Bangladesh but are a new concept for *haor*-dwellers in the northeast.** Community-based promotion of floating cultivation by NGOs is a recent development in the country. Recognizing the potentials of floating cultivation in the *haor* region, a pilot project was implemented in 2005-2006 to introduce this environment-friendly, natural, resource-based technique in several villages of the Habiganj district of Bangladesh. Lessons learned from this phase inspired two international organizations to scale up floating gardening in other areas of the *haor* region to address food insecurity for local, marginalized communities.

49. **This initiative was a technology transfer project to improve food security in the northeast by promoting a wetland-suitable agro-technique from the south.** Floating gardening can be a useful option to tackle both annual and severe monsoonal water logging to improve food security. The National Adaptation Program of Action (NAPA) of Bangladesh listed floating gardening as one of 15 major projects. (Durbar & Kathmandu 2010) Given the physical structure of the platforms, floating cultivation is not suitable in all open waters and cannot withstand devastating floods or strong waves.

50. **Further research is required to determine what modern technologies and policy measures can be helpful in the use and expansion of floating gardens.** There is scope to make the platforms stronger using modern technology or other traditional materials such as bamboo cages/rafts. However, such measures will increase input costs significantly. In addition to on-going, sporadic, non-government initiatives, the Government of Bangladesh and multilaterals should focus on agricultural extension systems that promote this technique on a wider scale. Local governments should be involved in these extension systems to ensure access to the common resource pool (e.g. water hyacinth, water bodies, fallow land) and access to markets to sell the produce. This production system can prove useful for sustained food production in many wetlands during normal floods as well as for the rebuilding of lives after disastrous floods through vegetable production and the advanced production of seedlings for winter cultivation. But before such scale-up, further assessment is needed to ascertain the vulnerability of this agro-landscape management technique to possible climate change variability.

3.4. Rising sea level risk management

51. **Scientists recently reported that a large part of the West Antarctic Ice Sheet is doomed to collapse, meaning that in coming centuries the sea level will rise at least four feet and probably much more.** (Sumner 2014; World Bank Group 2014) Climate change impacts accentuate other natural disasters such as tsunamis which may be higher under the influence of rising sea levels. As the climate changes, so will the fresh and saltwater resources that form the foundations of many communities and economies. As a result, our relationship with water will also require change. Pacific island nations are among the world's most physically and economically vulnerable to climate change and extreme weather events like floods, earthquakes, and tropical cyclones. The following case study analyzes the utilization of TKT in the Marshall Islands to learn best practices that can be used elsewhere and scaled up within current and future

climate change mitigation and adaptation projects.

Case Study: The Marshall Islands

52. **Understanding the role of TKT in SIDS is critical to understanding climate change resilience and adaptation, not only because SIDS are uniquely exposed to the forecasted effects of climate change, but more importantly, because of their long history of resilience to environmental variability.** Although most islands in the Pacific are small, their traditional communities hold valuable knowledge on seasonal cycles, ecological processes, and the management of biocultural diversity. The Pacific islands span from Papua New Guinea in the West to Easter Island in the East. This vast expanse has been conceived of in a number of ways, including regionally, as Polynesia, Micronesia, and Melanesia; geographically, as high and low islands; and linguistically, with diversity represented by approximately 20% of the world's 7,106 living languages. (Lewis et al. 2014) Over several thousand years, Pacific Islanders developed knowledge systems that enabled extensive sea-faring travel and the initial settlement and continuous habitation of islands across a wide geography. Because of their remote locations and a need to be self-sufficient (not necessarily within each individual island, but among islands), the knowledge systems of Pacific Islanders are deeply rooted and complex. Compared to other small islands throughout the world, knowledge systems in the Pacific Islands are well documented, remain widely practiced (e.g., traditional calendars that guide resource use and management), and stand out in their potential to improve our understanding of resilience to environmental changes.

53. **The Marshall Islands were settled between 2000-1000 BCE by Micronesians who canoed between island chains using traditional stick charts[8] and today have a population of over 68,000.** They consist of 1,156 islands and islets across two archipelagic island chains of twenty-four low-lying atolls, ring-like islands built upon coral reefs that encircle or partially encircle lagoons. The islands are built upon coral rather than volcanic matter, are of lower elevation, and are more susceptible to sea level rise.

54. **Stick charts serve as an example of TKT for Pacific Islanders.** While stick charts have practical applications including navigation, they also contain elements of cultural heritage. Studying Pacific islands in the 1970s, Robert Johannes listed the complex knowledge conveyed by stick charts including "stock structure, inter-annual variability in stock abundance, migrations, the behavior of larval/post-larval fish, currents and the nature of island wakes, nesting site fidelity in sea turtles, spawning aggregations and locations, local trends in abundance and local extinctions." (Johannes and Neis 2007)

55. **The TKT exhibited by Pacific Islanders, including their traditional calendars and charts, account not only for astronomical observations, but also for environmental, seasonal, and climatic occurrences.** Their multi-generational knowledge of climate can prove useful in detecting fluctuations within scientifically unrecorded time-periods. These ancient knowledge systems could also be invaluable resources for future generations of SIDS inhabitants that may face increased climate variability, severe storms, rising sea levels, and food and water scarcity.

[8] Sticks hatched in such a way as to represent the distances between islands. Some sticks would be bent or straight representing different routes or ocean currents.

56. **The Marshallese have developed numerous disaster reduction strategies due to their long-term rapport with the sea that have allowed them to notice when the seasonal environment is out of sync.** The main disaster risk reduction strategies practiced within rural indigenous populations in the Republic of the Marshall Islands (RMI) can be grouped into a number of categories including land use planning, sustainable housing, food resilience, early warning systems, and social resilience. Settlement patterns in the Marshall Islands were traditionally governed by environmental considerations such as wind, wave action, storm protection, etc. This began to change after World War II when settlement construction departed from this traditional wisdom as Japanese and US troops selected areas on the basis of base security and favorable lagoon conditions for large ships and seaplanes. These settlements have continued with the intensification of residential housing. However, unlike the traditional settlement sites, these new buildings are exposed on the windward side of the atolls and have consequently paid a heavy price in damage from typhoons and high tides.

57. **While the environmental consequences of climate change will bring many significant challenges to maintaining adequate supplies of fresh water to atoll dwellers, traditional knowledge offers viable solutions.** Water from fresh water 'lenses' on the Marshall Islands is accessible for humans in three different ways. First, water is available through differences in the tidal flux that releases fresh water into the edges of the islet/ocean at lower tides. Second, fresh water is available in shallow pits (natural or anthropogenic) that sink into the lenses. This second form of fresh water comes from very creative inventions known as taro pits. These small holes in the ground-water lens are lined with successive layers of plants, organic mulch, and coral rubble to create humidity pockets. Layers of plants around the pit protect the pocket from sun and wind keeping the temperatures cooler and humidity higher within. The net effect is that water loss from the hole in the lens is reduced. Active management of access to the freshwater lenses also creates new microhabitats. Inside the taro pit, humidity is quite high. This microclimate is a suitable habitat for some of the food and medicinal plants people use that would otherwise be difficult or slow to grow in the atoll environment. Management of taro pits as humidity pockets is a means for increasing food production and reducing water consumption. Maintaining such practices is key to survival.

58. **Third, the Marshallese are also known for land expansion processes, particularly on the island of Rotuma on which the islanders identified a freshwater spring that flows into the ocean at low tide 10 meters from shore below a coral shelf**. Coral boulders were stacked around the spring creating a pool area that would fill with mostly fresh water to be used for drinking or other purposes. Boulders were also arranged between the shore and the pool to create a walking path and eventually this was expanded to form a land bridge. Over time, with natural deposition of sand on one side of the land bridge, regular piling of additional coral boulders along the edge, and planting of trees and shrubs, the land became stabilized as a part of the island.

59. **Each island culture has its own traditional type of housing conditions, each of which offers excellent protection against inclement weather and is appropriate to the local environment.** In the Torres Strait Islands, off the far north coast of Australia, the Saibai have adapted to higher sea levels by raising their homes on stilts, a return to traditional housing design. The Samoan *fale* has a high thatched roof to protect against sun and rain, but no walls so that the breezes can keep it cool. The *kanak* in New Caledonia has thick walls and no windows, with a fireplace inside to keep it warm during cold nights, while the smoke keeps out the mosquitoes. In Fiji, traditional housing, or *bure,* are extremely resistant to strong winds with deeply buried, strong hardwood posts, steeply angled, four-sided roofs, and secure bindings to hold them down. Modifications to

bure and other traditional housing architecture have occurred throughout the 20th century with the addition of modern tools such as nails and iron roofing. Counterintuitively, the use of these modern tools has resulted in more vulnerability. In order to mitigate the effects of climate change on SIDS, development initiatives should incorporate traditional building techniques and settlement patterns that adhere to local climate conditions. Engineering studies should be conducted to assess why traditional housing is much more durable. The insights from such studies can inform the design of housing in other parts of the world with similar climatic conditions.

60. **Traditional housing patterns and architectures, food systems, navigational and resource charts, taro pits, other water harvesting techniques, and land extension processes are invaluable forms of TKT. This type of knowledge can be scaled up locally and introduced in other SIDS facing similar risks associated with climate change**. However, there are significant challenges and limitations to such TKT because the scale of future change is likely to overwhelm entire islands and their cultures. The RMI and other SIDS are not as integrated as they once were, meaning that they must become more self-sufficient as individual islands rather than extended archipelagos. Nonetheless, the knowledge systems should be integral parts of any development intervention in the Marshall Islands. There is also a significant scope for introducing and utilizing modern information and communication technologies (ICT) such as computers, tablets, communication devices, GIS, and GPS to detect, record, and share information regarding traditional resource endowments and climate events.

3.5. Rainwater harvesting

61. **Climate change will exacerbate water stress, but certain traditional practices show enormous promise in managing water**. Springtime snow cover in the Northern Hemisphere will likely drop 10 to 30 percent by 2100, making comprehensive water management crucial. (Word Bank Group 2014) Water managers will need a flexible mix of strategies to confront the challenges ahead. Various strategies include harvesting rainwater, reusing water, improving storage systems, and diversifying crops. The common goal of all forms of water harvesting is to secure water supply for annual crops, pastures, trees, and animals in dry areas without tapping groundwater or river-water sources. In the past, water harvesting was the backbone of agriculture in arid and semi-arid areas worldwide. After a decline, it has garnered renewed interest over the past decades. The following case study sheds light on ancient and contemporary water harvesting techniques in India.

Case Study: Water Harvesting Systems in India

62. **This case study focuses on a project carried out in and near the villages of Ambevangan, Manhere, and Titvi in Akole Taluka of the Ahmednagar district in Maharashtra State. Harvesting rainwater in India dates back thousands of years.** Subsistence agriculture is the main form of livelihood in these rural areas. Annual rainfall varies from 2,000 mm in the west to 600 mm in the east. It occurs almost entirely during the monsoon period from June to September. There is little or no rain during the rest of the year. The driest months are April and May, when temperatures climb to over 40^{o} C. Excessive monsoon rains used to flow as surface runoff from the project area to lower elevations to provide water only during the monsoon season.

63. **With help from the BAIF Development Research Foundation, communities in the area have**

adopted sustainable technologies for water harvesting that are in use year-round. The practice employs a wide range of approaches to water conservation and utilization. Various barriers (contour bunds, *nalla* bunds, check dams, gabions) and shallow excavations (contour trenches, farm ponds, reservoirs in bedrock) at right angles to the slope arrest the flow of surface runoff. Contour hedging, and the replanting of nonagricultural land were also introduced. These measures complement the terracing of hill slopes for agricultural purposes. Shallow excavations improve the infiltration of water. Masonry tanks contain the water from springs and seepages. Wells that have been dug are deepened and other wells are re-bored to make better use of the aquifer. Water is also collected from the roofs of dwellings. Another traditional practice was applied to identify the location of ground water. For example, Hindu/Buddhist traditions revere the *Ficus glomerate tree*, known locally as *umbar*. *Umbar* is an indicator of shallow ground water. The presence of *umbar* marked places where wells were dug to tap springs. Local TKT also provides a soil classification that proves to be a useful basis for categorizing the aquifer properties of local earth materials. These water harvesting technologies are small-scale, relatively cheap to implement, and easily replicated. The technologies for conjunctive use of water resources come from a comprehensive survey of ancient and modern approaches to water-resource management in other dry regions of India and worldwide. They have undergone modification to fit local circumstances, particularly with regard to water, soils, bedrock, and topography.

64. **The project's water-harvesting techniques augment the local practice of traditional cultivation of land that involves returning nutrients to the soil in the form of ashes that are left over from burning tree branches and leaves on selected plots.** Rice and dry crops are planted as seedlings in the ashes after the first rainfall of the monsoon. Later, the seedlings are transplanted in the fields. This is the *rab* system of fertilizing, which takes its origin from a once widely employed type of shifting cultivation called *dalhi* (*kumri*).

65. **Indigenous knowledge, attention to local religious practices, and respect for traditional and folk approaches to communication were indispensable to the success of the project.** The project technologies provided logical extensions of this knowledge. For example, a watershed committee was formed in each of the villages to facilitate communication. This was done on the basis of a tradition known as the *ayojan*, which is a village planning committee that takes responsibility for decisions affecting the community.

66. **The project benefited from the integration of modern science such as analyses of images from Earth satellites in orbit, the use of GPS and GIS, and field and laboratory techniques in hydrology and hydrogeology employed alongside traditional hydrology, local religious beliefs, traditional technical knowledge, and social institutions**. The project also made a contribution to the advancement of gender equity in the area as women can now work longer in the fields. Illnesses connected with shortage of water have been substantially reduced. The young people are no longer leaving the villages in search of livelihood in large numbers. Most importantly, the people have assumed ownership of the project and have begun to share the knowledge and technology with others.

67. **This TKT is readily transferable across some 500,000 km^2 of western India due to similarities in bedrock geology.** The practice would no doubt be widely applicable in other areas, regardless of climate and geology, and has been replicated by BAIF over a wider area, thanks to support from the National Bank for Agriculture and Rural Development (NABARD) under the Indo-German Watershed Program.

68. **In addition to those in India, there are many modern technologies that can be introduced to IPLCs to facilitate water harvesting.** For example, in Ethiopia, a company called Architecture and Vision has designed and implemented the Warka Water Tower, a 300-foot tall and 13-foot wide bamboo tower with mesh netting that captures moisture from the air (as much as 25 gallons of water in a day) and directs it into a holding tank where the water can be accessed through a spout.

Case Study: The Water Man of India – Rajendra Singh[9]

69. **A large population deprived of water has been impacted by the regeneration of five rivers that have started flowing again in the semi-arid region of North India**. This study deserves separate mention within rainwater harvesting because of the magnitude of change that has been achieved. Rajendra Singh is a well-known water conservationist and environmentalist from the Alwar district of Rajasthan in India. He runs an NGO, *Tarun Bharat Sangh* (TBS), that was founded in 1975. The NGO is based in village of hori-Bhikampura in Thanagazi Tehsil, near the Sariska Tiger Reserve, and has been instrumental in fighting the slow bureaucracy and mining lobby. It has helped villagers take charge of water management in their semi-arid area close to Thar Desert through the use of *johad* (rainwater storage tanks), check dams, and other time-tested and ground-breaking techniques. Starting from a single village in 1985, over the years TBS helped build over 8,600 *johads* and other water conservation structures to collect rainwater for the dry seasons, has brought water back to over 1,000 villages, and has revived five rivers in Rajasthan including the Arvari, Ruparel, Sarsa, Bhagani, and Jahajwali.

70. **The groundwater was replenished, water was stored in rocks, and limits were set on water exploitation.** To save water, the cultivation cycle was aligned with the rain cycle. The stress was on controlling evaporation loss and on the disciplined use of the water. Water storage structures were created only in areas where water could seep underground. This has resulted in the resettlement of villages where people depend on cultivation and animal husbandry.

71. **The process involved studying the rock structures where water storage bodies can be created, where water evaporation can be controlled, and where crop cultivation can be adjusted to the availability of water.** Crop cycles were altered and today people have resettled in once deserted villages. Similarly, the tradition of step wells[10] in Rajasthan in India is an object of study, with the aim of transferring it to other semi-arid and arid regions across the world. For this purpose, more research needs to be done in the area of morphology and crop cycle adjustment. Key identifiers need to be defined which can then guide the implementation of the process in different geographies. The sample and data collection methods used by Mr. Rajendra Singh's *Tarun Bharat Sangh* need to be studied. Action research can be adopted to implement this model in some arid region of Africa or the Middle-East.

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[9] http://tarunbharatsangh.in/we-people/

[10] A stepwell is a subterranean edifice and water source. It is an architectural form that was long popular throughout India, but particularly in arid regions of the Indian subcontinent. It incorporates a cylinder well that extends down to the water table and is a complex engineering feat. Stepwells were excavated several stories underground in order to reach the water table, the level at which the soil or rock is always saturated with water. Stylistically varied, they incorporated flights of stairs leading from the ground level down to the water.

3.6. Land use and agriculture adaptation to climate change

72. **Water conservation, soil management, and land use changes are several methods that can be adopted to adapt to climate change.** IPs have used all three of these methods to maintain food security, to prevent the loss of natural landscapes due to climate changes, and to prepare their communities for recurring natural disasters. The following case study involving the mountainous climate in the South American Andes Range provides insight into how local TKT can be harnessed to mitigate and adapt to climate change.

Case Study: Climate Change Adaptation the South American Andean Mountains

73. **The Indigenous Otomí People in Mexico maintain traditional soil and water management practices through small-scale dams, terraces, management of the erosion and deposit processes, sedimentation management techniques, and systems for classifying relationships between soils, water, and soil typology.** These practices help the Otomí people to maintain agricultural production during periods of drought and water shortage.[11]

74. **Across the Andes in South America, there is a long tradition of agricultural practices that conserve the natural diversity of crops such as potatoes, quinoa, squash, and fruits allowing IPLCs to manage native and wild agro-biodiversity.** Traditional mountain communities possess a rich knowledge of the genetic characteristics and varieties of each native crop and its wild relatives. Using this knowledge, communities have applied selective breeding methods to increase the resilience of cultivated crops to variable environmental conditions brought about by global climate change.

75. **In Peru and Bolivia, Waru Waru is an ancestral technology that increases soil humidity levels for cultivating tubers and grains.** Waru Waru combines raised beds with irrigation channels to prevent damage by soil erosion during floods. The technique ensures both the collection of water (fluvial water, rainwater, or phreatic water) and subsequent drainage. The drainage aspect makes it particularly interesting for many areas subjected to risk of brutal floods such as tropical parts of Bolivia and Peru where it emerged.

76. The technology helps farmers maintain high yields during dry periods thanks to stored soil humidity and to mitigate the negative impacts of flooding by facilitating drainage. Preserving foods has been an age-old practice in arid and semi-arid regions. This practice reduced rural families' vulnerability to droughts, irregular rainfall, harvest losses, and extremely cold winters, which are all impacts that are set to increase due to climate change.

3.7. Partnership of government and indigenous people to control climate change

Case Study: Governor's Task Force[12]

77. **Protecting forests can deliver a wide range of social and environmental benefits at a relatively low cost**. However, state and provincial governments must play a leading role in implementing the policies and practices needed to curb deforestation and combat climate change.

[11] https://assets.publishing.service.gov.uk/media/57a08a5d40f0b64974000574/120625_ENV_AdaMouEnv_BRIEF2.pdf
[12] https://static1.squarespace.com/static/5896200f414fb57d26f3d600/t/5b98280b88251b2a09be1730/1536698424833/GCF+New+Alliances+for+People+and+the+Planet+Report+2018.pdf

The deforestation of Indigenous Peoples' forests in Brazil, for example, would likely have been twenty-two times higher than without government protection.

78. **Partnerships between Indigenous Peoples and state and provincial governments are delivering for communities, conservation, and climate.** The Governors' Climate and Forests (GCF) Task Force was created in 2008 by governors from states and provinces across many nations that are leading the way in building robust jurisdictional programs to protect forests and climate while enhancing rural livelihoods. The GCF Task Force now serves 38 states and provinces from ten countries including Brazil, Colombia, Côte d'Ivoire, Ecuador, Indonesia, Mexico, Nigeria, Peru, Spain, and the United States.

79. **The section below highlights four success stories from Brazil, Indonesia, Mexico, and the United States** in which subnational governments and IPs have partnered in innovative ways to create just and sustainable outcomes that provide positive pathways and possibilities for people and the planet. While the TKT is not explicit, the land rights and support accorded to IPLCs is critical for combating climate change

80. **Puyanawa Tribe, Acre, Brazil.** The state government and the Puyanawa tribe understood that conserving forests would benefit ranchers and urban inhabitants. This was done by controlling rainfall, reducing drought and flooding, increasing agricultural productivity, and enhancing water quality while attracting international financial support for climate action. Once the government recognized the Puyanawa as guardians of the forest in a way that benefited everyone, community demands for greater control over customary lands ceased to be at odds with government policy and started to be a means to it. In 2017, the German Development Bank signed a €30 million agreement to support the continued reduction of emissions from deforestation.

81. **Tambrauw District, West Papua, Indonesia.** The Indonesian government's development policies have affected indigenous tribes, drastically impacting their control over forests and livelihood. This has resulted in the destruction of indigenous forests and the forced displacement of local communities as well as in a great deal of anger and protest. Government and local communities then joined hands to understand a new model of development. Today, deforestation rates and social conflict in Tambrauw are low and are expected to remain so in the foreseeable future, even as deforestation and violence continue in neighboring regions. Development goals such as rural electrification are being met with small scale hydropower and other sources of renewable energy.

82. **Yurok Tribe, California, United States.** First contact with non-natives took place in the year 1775 and, by the end of the gold rush era, over 75% of Yurok tribe members had died. In 2010, the tribe partnered with the California Air Resources Board to draft regulations that allowed tribal forest projects to qualify for the carbon credit program. With the revenue they have received from their commitment to protecting their forests and increasing carbon stocks, the tribe has begun reacquiring their ancestral territory that has not been under tribal ownership in over a century.

83. **The Maya Zone, Quintana Roo, Mexico.** In 1920, the Mexican government implemented agrarian reforms and established collective, communally-managed land grants called *ejidos*. *Ejidos* managed by Mayan communities practicing sustainable forestry were able to keep their forests, cultures, and communities largely intact. As the benefits of this long-term approach became apparent, popular support for the more sustainable Mayan forestry methods grew in

Quintana Roo. The Maya and the government of Quintana Roo have formed a partnership, the Emissions Reduction Initiative, aimed at reducing emissions from deforestation while promoting local control, sustainable development, and natural resource management.

Case Study: Climate Benefits, Tenure Costs: The Economic Case for Securing Indigenous Land Rights in the Amazon [13]

84. **It has been found that tenure-secure indigenous lands have low deforestation rates.** The modest investments needed to secure land rights for indigenous communities will generate billions in returns—economically, socially, and environmentally—for local communities and will mitigate the effects of climate change.[14] This case study quantifies for the first time the economic value of securing land rights for the communities who live in and protect forests, with a focus on Colombia, Brazil, and Bolivia.

85. **From 2000 to 2012, the average annual deforestation rates inside tenure-secure indigenous lands were two to three times lower than in similar forests without secure tenure in Bolivia, Brazil, and Colombia.** The three countries undertook a regularization and titling process to recognize and protect indigenous lands in the 1990s that has sped up in the past decade. The effects on reducing deforestation are already observable, suggesting that deforestation rates have declined over time and that these effects will likely continue if the indigenous lands remain secure.

3.8. Community-based monitoring and information systems (CBMIS)

86. **CBMIS generate information that serves as the basis for IP's collective analyses and the resulting decisions that strengthen stewardship of their lands, territories, and resources to further their community development plans. CBMIS also assess and sustain traditional livelihoods with appropriate technologies and innovations and strengthen low-carbon climate change actions within IPLCs.** (Tebtebba Foundation 2019) In openly sharing and reporting information about the changes observed in their environments, IPs have been able to collectively analyze and decide on responses to those changes. CBMIS integrate traditional monitoring knowledge and practices with new technologies that maximize the systematization of baseline information and further the monitoring of changes in the environment through the years. The following case study sheds light on the use traditional knowledge that incorporates conventional technologies to tackle the rising risk of floods in Nepal.

Case Study: Coping with Floods in Nepal[15]

87. **The Trakarding Glacier at the eastern end of the Rolwaling valley on the Nepalese-Tibetan border of the Dolakha district has been around for centuries.** However, due to global warming, its moraine lake, Tsho Rolpa, has grown at an alarming rate and threatens to disrupt the 150-meter moraine dam containing it. According to an 2011 study by the International Center for Integrated Mountain Development, a sudden break of the moraine dam would destroy many of the settlements in the valley as well as expose 20 percent of the agricultural land to damage, potentially affecting 142,000 people directly and another 524,000 indirectly. From the mid-1990s

[13] https://www.wri.org/publication/climate-benefits-tenure-costs
14 https://www.wri.org/news/2016/10/release-secure-land-rights-amazon-brings-billions-economic-and-climate-benefits-says
[15] NEFIN, CIPRED (2016) Climate Change and Indigenous Peoples, Policies and Practices in Nepal.

onwards, this lake and its dam have become the subject of several national and international programs.

88. **A traditional Sherpa habitation, the settlement of Rolwaling dates back to the beginning of the 16th century.** The valley's striking natural beauty stretches 30 km east-west along the Tibetan border and is nestled in the shadow of the Rolwaling Himal. It is believed that the Buddhist Master Padmasambhava meditated in the valley when introducing Buddhism to Tibet, enshrining Rolwaling with the prestige of being a *beyul*, a refuge and shelter for pious mountain dwellers.

89. **The Rolwaling Sherpas were engaged in an agro-pastoral economy based on seasonal transhumance and social consensus regarding the sustainable management of cultivable land, forests, and high-pastures.** The narrow valley bottom and steep slopes provide limited space for cultivating potatoes at altitudes ranging from 3,600m to 4,100m. Yak grazing pastures can be found as high as 5,400m above sea level, and the dense mountain forest covers the entire lower, north-facing valley slope offering firewood and timber.

90. **The valley, which has recently seen the construction of a large hydropower station and a road linking Rolwaling to Charikot, has undergone fundamental socio-economic changes.** Even before construction, the Rolwaling Sherpas had already begun their social and economic transition. This was due to the rapidly increasing global demand for adventure tourism in the Himalayas. The Sherpas, however, were faced with an increasing imbalance between demographic growth and the available natural resources for a transhumant agro-pastoral lifestyle, which led half of the population to permanently resettle to Kathmandu before the 1990s.

91. **The Rolwaling community prepared to cope with flash floods by building a solid embankment of boulders.** These boulders were collected from the river and reinforced with wooden poles to protect the Beding plain and its potato fields. Coping with floods and disaster preparedness has always been an essential part of the agenda of the headman of the Rolwaling community and is an important part of local indigenous knowledge. Village disaster preparedness is based on four pillars of local knowledge, starting with observation, followed by anticipation, then adjustment, and finally communication. These types of local experiences become tacit collective knowledge and are rarely shared with outsiders.

92. **In November 2003, the Rolwaling Sherpas collectively mobilized to try and force the river back into its original bed by building a boulder dam to prevent future floods.** However, despite the collective effort, the exercise proved to be futile during the next monsoon season. In the aftermath, the community submitted a request for financial assistance to the Swiss Development Cooperation in 2007. Under the local community government and with aid from the Swiss, a solid 600-meter gabion dam was designed by an engineering firm to protect the village from the floods. This example is a striking illustration of how TKT in and of itself can often be insufficient. However, when coupled with modern methods, TKT can create viable, robust solutions through the use of partnerships and modern technology.

Chapter 4. Challenges and Opportunities for Accessing and Scaling-up TKT

93. **TKT systems are part of a cultural complex that encompasses land, biodiversity, language, naming and classification systems, rituals, spirituality, and worldview.** They provide the basis for local decision-making about many fundamental aspects of day-to-day life including hunting, fishing, gathering, agriculture, husbandry, food production, water usage, health, and adaptation to environmental or social change. Some forms of traditional knowledge find expression in places, stories, legends, folklore, rituals, objects, and songs. In many cases, TKT has been passed down orally from generation to generation and is therefore seldom documented. There is a lack of documentation owing largely to IPLCs remote locations and often politically marginalized geographies. Also, there are instances where IPLCs are protected by law and interaction with developed world is prohibited or restricted to minimize or prevent changes in their lives and practices. For such areas, newer modes of investigating traditional knowledge without impacting local IP setup and thinking process have to be considered to the extent feasible including using principles of prior and informed consent.

94. **IPLCs face challenges in defending their legal rights and in effective governance over TKT.** The first case study in this section provides a successful example of IPLCs working with national and international governments to protect their legal rights to indigenous knowledge through IPRs in Canada. The second case study documents a less positive experience in which the lack of land rights has devastated the Batwa culture in Uganda. The third and final case study documents how IPLCs in Peru have been able to reclaim TKT and traditional livelihoods through good governance. It behooves governments to adopt these successful stories to bring desired impact on these marginalized populations.

4.1. Risk context of TKT

95. **Traditional knowledge is regulated by customary norms and embedded in a web of relationships that are often *sui generis*, that have specific rules for practice, and that have unique ownership codes. These traits make it difficult for TKT practices to be replicated in foreign cultures and climates.** Once traditional knowledge is shared outside of a community, it enters alien social and legal contexts. There has been a steady evolution in the international treaties and norms governing use of indigenous knowledge,[16] however attempts at arriving at frameworks for governance of climate-specific TKT are in their infancies. This poses significant risk in terms of loss of TKT through benign neglect or well-intentioned, but misguided endeavors to scale up or genericize TKT in order to encourage wider adoption. Thus, there are attendant risks that the lack of appropriate policy measures to conserve and maintain TKT will mean irreversible loss of precious knowledge or irreparable damage to indigenous communities through loss of habitat.

96. **Conversely, using conventional approaches such as chronicling or replicating TKT without the appropriate context or synthesizing TKT with modern science can lead to undesirable outcomes which may sully the cause of deploying TKT.** While the Paris Agreement calls for the creation of a platform for TKT, concerns have been raised over potential adverse consequences of knowledge exchanges. Co-learning and co-production processes involving traditional and conventional knowledge systems do not guarantee fairness and equal standing, nor do they address power asymmetries. As a result, the south-south knowledge exchange paradigm prevalent in

[16] E.g. Nagoya protocol - WIPO's attempts at a potential international treaty to regulate international access to genetic resources, traditional knowledge, and folklore (now referred to as traditional cultural expressions).

conventional technological context cannot be viewed as unproblematic for information exchanges in climate TKT context, and potentially carries significant risks. While the establishment of appropriate governance frameworks or specific policies is beyond the scope of this paper, the authors have endeavored to unpack some of the critical issues that are unique to TKT in the climate context.

4.2. Gender issues in TKT

97. While women are disproportionately affected by climate change, detailed studies of this aspect and incorporating this in terms of policies governing TKT are yet to be fully undertaken. Traditionally, women are the key agents that manage all aspects of livelihood, health, and social security. Yet there is a great scarcity of women-led and women-specific programs related to traditional knowledge and its impact.

98. In cognizance of this, UNESCO[17] stresses the need to develop a framework for monitoring gender sensitivity in all components of the adaptation process. Along the same lines, this UNESCO paper notes that there is a need for tools such as participatory approaches and empowerment efforts in addition to analyses that highlight the linkages and interaction between climate change, adaptation, TKT, and gender, among other factors. It also discusses guidelines and conventions relevant to the use of indigenous and traditional knowledge for adaptation. While these guidelines and conventions exist, there appears to be little or no evaluation of their practice and effectiveness. The impact evaluation of guidelines and conventions poses a significant area of research. A Maturity Model with regards to indigenous knowledge along the lines of ISO Standards can be developed based on these conventions and countries can be certified against it.

99. The allocation of land rights in various traditional setups has changed the lives of hundreds of women and has helped both governments and the tribes to work in close connection. The UNESCO report highlights the important role of gender sensitivity in TKT as well as the role of land rights and tenure, which the report categorizes as ignored and undeveloped.

4.3. Legal context of TKT

Intellectual property rights

100. **In any effort to access, document, or scale up TKT, due consideration has to be given to IPRs.** The knowledge and technologies contained within landscapes, households, individuals, oral traditions, texts, and elsewhere belongs exclusively to the communities that maintain these systems and access to such TKT must be restricted. Unfortunately, IPRs are weak to non-existent in many developing countries where IPLCs live. These communities own a plethora of valuable knowledge and technologies—particularly with regard to medicinal plants—that needs to be acknowledged, respected, and rewarded. One example of TKT that has already proven its value without due compensation is *urari* (curare), a traditional poison applied to darts and arrows in northern Amazonia that played a significant role in helping Western scientists understand neurophysiology and the modern use of anesthesia.

[17] http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/UNFCCC-TP-2013-11.pdf

101. **The relationship between TKT and IPRs is a complicated contemporary legal problem.** Questions around the protection of indigenous knowledge present issues unlike any other that intellectual property law has had to consider. IP's concerns include legal questions involving copyright, patents, trademarks, designs, and/or confidential information. They also raise issues that are not always legal or commercial in nature that include ethical, cultural, historical, political, religious/spiritual, and moral dimensions.

102. Intellectual property law is largely European in derivation and promotes a particular cultural interpretation of knowledge, ownership, authorship, private property, and monopoly privilege. (Anderson 2010) IPs do not necessarily interpret or conceptualize their TKT systems in the same way through these concepts. Their interests in intellectual property law can affect over 370 million people worldwide as well as researchers, development institutions, corporations, or government agencies working with IPLCs. A platform connecting intellectual property laws and TKT must be initiated at least as a prototype, and the effect and learning the platform generates can be evaluated and used as guiding factors in the definition of intellectual property laws.

103. **It is clear that IPs must be centrally involved in developing appropriate frameworks for access to and use of their knowledge and technology**. Future directions are dependent upon the development of frameworks that enhance and embolden indigenous perspectives about existing and emerging knowledge management approaches. TKT can no longer be considered a raw-resource from which others benefit. IPLCs are asking for their cultural systems and ways of governing knowledge access and use to be recognized as legitimate as well as that they themselves be respected as custodians/owners/nurturers of knowledge that is valuable within and beyond local contexts. A critical evaluation of categories and frameworks that have been taken for granted is crucial for developing new strategies in this area. Rethinking how we do research, how we conceptualize knowledge, how we share knowledge, how we recognize legitimate overlaps in knowledge use and circulation, and the extent of the role of law in influencing knowledge exchange are necessary starting points. The case study below illustrates the successes of the indigenous Pauktuutit people of Canada in tackling the challenging issue of IPRs.

Case study: The Pauktuutit Inuit Women's Association of Canada

104. **Pauktuutit is a national organization representing Inuit women in Canada. Its mandate is to foster a greater awareness of the needs of Inuit women and to encourage their participation in community, regional, and national concerns related to social, cultural, and economic development**. Pauktuutit has worked to inform and raise the capacity of Inuit communities to participate in discussions on national and international policies and laws that can influence the success of economic activities that rest on craft commercialization and cultural heritage. In partnership with Indigenous and Northern Affairs Canada, Global Affairs Canada, International Trade, Status of Women Canada, Canadian Heritage, and Environment Canada, Pauktuutit has pursued activities dedicated to protecting Inuit cultural heritage and cultural property. Fundamental to the project has been the need to raise awareness at the community level about current IPRs and standards.

105. **The Arctic adaptation of the Inuit has inspired some remarkable innovations and technologies that the modern world has appropriated. Many elements of Inuit material culture have been appropriated without due recognition or compensation**. The *parka*, *kayak*, and *anorak* are obvious examples. The traditional boot, the *kamik*, is now a trademark brand of outdoor footwear made by Genfoot. The logo for the product line is an *inukshuk*, a traditional

structure of piles boulders or stones that was used as a communication device in Artic cultures. This exploitation of traditional knowledge and the intellectual property that it encompasses is not uncommon among IPLCs around the world. A 1997 study found 81 percent of Canadian indigenous artisans had experienced some form of misappropriation or misuse of traditional designs. It is now critical that IPs develop the tools and skills to protect their heritage and to ensure they benefit from use of their intellectual property.

106. **One specific objective of Pauktuutit has been to evaluate and protect the IPRs associated with the production and marketing of an Inuit woman's parka called an *amauti*.** The *amauti* is an example of Inuit creativity that employs traditional materials, designs, and motifs still in use today and that has yet to be exploited or misappropriated as have other Inuit creations. The project's efforts to build capacity at the community level has helped the Inuit to evaluate the limitations of existing IPR laws and has helped in the search for solutions. The lessons that are learned may be valuable to IPLCs elsewhere.

107. **While the value of TKT has changed dramatically in the last ten years, there is not yet an international consensus about how indigenous rights to the protection of their knowledge systems can be secured, either within an intellectual property system or through some other policy framework**. As a result, IPLCs around the world have not been able to fully participate in many of the economic opportunities of the modern world. Their full participation has been limited in part by existing IPR laws and conventions. As the laws are currently formulated, much of their material and cultural heritage is vulnerable to exploitation and misappropriation. Fortunately, there are a number of initiatives that now acknowledge these shortfalls including the Convention on Biological Diversity (CBD), the World Intellectual Property Organization (WIPO), *Agenda 21*, and The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement). IPLCs have become active participants in these and other processes and are working hard to control and manage sustainable development practices that meet their unique social and environmental circumstances.

Land rights

108. **Research has proven that when infrastructure development, deforestation, resource extraction, agriculture, pastoral conversion, and climate change encroach on IPLCs, they often lose their land and the TKT that protects and maintains its balance.** A primary interest of IPLCs is to acquire titles to native land, including rights to subsurface minerals and the rivers that run through their territories. According to Per Fredrik Pharo, Special Adviser to the Norwegian Ministry of Climate and Environment: "Investing in tenure rights of Indigenous Peoples and then investing in capacities to defend those rights is an unbelievable effective climate mitigation strategy." Hence, efforts must be made to strengthen existing land tenure for IPLCs and TKT. The case of the Batwa culture of Uganda below demonstrates the importance of land tenure.

Case study: Batwa tribe in the Bwindi Impenetrable Forests of Uganda

109. **The Batwa, also known as the Abayanda or Twa, represent the easternmost group of Central Africa's tribal population. Uganda's 6,700 Batwa are concentrated in three rural districts in the southwest of the country.** (Uganda Population Secretariat 2008) The Batwa were once important in the courts of the pre-colonial kings and chiefs as performers, spies, hunters, and warriors. By the 1930s, cultivation and tree felling had greatly reduced the forest territories of the

Batwa and they became increasingly dependent on farmers for food and land. In the early 1990s, conservation projects led to the Batwa in Uganda being evicted from the forest and estranged them from traditional food, shelter, and medicinal resources. These IPs, like other groups in sub-Saharan Africa, experience poorer than average health outcomes, marginal social status, and are particularly sensitive to environmental change due to their resource-based livelihoods and traditional health systems.

110. **The centuries-long cohabitation of Batwa and gorillas in the forests worked well as evidenced by the gorillas' continued existence today**. However, international donor agencies, national governments, and local officials have supported the establishment of national parks such as The Bwindi Impenetrable National Park in which the interests of game animals are given priority over the interests of the Batwa, who are the best caretakers for the land. Gorilla conservation is a major threat to the Batwa. This is also the case in Rwanda and the Democratic Republic of the Congo where Batwa have been stereotyped as poachers. Some people, especially northerners, assume that because Batwa hunt, they hunt everything. No known Batwa group eats gorilla and the evidence suggests that they have never done so.

111. **The Batwa, who owned the forest and had lived there for generations without destroying it or its wildlife, only received compensation if they had acted like farmers and destroyed part of the forest to make fields.** This is a classic case of hunter-gatherers' land rights being ignored by local, national, and international agencies. The World Bank had policies that obliged Uganda to assess the impact of the parks project on IPs and to assist people affected by World Bank-financed interventions. Despite the promise of 'prior and meaningful consultation' and 'informed participation,' it was not until four years after the evictions in 1995 that an assessment of the Batwa's situation was carried out. (Lewis 2000) Twenty-six years after eviction, the Batwa still have not been given land to settle. They remain largely on farms, government land, and church land as squatters, tenants, and laborers.

112. **This dislocation and subsequent adjustment to life outside of the forest has led to a significant, detrimental cultural and socio-economic transition.** After decades of increased social and environmental stress, the Batwa have now been integrated into society at the lowest level. Inter- and intra-state upheavals and violent conflicts have undermined their livelihoods and culture even further. For numerous Batwa communities, near or absolute destitution has become a reality. Despite the unprecedented hardships they have experienced, they are making courageous and determined efforts to defend and promote their rights.

113. **The Batwa are renowned for their TKT. For example, studies have identified dozens of local medicinal plants used by the Batwa, many of which contain active compounds against diseases such as malaria, diarrhea, and intestinal worms.** Sadly, few community members are learning to use traditional medicine compared to the past. Most Batwa villages have at least one traditional herbalist. However, many lament that their knowledge is not being passed on to younger generations. Most Batwa find themselves with neither a viable traditional life, nor access to the benefits of modern society. As cheap, mass produced goods became widely available, the Batwa's craft economy has become increasingly ineffective, and they have become more dependent on marginal subsistence strategies such as casual day labor and begging.

114. **Despite legal support at the international level requiring states to respect, protect, and promote the integrity of IP identities, hunter-gatherers are widely denied the right to hunt and gather.** This is a major problem for the Batwa who are prevented from hunting and gathering

in the majority of remaining forest on their ancestral lands. Although other ethnic groups are also denied the right to hunt, the effect of this ban is not comparable to its effect on forest-orientated Batwa. Hunting and related activities are central to the cultural, economic, and religious identity of Batwa, but are not central to the identities of their neighbors. Frequently without identity cards, land, education, or effective access to justice, many Batwa feel like a stateless community within a state. Successful adaptation to social and climatic pressures depends on the extent to which they can reduce their sensitivity to negative health outcomes. Land tenure and security, economic self-sufficiency, and revitalized TKT are fundamental to this aim.

115. **It is only through the Batwa's long-term custody of the area that current residents have access to abundant and robust forests.** Hunting and gathering is often considered ecologically unsustainable, backward, and a wasteful use of land. The widely held and strongly discriminatory notion is that hunting and gathering are not legitimate uses of land and confer no rights to continued occupancy. This contrasts with the widely held view that agricultural and sometimes also pastoral usage constitutes legitimate land use for which the occupants can claim exclusive rights and cannot be dispossessed without due process and restitution. The Batwa want community-based planning, transparency in project funding, and training so they can manage projects themselves. They would like to be able to visit other Batwa communities to see how they are coping, to share experiences, to discuss ideas, and to build networks. In accordance with international standards on IP rights, Batwa collective land rights should be recognized in the constitutional law of the countries where they live. Land rights lost by Batwa communities and individuals during independence should be restituted. Challenges will persist since the Batwa are caught between violent uprisings, the farmers who despise and exploit them, the governments that neglect them, and the conservationists who have put an end to their forest hunting and gathering lifestyle.

116. **Land must be clearly demarcated, officially registered, and effectively monitored to ensure Batwa are not dispossessed of this land in the future**. Land allocated to Batwa must be of good quality with effective access to water. clay, forest resources, and/or lakes. Forest conservation projects in traditional Batwa areas must fully involve Batwa communities if genuinely sustainable conservation is to be achieved. The effects of internationally funded game parks and conservation areas on the Batwa should be monitored so that funding agencies ensure the full respect and, where necessary, restitution of Batwa rights. Consultations with each Batwa community should establish their specific needs in relation to forests and land in a project area, and the Batwa should be represented at all levels of project management. This will require a range of capacity building measures so that communities can organize and represent themselves effectively. In the design and implementation of aid and development programs, emphasis should be placed on supporting long-term skill training, education, advocacy, and legal support as well as on meaningful and full consultation with Batwa communities.

117. **In summary, TKT is part of the land that is integral to IPLCs and it is the glue that holds landscapes together.** Strengthening and expanding existing land rights will enable the preservation, development, and transfer of TKT within and between diverse IPLCs worldwide. Giving land rights to IPLCs such as the Batwa will mitigate climate change and the continued erosion of biocultural diversity caused by external extraction and conservation interests. Modern technologies can play an important role in mapping traditional landscapes, documenting TKT, and integrating dispersed Batwa communities through improved communication, energy, and organization capacities.

4.4. TKT governance in climate change context

118. **There is scope for complementary partnerships between TKT and conventional climate science, especially with regard to seed banking and ICT that can be of assistance in mapping, knowledge management, and market access**. Continued collaboration and assistance can enable the scaling-up of initiatives such as the Peruvian Potato Park in other Andean communities and elsewhere where IPLCs struggle to subsist and to hold on to their land and TKT. However, other factors should be paid equal attention. There are numerous examples of designated protected areas that have failed in which the communities are not able to live or derive benefits. The viability of TKT may have less to do with how effective they are in addressing the effects of climate change, but more with how governments respect IP rights to land and livelihoods and commits to land (or marine) conservation. Designated lands are protected in diverse ways and can impact IPs differently, often in adversely. Advocating for the scale-up of protected areas is too generalized a way of thinking without understanding the issues holistically.

119. **Enhancing and supporting the adaptive capacity of IPLCs will only be successful if it is integrated with other strategies such as disaster preparation, land-use planning, environmental conservation, energy concerns, education, and national plans for sustainable development.** Additionally, there is a need to develop a clear process to identify the relevant traditional insights and techniques that have the potential to contribute to the mitigation of the consequences of climate change along with developing a process to evaluate the most meaningful methods and processes for TKT's integration into conventional systems. In many instances, adaptation to new conditions requires additional financial resources and the transfer of technological capacity that most indigenous communities do not possess. While short-term adaptation activities are underway, resource and capacity constraints limit the implementation of long-term, scaled-up strategies. Some mitigation measures may have undesirable direct and indirect consequences for IPLCs. For instance, certain agricultural initiatives may reduce GHG emissions, but may also lead to an increase in monoculture crops and plantations and the associated decline in biodiversity and food security. Either way, the full and effective participation of IPLCs and harnessing of traditional knowledge is crucial to national and international mitigation measures to ensure that such schemes do not negatively affect vulnerable communities.

120. **Support for the very communities from which TKT is derived and sustained is a necessary component of any strategy to protect and scale up TKT.** Support and sustainability for indigenous cultures include issues of health, housing, food, intellectual property and land rights, and the capacity for cross-generational transfer and transmission of knowledge. Outside interventions with the prior and informed consent of local communities must focus on empowerment by taking strength or asset-based approaches that maximize local TKT by focusing on what is there, not what is not there. In order to focus on the comparative advantage of IPLCs, top-down policy makers and practitioners need to listen and learn from the "bottom" as the critical TKT for the maintenance and enhancement of landscapes is local.

121. **Greater involvement and ownership in decision making by IPs is important for the greater success of programs involving use of TKT.** An interesting illustration is the Canadian Mackenzie Valley Resource Management Act (MVRMA)[18] that establishes co-management

[18] http://www.reviewboard.ca/upload/ref_library/1247177561_MVReviewBoard_Traditional_Knowledge_Guidelines.pdf

boards and new decision-making processes that give aboriginal peoples a greater role in the management of land and water and the protection of the environment in the Mackenzie Valley. The MVRMA applies throughout the Mackenzie Valley region, and it also fulfills commitments made by Canada in Mackenzie Valley settled land claim agreements. The more detailed case of the Potato Park in Peru is presented below.

Case Study: The Potato Park in Peru

122. **The Andean Mountain Range is one of the most biologically and culturally diverse regions in the world. The range contain two recognized hotspots of biodiversity, two of the eight important centers of the origin of major cultivated species, and 20 of the 36 UNESCO World Heritage Sites in South America.** More than 205 languages are spoken in the Andean countries. This diversity is deteriorating rapidly in the face of climate change. Policies in the region have failed to comprehensively address TKT and the important role that it can play in the challenges ahead. The Potato Park in Peru is one exception that has already begun to bare results and positive effects.

123. **Quechua communities in the Pisac, Cusco area of Peru have established the Potato Park as a community-based, agrobiodiversity-focused conservation area.** This initiative has brought together 7,000 villagers from six indigenous communities (Amaru, Chawaytire, Cuyo Grande, Pampallaqta, Paru-Paru, and Sacaca) to jointly manage communal land for collective benefit. The aim is to conserve their landscape, livelihoods, and way of life as well as to revitalize their customary laws and institutions. It is recognized as an Indigenous Biocultural Heritage Area (IBCHA) that celebrates the tremendous diversity of native potato species and varieties characteristic of Andean food systems. It is based on a model developed by ANDES, a Cusco-based IP NGO working to protect and develop Andean biological and cultural diversity and the rights of the IPs of Peru. The model consists of a community-led and rights-based approach to conservation grounded in indigenous traditions and philosophies of sustainability and the use of local knowledge systems, skills, and strategies related to the holistic and adaptive management of landscapes, ecosystems, and biological and cultural assets (www.andes.org.pe).

124. **The region is an important micro-center of the origin and diversity of the potato that has been cultivated by Andean farmers for over 7,000 years.** This tradition continues today with over 900 varieties of native potatoes currently being grown in the park area together with various other Andean food crops. Traditional farming techniques, including the use of traditional tools, complementary plantings, and ritual offerings to *Pacha Mama* (Mother Earth) are commonly practiced by the IPLCs of the park. *Mita*, community labor, is still widely practiced in the area as well. According to the traditional tenet of reciprocity, the Earth gives crops to the farmers and in return the farmers give elaborate *pagos* (offerings or payments) to the Earth. This approach to the management of TKT provides a nurturing environment for diversity and the health of plants, animals, and humans.

125. **Traditional Andean societies are based on principles of ecological, productive, and social sustainability, leading the Inca to be classified as an example of a sustainable society**. At its core, Incan society had a profound respect for *Pacha Mama* and reverence for the power and fragility of the *Apus*, the Mountain Gods. These principles have historically been integrated into landscape conservation strategies that combined the management of agricultural spaces with natural and culturally important areas (*huacas*) in a holistic system. At the time of the Spanish

conquest, the Incas cultivated almost as many species of plants as the farmers of all Asia or Europe. On mountainsides up to four kilometers high and in climates varying from tropical to polar, they grew a wealth of roots, grains, legumes, vegetables, fruits, and nuts. In Peru alone, an estimated one million hectares of steep slopes were converted into agricultural fields using terracing, irrigation canals, catchments, and reservoir structures. Today over half of these terrace-covered slopes have been abandoned.

126. **The Potato Park area is a center of diversity for a wide range of Andean food crops including quinoa (*Chenopodium quinoa*), kiwicha (*Amaranthus caudatus*), tarwi (*Lupinus mutabalisis*), oca (*Oxalis tuberosa*), mashua (*Tropaeolum tuberosum*) and, most importantly, the potato (*S. tuberosum*).** The wealth of the area is based on the 1,200 traditional varieties or landraces of potato that are named, known, and managed by the local people (The Park hopes to ultimately re-establish all the world's 4,000 known potato varieties). A typical farm plot may contain 250-300 varieties. The economy of the area around the Potato Park is largely dependent on the potato both in terms of local consumption and regional barter trade. This trade has important nutritional as well as economic value, allowing the highlanders to exchange the carbohydrates and meat that they produce in the form of potatoes, guinea pigs, llama, and alpaca for vegetable protein from the grains produced at middle altitudes as well as for vitamins and essential fatty acids from the fruits and vegetables grown in sub-tropical gardens at lower altitudes nearer the Amazon. Vertical trade of this kind has been an integral part of the economy of the region since pre-Incan times. (Marti and Pimbert 2005)

127. **However, TKT, though a cornerstone of long-term food security, may not be enough to respond to rapid climate transformation.** The complexity of these production systems and the value of the indigenous knowledge upon which they are based must be appreciated as powerful resources and as complementary to western scientific knowledge to develop solutions to address the impacts of climate change.

128. **Locally, the Potato Park is recognized as a conservation area and is quickly becoming a popular ecotourism destination.** Technicians from the Potato Park, along with ANDES staff, are currently working with organizations in three other areas to establish other IBHAs based on the Potato Park model and experience. In 2001, ANDES collaborated with the Rockefeller Foundation to test the viability of the Potato Park as a pilot program for the protection of local knowledge systems. The study emphasized the importance of traditional knowledge and called for its protection under law by the World Intellectual Property Organization where the results were presented in 2005.

129. **The Potato Park has demonstrated that successful biodiversity and ecosystem management depends largely on local, regional, and global cooperation, technology, the recognition of intellectual and property rights, the dynamics of landscapes, and the critical role of TKT**. This ensures the conservation and sustainable use of biodiversity at all levels and contributes to the equity, opportunity, security, and empowerment of local and indigenous communities as well as to the sustainability of the biological resources and landscapes.

130. **Despite its success, the Potato Park is still dependent on external sources of funding.** This limits the long-term viability and potential for replicating the model elsewhere, especially in remote areas inhabited by IPLCs where governance, funding, and market access are limited. Nevertheless, the Potato Park is an excellent example of biocultural revitalization and of

collaboration between western science and TKT resulting in a wide range of positive outcomes for IPLCs.

Chapter 5. Inferences and the Way Forward

131. **There is a strong rationale for complementing traditional knowledge with modern science to address climate change.** More importantly, the benefits of the adoption of traditional innovation may be broader and not just limited to IPLCs. The case studies presented suggest a wide scope for knowledge and technology transfers and partnerships that benefit IPLCs, the private sector, and the climate.

132. **The critical role of IPs in combating climate change is recognized in the Paris Agreement[19] and it is incumbent upon the WBG to act on this call.** IPs have time and again been proven to be the best custodians of ecosystems including forests. According to Victoria Tauli-Corpuz, UN Special Rapporteur on the Rights of Indigenous Peoples: "Studies over the last year have shown that Indigenous Peoples outperform every other owner, public or private entities on forest conservation."[20]

133. **The literature on how traditional knowledge systems can be utilized for addressing climate change is sparce.** Some programs have supported harnessing of traditional knowledge[21] to tackle climate change and have distilled certain lessons from those interventions. However, systematic efforts to mainstream TKT on a large scale or attempts to synthesize TKT with conventionally understood innovation systems has been very limited. This is where the authors believe that this paper adds to existing knowledge.

134. **While there is relatively substantial literature on the importance of leveraging traditional knowledge for development,[22] the importance of traditional knowledge in addressing climate change has only recently been appreciated and remains an under-studied topic.** Most studies and projects have focused exclusively on supporting IPs within their own habitats i.e. helping indigenous communities to become more financially well-off by leveraging their traditional knowledge. This means that the findings of these endeavors are unlikely to meaningfully inform other interventions as each project is *sui generis* i.e. aimed at a population or issue that is unique. Additionally, the lessons of one intervention cannot be applied to other contexts or be substantially scaled up to address broader challenges for general populations. Furthermore, only a handful of these studies and projects on traditional knowledge have been aimed at climate change.

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[19] Article 7.5 acknowledges: Adaptation action should follow a country-driven, gender-responsive, participatory and fully transparent approach, taking into consideration vulnerable groups, communities and ecosystems, and should be based on and guided by the best available science and, as appropriate, traditional knowledge, knowledge of Indigenous Peoples and local knowledge systems.

[20] http://unsr.vtaulicorpuz.org/site/index.php/en/statements/106-statement-cop21

[21] https://www.ifad.org/documents/10180/2a1e3eb4-51a3-4746-8558-2fc1e6d3e645

[22] http://sdg.iisd.org/news/unfccc-reports-on-indigenous-and-traditional-knowledge-for-adaptation/

135. **Unsurprisingly, there is greater documentation of indigenous and traditional knowledge and resources[23] in developed countries[24] than in developing countries.** Further, these developed countries have launched efforts to understand indigenous, traditional knowledge's potential role in addressing climate change. However, the greatest repositories of traditional knowledge and the number of people to be impacted by climate change live outside developed countries. More importantly, since most developed countries tend to be non-tropical, the lessons from their experience are of limited value i.e. mostly restricted to arctic regions,[25] though there are interesting examples of such endeavors in other climatic regions.[26] Despite these shortcomings, developed nations' documentation and knowledge of indigenous TKT can provide guidance to efforts to protect TKT elsewhere.

136. **Substantial literature on traditional knowledge revolves around preserving intangible cultural heritage.[27]** This literature does the much-needed job of sensitizing the development community to the need to preserve traditional knowledge. This paper builds on this work and advances the need for synthesizing conventional innovation systems with traditional knowledge to combat climate change.

137. **Connotations of traditional knowledge vary in literature.** Many studies use the term to identify what has been tacit knowledge in certain societies or civilizations over several millennia, but that does not fit into conventional systems of science and innovation. However, numerous studies restrict the term to refer to knowledge held by indigenous communities. These are not necessarily mutually exclusive, but this clarification is important. This study uses the term more holistically.

138. **The authors found that the focus of most studies and projects involving TKT has been on agriculture[28] and water management.** While this is unsurprising as agriculture and water management are fundamental issues, there is scope for leveraging other forms of TKT[29] as well.

139. **Other areas in which role of TKT has been relatively well studied are bio-discovery and medicine.[30]** As a result of these studies, the legal issues related to TKT and IPRs in bio-discovery

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[23] https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20110011237.pdf
https://www.cambridge.org/core/journals/polar-record/article/div-classtitlecontributions-of-traditional-knowledge-to-understanding-climate-change-in-the-canadian-arcticdiv/3071259EEF4A71F160BB0BD2B73CA7BD
https://www.fs.fed.us/pnw/pubs/pnw_gtr879.pdf
https://www.nps.gov/subjects/tek/climate-change.htm

[24]https://www.climate.gov/teaching/professional-development/traditional-knowledge-and-climate-change-impacts-indigenous-people, https://nccwsc.usgs.gov/sites/default/files/files/ACCCNRS_IndigenousPeoplesPrimer_%26_TK.pdf

[25] http://arcticadaptationexchange.com/share/aklavik-elders-traditional-knowledge-climate-change-and-community-health
https://www.cbd.int/doc/publications/tk-cc-arctic-en.pdf

[26] https://www.pacificclimatechange.net/news/vanuatu-traditional-knowledge-project

[27]http://unesdoc.unesco.org/images/0022/002253/225313E.pdf

[28]http://www.wageningenacademic.com/doi/pdf/10.3920/978-90-8686-820-9_12
http://www.sdhsprogram.org/publications/building-on-farmers-perception-and-traditional-knowledge-biodiversity-management-for-climate-change-adaptation-strategies/
http://www.youris.com/Environment/Desertification/Adapting_Farmers_Traditional_Knowledge_To_Climate_Change.kl

[29]http://unesdoc.unesco.org/images/0021/002166/216613e.pdf
http://eatlas.org.au/content/mtsrf-synth-traditional-knowledge-climate-change-adapt-torres-strait
https://cmsdata.iucn.org/downloads/indigenous_peoples_climate_change.pdf
http://unfccc.int/resource/docs/2013/tp/11.pdf

[30]https://www.amazon.com/dp/1517124174/ref=wl_it_dp_o_pC_nS_ttl?_encoding=UTF8&colid=17DTTKMQ6JH4V&coliid=I13NQILYJP90PI

and medicine [31] have been fairly well researched, and there are national and international treaties and frameworks[32] to address legal issues in this field. It is unclear why concern for legal issues that pertain to TKT and climate change has not evolved to a similar degree. Two plausible reasons are that climate change TKT may not be amenable to protection and monetization the way medicines are and that there have been no high-profile cases where a certain ecological know-how has been subject of litigation[33] or contention, which would prompt greater attention to the topic. It is to be noted that it was bio-piracy that motivated India to develop its Traditional Knowledge Database Library (TKDL).[34] It is quite possible that a deeper understanding of TKT and how it can co-develop solutions for climate change will uncover some widely renowned discoveries similar to the Samoan discovery of active ingredients for potential therapies for AIDS and cancer.[35] Such climate-related discoveries would stimulate a louder call for establishing norms to deal with intellectual property distinct from existing frameworks such as the Nagoya Protocol or the Convention on Biodiversity (CBD).

140. **This report aims to further the wide adoption of traditional knowledge for climate change by advancing the understanding of traditional knowledge systems as compared and contrasted to conventional innovation**. Certain WBG studies[36] have done pioneering work on the impact of climate change on IPs. However, the scope of those studies did not include the use of traditional knowledge to adapt to climate change. Our attempts to link traditional knowledge with innovation systems advances the thinking developed by previous WBG research. The topic of utilizing traditional knowledge in conjunction with conventional innovation systems is gaining widespread support and momentum as evidenced by interest taken by the World Economic Forum on the subject.[37] While there have been laudable efforts in understanding TKT[38] and countries have taken significant measures to protect and harness TKT in general, TKT research for climate change is its infancy and the task of fully leveraging TKT for climate change has only begun.

141. **Many countries such as India[39] and Brazil have included the use of traditional knowledge in their Nationally Determined Contributions (NDCs) and they provide an excellent opportunity for the WBG and other multilateral development banks (MDBs) to engage in TKT in client countries**. India's NDC states "*The National Mission for Sustaining the Himalayan Ecosystem (NMSHE) addresses important issues concerning Himalayan Glaciers*

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https://www.amazon.com/dp/9280525875/ref=wl_it_dp_o_pd_S_ttl?_encoding=UTF8&colid=17DTTKMQ6JH4V&coliid=I3BWVORXGIASHQ

[31] https://www.venable.com/files/Event/ae5f33d5-b173-4225-872f-cd85b0e14da3/Presentation/EventAttachment/aae1065d-ab18-4f99-820c-0130902dfd3b/420.pdf

[32] http://www.wipo.int/tk/en/igc/

[33] http://www.piipa.org/images/PDFs/Traditional_Knowledge_Biopiracy_Peruvian_Maca_Root.pdf
https://www.amazon.com/dp/1781005451/ref=wl_it_dp_o_pC_S_ttl?_encoding=UTF8&colid=17DTTKMQ6JH4V&coliid=I2B8BZJTZVGQO7

[34] http://www.tkdl.res.in/tkdl/langdefault/common/Abouttkdl.asp?GL=Eng

[35] http://www.piipa.org/images/IP_Book/Chapter_4_-_IP_and_Human_Development.pdf
http://newscenter.lbl.gov/2004/11/05/samoas-gift-to-the-world/

[36] https://elibrary.worldbank.org/doi/abs/10.1596/978-0-8213-8237-0

[37] https://www.weforum.org/agenda/2016/11/indigenous-peoples-are-the-real-climate-experts/

[38] http://unctad.org/en/pages/PublicationArchive.aspx?publicationid=1298
http://www.ictsd.org/downloads/2008/06/cs_dutfield.pdf
https://www.grain.org/article/entries/2088-unctad-meeting-on-traditional-knowledge
http://unctad.org/en/docs/ditcted200518_en.pdf

[39] http://www4.unfccc.int/Submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf

and the associated hydrological consequences, biodiversity and wildlife conservation and protection, traditional knowledge societies and their livelihood and planning for sustaining of the Himalayan Ecosystem. Government has also launched National Mission on Himalayan Studies to complement NMSHE with the objective of building a body of scientific and traditional knowledge along with demonstrating replicable solutions to the problems in thematic areas including natural resource management, capacity building, long-term ecological monitoring etc.[40]"

142. **The WBG review of Intended Nationally Determined Contributions (INDCs)[41] should include an assessment of the activities of countries involved in TKT and climate change. Greater coordination among MDBs on the topic would be helpful to share best practices**. The CIF, including the Forest Investment Program (FIP), the Dedicated Grant Mechanism (DGM), the Climate Technology Fund (CTF), and the Scaling up Renewable Energy in Low Income Countries Program (SREP) are uniquely positioned to place more value on TKT as an integral component of climate change solutions. If the CIF intends to fully deliver on its mandate to support developing countries in their efforts to mitigate and adapt to climate change, then the interests of IPLCs and their TKT must be more-fully incorporated into its programs.

143. **Measures to synthesize traditional knowledge with innovation systems need to be emphasized. The scaling-up and mainstreaming of traditional knowledge for climate and environmental purposes must be stressed.** The CIF could serve as a model for other development and climate change initiatives by exploring new financing modalities to support modern and traditional technologies and innovation that supports the 2015 UNFCCC Conference of Parties 21 (COP 21), the Paris Agreement, and the 2015 UN Sustainable Development Goals (SDGs) to end poverty, fight inequality and injustice, and tackle climate change by 2030.

144. **Development interventions have failed to induce IPs to participate in global climate initiatives because these interventions have lacked both the will and the instruments to allow people to use their own knowledge and technology**. Measures to mainstream traditional knowledge have not had the desired success. Key barriers include a lack of adequate understanding of the value of traditional knowledge, a lack of understanding of TKT interplay with conventional innovations, and weak political will. Demonstration effect can alter this as illustrated by the traditional water harvesting success in India[42] leading to full scale program by government of Maharashtra[43] utilizing traditional knowledge to a great extent.

TKT Experience within the World Bank (as an example of MDB role)

145. **The World Bank Group has worked with IPLCs across a number of sectors including the areas of forests, agriculture, water, and climate change. However, there is more room to achieve the desired impact on the ground by making the best use of TKT to improve wellbeing.** One seminal study that the WBG has conducted on a related topic was the report *Poor People's Knowledge.*[44] The report worked with a relatively limited definition of traditional

[40] http://dst.gov.in/sites/default/files/NMSHE_Mission_document.pdf
[41] http://spappssecext.worldbank.org/sites/indc/Pages/FAQ.aspx
[42] http://www.bbc.com/news/science-environment-32002306
[43] http://mrsac.maharashtra.gov.in/jalyukt/
[44] https://openknowledge.worldbank.org/bitstream/handle/10986/15049/284100PAPER0Poor0peoples0knowledge.pdf?sequence=1&isAllowed=y

knowledge and approached it strictly from prism of economic development. The approach was heavy on intellectual property protection. Studies by other agencies have approached traditional knowledge from many other angles, but mostly those involving sustainability and preserving cultural heritage.

146. **Works that have dealt with IPs[45] have focused on how they can be protected and served. There is a scope to improve the documentation of their traditional knowledge.** The Bank has participated in workshops and summits on traditional knowledge but could consider a more central role. Additional support from Bank and other MDBs in this direction could contribute to a vast storage of and access to tested and documented TKT. An illustrative list of WBG memos and workshops includes:

- Middleton, M. (2007) IK Notes: Using Traditional Knowledge in Economic Development. The Impact of Raised Field Irrigation on Agricultural Production in Puno, Peru.[46]
- Davis, S. H., Ebbe, K. (1995) Traditional Knowledge and Sustainable Development.[47]
- Prakash, S. (2003) IK Notes: Nurturing Traditional Knowledge Systems for Development.[48]
- Lambert, J. (2001) IK Notes: Ethiopia: Traditional Medicine and the Bridge to Better Health.[49]
- Bodeker, G., et al (2000) IK Notes: Traditional Medicine and AIDS.[50]
- Lambert, J., et al (2011) The Contribution of Traditional Herbal Medicine Practitioners to Kenyan Health Care Delivery, Results from Community Health-Seeking Behavior Vignettes and Traditional Herbal Medicine Practitioner Survey.[51]
- Rosoanaivo, P. (2006) IK Notes: Traditional Medicine Programmes in Madagascar.[52]
- Dr. Yahaya, S, et al (2004) IK Notes: Traditional Medicine in Uganda: Historical Perspective, Challenges and Advances.[53]
- Narayan, D. (1999) Can Anyone Hear Us? Voices of the Poor.[54]

147. **Traditional energy is one area where targeted action is required.** Traditional energy impacts the environment. An illustrative list of memos concerning traditional energy includes:

- Wilton, M. (1996) Regional Program for the Traditional Energy Sector, Traditional Energy – The West African Experience.[55]

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[45] http://documents.worldbank.org/curated/en/654311468010837927/Indigenous-peoples-and-climate-change-in-Latin-America-and-the-Caribbean

[46] https://openknowledge.worldbank.org/bitstream/handle/10986/10719/391330PE0iknt9901PUBLIC1.pdf?sequence=1&isAllowed=y

[47] http://documents.worldbank.org/curated/en/517861468766175944/pdf/multi-page.pdf

[48] https://openknowledge.worldbank.org/bitstream/handle/10986/10776/312560ENGLISH0iknt61.pdf?sequence=1&isAllowed=y

[49] https://openknowledge.worldbank.org/bitstream/handle/10986/10803/multi0page.pdf?sequence=1

[50] https://openknowledge.worldbank.org/bitstream/handle/10986/10812/multi0page.pdf?sequence=1&isAllowed=y

[51] https://openknowledge.worldbank.org/bitstream/handle/10986/13588/651330WP0Box360onTradHealthMedFINAL.pdf?sequence=1&isAllowed=y

[52] https://openknowledge.worldbank.org/bitstream/handle/10986/10739/359160rev0PAPER0iknt91.pdf?sequence=1&isAllowed=y

[53] https://openknowledge.worldbank.org/bitstream/handle/10986/10770/312570iknt67.pdf?sequence=1&isAllowed=y

[54] http://www.deepanarayan.com/voices_of_the_Poor_volume_01.html

[55] http://documents.worldbank.org/curated/en/247561468756905486/pdf/multi-page.pdf

- Hughart, D. (1979), Prospects for Traditional and Non-Conventional Energy Sources in Developing Countries.[56]
- Kronik, J., Dorte, V. (2010) Indigenous Peoples and Climate Change in Latin America and the Caribbean.[57]

148. **Following four WBG projects on traditional knowledge are worth mentioning.** The four projects are:

- P086473 - Expanding Incomes & Labor Opps Based on Traditional Knowledge & Intellectual Property Protections. TTL: Kreszentia M. Duer. This was a training project in 2003 and no further document was obtained on the WBG portal. The TTL is also no longer with WBG.
- P121007- Traditional Knowledge as Prescription for Environmental Land Management. The TTL was Ms. Kirsten Spainhower, who is no longer with the WBG. Again, this was a small WBI pilot with no further documentation.
- P120754 - Impacts of Climate Change on Indigenous Peoples and Traditional Knowledge was a project initiated in 2013. The TTL was Luis Felipe Atahualpa Duchicela Santa Cruz. While the portal has little information on final report and outcome, the available material suggests that it was a multi-agency program which collected numerous case studies and built a donor database that supports similar initiatives.
- PPG7 – A pilot program to conserve the Brazilian rainforest was a project launched in 1992.

149. **On the topic of supporting IPLCs on habitat loss and maintaining biodiversity, the WBG has been relatively more active, especially through mechanisms such as Global Environment Facility, the Climate Investment Funds Dedicated Grant Mechanism, etc**. Illustrative projects include:

- World Bank (2015) Innovative Grant Program Helps Communities Fight Forest Loss.[58]
- Batmanian, G. J. (2018) DGM Program and Global Learning and Knowledge Exchange Project.[59]

Report Dissemination and Next Steps

150. **Proposed phase 2 of this project will involve the dissemination of this report.** The team will work with UNFCCC, major IP organizations, and climate change bodies to disseminate the report. The team will create a dissemination strategy to increase appreciation of the need for integrating TKT with climate solutions.

151. **Within the WBG, there could be a role for the Environment and Social Framework.** It could establish guidance for developing policy for the mainstreaming of TKT in climate solutions and also develop projects and programs that incorporate TKT as part of climate strategy.

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[56] http://documents.worldbank.org/curated/en/424531468766752721/pdf/multi0page.pdf
[57] http://documents.worldbank.org/curated/en/654311468010837927/Indigenous-peoples-and-climate-change-in-Latin-America-and-the-Caribbean
[58] http://www.worldbank.org/en/news/feature/2015/03/31/innovative-grant-program-helps-communities-fight-forest-loss
[59] http://projects.worldbank.org/P128748/fip-grant-mechanism-indigenous-peoples-local-communities?lang=en

152. **Identification of specific areas for collaboration between IPLCs and the CIF multilateral development banks including the WBG.** There is significant scope to further evaluate case studies to identify potential projects that can piloted by the WBG and other MDBs. Taking forward the dissemination plan for this study, a deeper dive is recommended to identify the case studies, their impact on the IPLCs, and the impact that the traditional knowledge has on development. Specific pilot projects can be run in small numbers and then evaluated for scaling. Adoption of traditional knowledge with inputs from modern technology in areas that can speed up the results of traditional knowledge can bring a strong synergy with more significant outcomes.

153. **Further research topics could include investigation into how IPLC traditional food habits can impact the health and climate.** This is a major research area that can have immediate positive impact on the modern world. Traditional food is environmentally friendly and is aligned with the local conditions. There are clear examples of control of heart conditions and cancer in areas that maintain traditional food habits. Cassava and millets are major source of traditional food that preserve both the health and water tables of the specific regions. In desert areas, generations have survived because of the use of millets as a dietary staple. Major studies need to be undertaken in this area and specific food habits of traditional world across the countries must be undertaken.

Annex 1: Review of Salient UN reports

Traditional Knowledge and its Role in Addressing Climate Change
- Review of the Salient UN reports

1. This annex summarizes key findings from five leading reports on the topic of TKT and climate change solutions provided by the United Nations Education, Scientific, and Cultural Organization (UNESCO), the United Nations University, UNFCCC, and International Fund for Agricultural Development (IFAD). A larger literature review can be found in the bibliography of this report.

2. **Report 1:** UNESCO Technical Paper: Best Practices and Available Tools for the Use of Indigenous and Traditional Knowledge and Practices for Adaptation, and the Application of Gender-sensitive Approaches and Tools for Understanding and Assessing Impacts, Vulnerability, and Adaptation to Climate Change.[60]

3. The report clearly states that it is desk research that reviews and summarizes literature provided by Nairobi World Program (NWP) partner organizations. The report mentions that "there is little evidence of the integration of indigenous and traditional knowledge into the implementation and monitoring of adaptation." It is rare to find a convincing action report that deals with monitored changes brought by the use of TKT. This methodology has yet to evolve. It requires strong commitment and capacity to work on the ground coupled with management capabilities to measure effects using verifiable metrics. Methods like surveys and literature reviews from the Internet will not provide satisfactory results on the ground. Large amounts of money are being wasted on such activities and it is time for agencies and governments to change the *modus operandi* if actual impact is desired.

4. The report notes that action research will not only generate dependable data but will also bring an impact on the ground by helping build local capacity. Action research will also help strengthen local organizations that are failing because of a lack of finances and a lack of direction. Only large international bodies like the WBG and UNESCO are capable of bringing this change. Action research will also excite researchers and participants as the goals and processes will be designed and monitored by them. The results of research initiatives must be made available worldwide for others to adopt their methodologies.

5. The United Nations Declaration on Rights of Indigenous Peoples to their Traditional Knowledge is a strong message in support of TKT. The report suggests that the positive work that has been done in this direction must be evaluated and future programs must be designed based on the evaluation findings. Organizations like the Food and Agriculture Organization of the United Nations (FAO), IFAD, United National Development Programme (UNDP), the United Nations Environment Programme, the WBG, the Global Environment Facility (GEF), and the Asian Development Bank have dedicated policies and guidelines that seek to establish a mutually respectful dialogue with IPLCs. It would be worthwhile to investigate whether these guidelines can be standardized across organizations to allow uniform monitoring of various programs.

[60] http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/UNFCCC-TP-2013-11.pdf

6. The report highlights the important role of gender sensitivity in TKT as well as the role of land rights and tenure, which the report categorizes as ignored and undeveloped. The lifestyle and practices of local people stimulates TKT as soon as they get a sense of freedom on their own land. This is a public policy matter and governments must join hands with large international agencies like UNESCO and the WBG that can implement programs and bring measurable change. The issue of gender sensitivity tends to filter into a sociological aspect and researchers need to be cautious in allowing this during TKT studies.

7. Further, the report mentions that technology and ICT are necessary for the expansion of results of one success story. Map design through the use of drones has brought verifiable results in THE Amazon region. While restricting climate change is the major goal of many studies worldwide, TKT studies must also include studies on adaptation to climate change. This completes a cycle of not just cause and effect, but retranslates it as cause-effect-adaptation, which the report's authors recommend as an approach to analysis.

8. Finally, the report recommends strong data dissemination strategies to broadcast the results of these new studies. Governments in developing countries that will be impacted by climate change have to be encouraged to adopt these programs. Studies and programs run by most organizations fail in this aspect, resulting in zero gain from these exercises.

9. **Report 2**: UNESCO Technical Paper: Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation.[61]

10. Once again, this is a technical report that provides an overview of relevant published sources in the scientific and grey literature, but it lacks clear evidence of programs with specific targets. The paper talks about how climate change research tends to be limited to the study and impact of practices directly changing the climate. Indigenous knowledge has been widely recognized in fields such as agroforestry, traditional medicine, biodiversity conservation, customary resource management, applied anthropology, impact assessment, and natural disaster preparedness and response.

11. The report recommends that preserving indigenous knowledge must be undertaken sector-wide with specific goals and outcomes. In dealing with TKT and climate change, it is important to include related aspects such as sustainable livelihoods, modernization, and the development of guiding public policy. The report also discusses the impact on regional flora and fauna from regional climate change and the effect of migration on retention of TKT. Weather data must be made available to poor countries free of cost so that they are able to take necessary preventive steps for natural disasters. Weather data sharing must become the new norm internationally.

12. **Report 3**: United Nations University Compendium: Advanced Guard – Climate Change Impact, Adaptation, Mitigation, and Indigenous Peoples.[62]

13. This report is compendium of over 40 case studies related to climate change and TKT. The report talks about the preservation of local genetic diversity in fields and herds as of the utmost importance. This helps in adaptation to climate change and the survival of local populations. Vast agricultural fields that grow weak hybrid varieties are destroyed by minor weather changes.

[61] http://unesdoc.unesco.org/images/0021/002166/216613e.pdf
[62] http://i.unu.edu/media/tfm.unu.edu/publication/242/UNU_Advance_Guard_Compendium_2010_final_web.pdf

During a freak frost in Andean Highlands in Peru in 2007, only those varieties of potatoes that were grown in the traditional fashion survived. Several attempts are being made to preserve local seed varieties across the world, but this needs a special push by organizations such as the WBG. In Indian cities today, one cannot find an outlet that sells local, original seed varieties. The species of plants once found growing in open land are not to be seen anywhere now. The original variety of basmati rice in the Indian city of Dehradun is now a topic of remembrance. Stores are flooded with hybrid long grain rice that has been produced to feed the largest portion of the population, but this hybrid is prone to damage from the slightest changes in weather.

14. This report also discusses the identification of IPs and being able to communicate with them as a necessary area of research. The use of ICT is helping to overcome these limitations. This report has identified population growth as a major issue in dealing with climate change. Political will and discussions of population growth in the UN were common a few decades ago, but now population control is considered taboo. Instead of attempts to reduce the rate of growth, the world of science and invention is busy discovering newer, cheaper, and more dangerous methods of feeding the growing population.

15. **Report 4:** UNFCCC Report: A Compilation of Good Practices, Tools and Available Data Collection Initiatives for the Use of Local, Indigenous and Traditional Knowledge and Practices for Adaptation. [63]

16. This report is a significant database of best practices related to TKT. In terms of methodology, this compilation of good practices, tools, and available data collection initiatives includes inputs from NWP partner and expert organizations that can be replicated across the globe. This is once again a literature review and is not substantiated by the actual collection of primary data.

17. **Report 5**: IFAD Report: The Traditional Knowledge Advantage - Indigenous Peoples' Knowledge in Climate Change Adaptation and Mitigation Strategies.[64]

18. IFAD has access to a dedicated financial instrument – the Indigenous Peoples Assistance Facility (IPAF) – which aims to strengthen IP communities and their organizations by financing small projects that foster self-driven development. IPAF builds direct partnerships with IPs to enable their communities to design, approve, and implement grass-roots development projects. Since 2007, IPAF has financed 130 projects for a total of US$4 million. IFAD is one organization that seems to have original data on projects. For example, the NERCORMP project in India has seen a sharp increase in forestry and agroforestry practiced by beneficiary households, which rose from two percent from the beginning of the project in 1997 to 45 percent. This is hard data achieved after actual work on the ground. Projects with IFAD can be explored and replicated in other regions.

[63] http://unfccc.int/files/adaptation/application/pdf/compilation_litkp.pdf

[64] https://www.ifad.org/en/web/knowledge/publication/asset/39180511

Annex 2: Existing Literature on Traditional Knowledge

Synthesis of Existing Literature on the Topic of
Traditional Knowledge and its Role in Addressing Climate Change

1. IPLCs are vital to the many ecosystems and in many instances enhance the resilience of these co-evolutionary systems. (Balée 2013) IPLCs perceive and react to environmental change in creative ways, drawing on TKT to find solutions that may help the global community cope with impending change. For example, in Bangladesh, villagers are creating floating vegetable gardens to protect their livelihoods from flooding. In Vietnam, communities are planting dense mangroves along the coast to diffuse waves from tropical storms. (Henriksen 2007) Climate change poses significant risks for IPLCs, the landscapes they inhabit, and the knowledge and technologies that bind the two together.

2. Local and indigenous societies harbor a portfolio of knowledge that is closely linked to the practical needs and management of local socio-ecological systems. As a result, IPs not only have detailed knowledge of plants, animals, fungi, and certain microorganisms, but also of specific types of minerals, soil, water, snow, topography, landscapes, and climactic and seasonal cycles. (Berkes et al. 2000) The body of literature on indigenous knowledge offers new and valuable insights into many current challenges. According to cultural ecologist Fikret Berkes, indigenous knowledge refers to "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 2012) Anthropologist Virginia Nazarea, argues that indigenous knowledge is therefore a "priceless human heritage" that must be protected. (Nazarea 1999)

3. Scholarly discussions have characterized indigenous knowledge as an extremely promising resource for development. (Gray and Morant 2003) Indigenous knowledge and its role in development is a complex issue. What makes a group of peoples or a category of knowledge indigenous? What about other communities, such as Maroons (descendants of Africans in the Americas who had settled in areas outside of the slave trade) and other local bearers of knowledge? Instead of indigenous knowledge, some scholars have used the term traditional ecological knowledge (TEK) to define the knowledge base acquired by IPs over many hundreds of years through direct contact with local ecosystems. TEK includes intimate and detailed knowledge of plants, animals, natural and supernatural phenomena as well as the development and use of appropriate technologies for hunting, fishing, trapping, agriculture, forestry, healing, and more. Recent interest in bridging the philosophical tradition of phenomenology with ecological issues has brought renewed interest to the field of TEK, particularly within the contexts of overpopulation, environmental degradation and climate change. (Abram 2007, 2010, Griffiths 2006, Hinzman et al. 2005, Green and Raygorodetsky 2010).

4. However, the word traditional can have misleading and even pejorative connotations with unintended consequences. The ongoing stigma associated with calling communities traditional can lead to dangerous framing that considers their knowledge antiquated or primitive. The reality could not be further from this characterization. Rather than primitive, much of the recent literature promoting TEK makes reference to its scientific rigor, noting the novel implications this knowledge offers for climate change adaptation.

5. The word ecological brings its own problems. IPs do not use this term to describe their knowledge. (Berkes 2012) For them, there is no separation between ecological knowledge and cultural knowledge. In most cases, the knowledge of IPLCs is inseparable from practice, so the separation of nature from culture does not make sense. Indigenous knowledge has more to do with relationships to the environment, rather than knowledge of the environment. For example, to differentiate ecology as an area of study separate from farming practices is erroneous for many IPs. For many indigenous communities, a farmer and an ecologist are the same person. While TEK does have the advantage of precision with reference to knowledge that is ecological, the term is unsatisfactory. (Nakashima 2002)

6. These challenges in definitions and terms have not gone unnoticed. A plethora of other terms have been used in both academic and non-academic literature. Other names include, but are not limited to, traditional knowledge, indigenous local knowledge, indigenous knowledge of the environment, farmers' knowledge, folk knowledge, indigenous science, and native science. (Berkes 2012, Nakashima et al. 2012, Whyte 2015) To productively engage IPLCs and their technologies in development, practitioners must go beyond the dichotomies of indigenous vs. scientific, modern vs. traditional, etc.

7. Recognizing the challenges associated with terminology, this report uses a conceptualization of TKT that is broader and inclusive of the diverse IPLCs who hold valuable, place-based knowledge and technologies to engage and manage surrounding landscapes. Much of this knowledge is held in local languages and rich oral traditions that incorporate TKT into stories, songs, objects, places, landscapes, and diverse ways of being. Though these knowledge systems have historically been undervalued by industrialized societies, recent research, including this report, demonstrates their integral role in landscape morphology.

8. The work of anthropologist Richard Reed with the Guarani in the border region between Paraguay and Brazil is a good benchmark for how to scale up TKT. (Reed 1996, 2000, 2005, 2006, 2008, 2009) Another inspiration for this report is the extensive body of work by ethnobiologist Darrell Posey. (Posey 1982, 1988a, 1988b, 1992, 1998, 2002, 2003a, 2003b) His research on the Kayapó of Brazil focuses on tropical forest communities, especially as they relate to indigenous IPRs. Nearly 20 years before the UN General Assembly adopted the United Nations Declaration on the Rights of Indigenous Peoples in 2007, Posey organized the International Congress of Ethnobiology that culminated in the 1998 Declaration of Belém, which outlined the responsibilities of scientists and environmentalists in addressing the needs of local communities and acknowledged the central role of IPs in all aspects of global planning. Although the language of The Declaration of Belém may seem somewhat antiquated today, it was the first time that an international scientific organization recognized a basic obligation that "procedures be developed to compensate native peoples for the utilization of their knowledge and their biological resources." The subsequent 2007 UN Declaration on the Rights of Indigenous Peoples was a statement passed by a congress of scientists and is a global human rights instrument.

9. Though there have been some interesting attempts to understand the role of traditional knowledge in tackling climate change, the literature and evidence of successful harnessing of TKT for meeting climate challenge is thin. The authors have attempted to understand the differences between traditional knowledge and conventional innovation systems, and how a richer understanding of the mechanisms by which the two systems function can inform policies aimed at fully leveraging traditional knowledge.

Annex 3: Methodology

1. Research for this report was conducted through an interdisciplinary desk review of the latest literature on indigenous knowledge, traditional ecological knowledge, technology, and climate change in order to clearly define and distinguish TKT. This material was complemented by interviews with a wide network of IPs, scholars, government officials, development practitioners, and entrepreneurs conducted over the phone, in person, and in conjunction with various conferences including the 15th session of the Permanent Forum on Indigenous Issues at the UN Headquarters in New York in May 2016[65] as well as the 17th and 18th forums in 2018 and 2019. Data is presented and analyzed in various case studies that are representative of various geographies, climates, peoples, knowledge bases, or technologies from regions of the world. Consultations were also held at numerous other fora in Bonn, Addis Ababa, and on the sidelines of spring meetings of the WBG in Washington, DC in April 2019.

2. **The Climate Investment Funds Indigenous Peoples' observers have nominated the following to provide technical peer review of this report:**

    a. Grace Balawang, Tebtebba Foundation, Philippines
    b. Fiu Matesera Elisara, Ole Siosiomaga Society Inc, Samoa
    c. Saro Legborsi Pyagbara, The Movement for the Survival of the Ogoni People, Nigeria
    d. Mrinal Kanti Tripura, Maleya Foundation, Bangladesh
    e. Saoudata Aboubacrine, Tinhihane, Burkina Faso

3. **In the margins of the World Bank International Forum for Indigenous People, the following global IP leaders were consulted on the preliminary findings:**

    a. Keikabile Mogodu (Bostwana Khewdom Council, Bostwana)
    b. Alexander Arbachakov (Agency for Research and Protection of Taiga, Russia)
    c. Balkissou Buba (REPALEAC, Republic of Congo)
    d. Joseph Ole Simel (MPIDO)
    e. Shamkay Limbu (LAHURNIP, Nepal)
    f. Grace Balawag (Tebtebba Foundation, Philippines)
    g. Alexey Tsykazev (UN EMRIP, Russia)
    h. Gulvayra Kutsenko (LIENIP, Russia)
    i. Parfait Dihoukamba (REPALEAC, Kenya)

[65] Time and budgetary constraints prevented field visits for specific case studies that would have enhanced the empirical basis of this report.

Annex 4: Paris Agreement and Decision

1. **The implementation of paragraph 136 must:**
   A. Be in accordance with the directive contained in the preambles to both the Paris Agreement and the Paris Decision: "Parties should, when taking action to address climate change, respect, promote, and consider their respective obligations on human rights…*the rights of Indigenous Peoples…."*
   B. Recognize that the preamble of the Paris Agreement also calls "for regional and international cooperation to mobilize stronger and more ambitious climate action by all Parties and non-Parties... including… Indigenous Peoples."
   C. Be in accordance with, and not fall below, international instruments that recognize the rights of Indigenous Peoples, inter alia, the United Nations Declaration on the Rights of Indigenous Peoples (UN Declaration), ILO Convention No. 169, The Outcome Document on the World Conference on Indigenous Peoples (WCIP) and the American Declaration on the Rights of Indigenous Peoples (American Declaration).
   D. Recognize and enable the promotion of Indigenous Peoples' traditional knowledge as adopted in Article 7, section 5 of the Paris Agreement: *adaptation action should …be based on and guided by the best available science and, as appropriate, traditional knowledge, knowledge of Indigenous Peoples and local knowledge systems….*
   E. Provide for full and effective participation of Indigenous Peoples in all aspects of the Platform's development and implementation, ensure respect for free, prior, and informed consent (FPIC) regarding the presentation and use of their knowledge; uphold the right to self-determination, the rights to participate in decision-making in matters affecting their rights, and the right to maintain, control, protect and develop their cultural heritage (UN Declaration Arts. 3, 18, 19, 31).
   F. Be consistent with the Outcome Document of the World Conference on Indigenous Peoples, WCIP OD, 2014, para, 36: "We confirm that Indigenous Peoples' knowledge and strategies to sustain their environment should be respected and taken into account when we develop national and international approaches on climate change mitigation and adaptation."

2. **To implement these provisions, a group of IPs called for three specific actions at the Marrakech COP 22 in November 2016 including** 1) a technical workshop on these forms of knowledge, 2) recognition of an IP expert group to provide advice on matters related to traditional knowledge and IP rights, and 3) the establishment of a platform for IPs to exchange and share best practices on mitigation and adaptation to address and respond to climate change as called for by the Paris Decision.

Annex 5: Conventional Science and Traditional Knowledge

Overview of Conventional Science and Traditional Knowledge- Compare and Contrast

1. **Countries all start with traditional practices. In some countries, with the advent of scientific methods, these were converted into modern technologies.** In countries that are now regarded as developed, embracing the scientific method to produce knowledge has resulted in a rapid increase in the pool of data and information available to drive innovation. Commercialization and competition for profits have provided the catalyst to respond to the demands of an ever-increasing population and the resulting pressures exerted on natural ecosystems. This mindset is vastly different from the trial and error approach that afforded the rise of traditional technologies. We have to go beyond describing the traditional practices *in situ* and move to assessing the effectiveness of traditional technologies that have the potential to elicit positive change when scaled up and applied to specific climate change phenomena. Industrialized countries have built their economies on innovation as conventionally understood. However, societies that have not embraced science have remained largely traditional.

2. **Traditional knowledge is uncodified. A clear process to identify, verify, and assess its capacity to make positive contributions to climate change adaptation and mitigation strategies has to be built as a first step.** This needs to be done by the researchers and program implementers from the conventional systems in close collaboration with the IPLC holders of traditional knowledge. Many indigenous communities are under threat and are losing self-respect and pride. As a consequence, their traditional knowledge is being eroded before it can be investigated for consideration as a contributor to climate solutions and economic development. Building trust is key to the success of this process.

3. **Changes in traditional knowledge are generally recognized, but the related drivers of these changes are not clearly identifiable or known with any degree of accuracy. Therefore, they are not recognized as motivators of innovations. Rather, they are regarded as simply part of a raft of responses to changes in natural phenomena that impact customary ways of doing things**. Scientific analysis can identify these drivers, provide clarity with respect to cause and effect, and enable more focused and precise modifications to be incorporated into their mitigation efforts. The scientific community, in turn, benefits from an expanded knowledge base capable of contributing new insights to spur the development of inventions and innovations.

4. **In many communities, traditional methods that are usually cherished and communicated by oral traditions, local languages, and beliefs are gradually being lost.** In response to this, many local communities have been proactive in protecting and safeguarding their cultural heritages. Collaboration with a number of international and regional bodies supports IPLCs in their quest for preservation. However, the protection of indigenous knowledge has yet to be taken seriously enough to engender a merger with modern methods. There has to be rational adoption and collaboration rather than impacting the wealth of traditional knowledge merely because of the use of technology. For example, the carrying of traditional knowledge via folklores should not be impacted just because now we have technology. Traditions add value and weight to the cause of traditional knowledge.

5. **If we can find ways to bridge the gap between the philosophies and insights of both systems, then countries will be better able to build relevant innovation systems enabling them to become more confident, resilient, and proactive in tackling climate change.** There are a number

of verified examples of the co-production of knowledge arising from the collaboration of IPs and scientists that have enabled them to cope with some of the challenges of climate change to their environment and livelihoods. Guyana, for example, has a system whereby the Amerindian people work to protect and preserve the naturally occurring fruit trees in the forest for their own food security while contributing to conservation of the natural biodiversity. In Jamaica, there are efforts to understand the varied use of cannabis for treatment of ailments and its potential for commercialisation. This has matured to the point that a research center is being set up to facilitate the coordination and collaboration between the two forms of knowledge.

Annex 6: Climate Change Risks to IPLCs

1. **Flooding associated with rising sea levels will have a substantial impact in lowland areas, particularly in China and much of South Asia**. However, the Netherlands, the UK, and large portions of the United States, Brazil, SIDS, and populations living in deltas will also be affected. In the Amazon and Ganges-Brahmaputra deltas in Brazil and Bangladesh, increased temperatures, changes in precipitation and runoff, and rising sea levels will have significant impacts on mangroves, fisheries, and the human populations that depend on these habitats. Coastal inundation stemming from rising sea levels will also affect water availability (i.e., saltwater intrusion could affect estuaries and freshwater sources) and agricultural land suitability, exacerbating the socioeconomic and health problems in sensitive areas.

2. **Rainforest biomes[66] and their constituent reservoirs of knowledge and resources in Central and South America, Central Africa, and Southeast Asia face significant climate change risk.** Warmer temperatures and decreased precipitation during already dry months are manifesting longer and more severe droughts and substantial changes in seasonality. These fluctuations, coupled with land use changes, could lead to devastating impacts including increased erosion, the degradation of freshwater systems, the loss of ecologically and agriculturally valuable soils, the loss of biodiversity, decreased agricultural yields, increased insect infestation, and the spread of infectious diseases. The climate and deforestation-driven substitution of forests to savanna-like and semi-arid vegetation has been dubbed the Amazon Rainforest's "die back." According to one estimate, current trends in livestock, agriculture, logging expansion, fire, and drought could destroy or severely damage 55 percent of the Amazon rainforest by the year 2030. (Nepstad et al. 2008) As rainforest is replaced by savanna, there will be significant impacts on the livelihoods of IPLCs who depend on these precious forests and the knowledge and resources that sustain their fragile ecosystems.

3. **Similarly, the Arctic, home to numerous IPs, has been particularly hard hit by a changing climate and the socio-economic, environmental, and cultural impacts this has had on human communities and the physical landscape are severe.** Past generations have skillfully adjusted harvesting activities and lifestyles to environmental changes, but now rapid climate change presents new challenges. Polar bears, walrus, seals, caribou, reindeer, and fish provide food to support local economies. These are also the basis for the IPLC knowledge and identities that are intimately tied to the land and its diverse ecosystem. For the Inuit of Nunavut, the ringed seal is the single most important food source throughout the year. The reduction and destabilization of sea ice has affected the seal population and, in turn, the polar bear population. The increasing disappearance of summer sea ice will have a significant impact on the Inuit as hunting, catching, and sharing seals and polar bears is as important for their diet as for their culture. In Finland, Norway, Sweden, and Russia, rain and mild weather during the winter season often prevent reindeer from accessing lichen, a vital food source. This has caused a notable loss of reindeer that threatens the cultures, subsistence, and economies of the Saami and many other communities that depend on reindeer herds.

4. **Some farmlands may benefit from warming, but others will not**. Researchers at the International Food Policy Research Institute (IFPRI) project that by 2050 suitable croplands for four top commodities—corn, potatoes, rice, wheat— will shift, in some cases pushing farmers to plant new crops. Climate change will open new areas to corn but may reduce production in

[66] A biome is a large naturally occurring community of flora and fauna occupying a major habitat.

current areas. Potatoes tend to grow best in cold temperatures suggesting that warmer temperatures will impact yields. Unlike crops facing steep reductions, rice—which can grow in warm or cold weather—may do well. Most climate scenarios show reduced wheat yields. (Asseng et al. 2013) New parts of Australia will become arable, but droughts will require more efficient farming if wheat cultivation is to continue. Warmer weather is also likely to spur more devastating pests and crop diseases. Indonesia's rice production will be largely spared by climate change, but corn may decline by as much as 20 percent. Changes in Asia, with its large populations and land area, will create major losses of arable land that will affect millions in India and China.

Annex 7: Innovation in TKT and Comparing Ecosystems

Analysis of the Role of Innovation in TKT and Comparing Ecosystems for Conventional Science and TKT

A7.1 Potential for innovation

1. **In developing economies, especially those that are heavily dependent on traditional means, there are no clearly defined innovation systems.** The integration of new information from various sources and sectors to catalyze innovation for economic development and problem solving are at best piecemeal and without strategic focus. The findings of research and development do not easily influence decision-making, production, and/or productivity. Implementation bodies are not sufficiently active in the drive to create new structures, to push for the development of new technologies to solve critical issues, or to design new financial mechanisms that enable innovations to be commercialized. As a consequence, active trawling for innovations and inventions does not take place as part of normal social and economic activities. Additionally, methods to monitor progress and the use of scientific discoveries do not form part of IPLC knowledge systems, or, if they are present, do not sufficiently inform policy development. There are indicators for comparisons between the developed countries that are being used to measure progress in the developing world. However, these indicators do not fully capture the realities of the variation in systems built mainly on traditional principles and those using conventional criteria. These realities significantly influence the likelihood of new insights and inventions becoming innovations that have the potential to ameliorate the impacts of climate change.

2. **In tackling climate change, the private sector, governments, academia, and civil society must collaborate to find solutions to bridge the knowledge divide, to identify innovations, and to have these innovations developed.** Currently, many of the decisions concerning climate change are expected to be driven by governments as in some parts of the world the private sector remains largely risk averse to investing in exploring innovations and remains aloof to the consequences of climate change on their bottom line revenues. The holders of traditional knowledge are members of both the small business sector and civil society and are for the most part omitted from the decision-making processes in their societies. In addition, they are unable to access the services that are freely available in the modern communities as in many instances they are far removed from the research, development, and financial services necessary for the adoption and dissemination of innovations.

A7.2 Monitoring progress

3. **In the modern world, many systems exist to monitor the progress and use of scientific discoveries. Further, the results of these innovations are available to enable comparison and the building of confidence in technological and business investments.** In the traditional world, these indicators have little relative value as there are few scientific and technological establishments, except possibly for testing. There is little research and development and are even fewer mechanisms to incorporate findings into existing or new processes and products. The results of the use of modern technology and the possibility of emerging innovations will require new indicators as distinct from those currently used to compare STI situations across countries. Implementing mechanisms with scale-up and marketing features often do not exist and therefore the climate for entrepreneurship is underdeveloped. Business operatives in these circumstances are

averse to change and shun novelty and the risk associated with adopting innovations. Risk aversion often leads to an inability to compete and results in the loss of markets and revenues. How progress is measured in these circumstances also needs new indicators that will capture the unique qualities of traditionally derived innovations.

A7.3 Juxtaposing traditional and modern societies regarding technological development

4. **Technologies from traditional societies are often seen as oddities by those in modern societies and are therefore not worthy of exploitation. This causes tensions between the exponents of both sets of technologies.** In countries where both traditional and conventional technologies reside, the traditional technologies are often seen as peculiarities in the urban areas. In rural communities, they still have a place. Conventional technologies needed for industrial and business operations in developing countries are often imported with little determination of the relevance and possible adverse effects on the natural environment and the livelihoods of Indigenous Peoples and their cultures. Although there are fledgling research and development systems in the developing world, they do not feature in the understanding and use of traditional methods and therefore may not contribute to the growth and development of these systems and economies.

5. **The more modern a society becomes, the less emphasis is given to traditional knowledge, except perhaps in folklore and tourism.** In some instances, the people in traditional communities and indigenous populations are themselves under threat and are left out of participating in the development of their societies. Their contributions are minimized and often ignored. As a result, indigenous pride and hope are gradually eroded. Oftentimes, tensions arise between traditional communities and their modern neighbours resulting in less collaboration.

A7.4 Transformation of traditional societies to tackle climate change

6. **To tackle climate change, traditional societies in both the developing and developed world have to be transformed to accommodate better organized and more efficient systems of knowledge generation while preserving their views of nature and their relationships with natural phenomena**. There are many examples to be found in North America such as the recent use of solar energy to reduce running costs of a coal museum in the USA. Traditional societies will have to incorporate scientific methodologies to sufficiently understand TKT and to enable them to determine its usefulness in the fight against the effects of climate change. If they are to gain the benefits of traditional knowledge, modern societies have to develop effective partnerships that involve the education and training of those steeped in the traditional methods. Special mechanisms for experimentation and implementation have to be devised. These initiatives must be built on the basis of mutual respect and trust.

A7.5 Differences between the ecosystems

7. **The ecosystems in which traditional and modern societies have arisen are decidedly different and will influence approaches to policy, planning, and implementation to mitigate and adapt to climate change.** In the traditional world, methodologies and technologies arise and evolve as a means of survival. This is becoming even more challenging in traditional societies than in conventional ones. Today, conventional operatives tend to be exploitative rather than collaborative with their traditional counterparts. In Jamaica, for example, the breadbasket parish of St. Elizabeth is a center built on traditional dry land farming methods. Mulch, a combination of grasses, has been

developed over many years to retain and reduce the use of water and also as a soil conditioner in rain-fed agriculture. Farmers in this region depend on rain-fed agriculture and are accustomed to planting the same range of traditional crops (onions, watermelons, vegetables, etc.). When the rains arrive, all the crops mature simultaneously, and the consequence is a glut of produce coming to market. Instead of collaboration between both sides to allow the orderly transfer of technology to solve the problem of overproduction and needless waste, the weak position of traditional producers is seen as an opportunity to exploit.

8. **While conventional science and technology systems are aimed at the division of labor in research, experimental design, scale-up, and technological investments as well as at adherence to standards and proper marketing, traditional systems are diffuse with no clear systems of execution and business networking.** An example of this is the creation of creole maize varieties in Mexico. Over time, each community has crossbred varieties to suit its climate and needs without any special emphasis on commercialization. Even though they are willing to share their knowledge in to facilitate the coordination between conventional and traditional technologies and to provide food in changing circumstances, they are heavily reliant on the goodwill and investments coming from the developed world. In modern dispensations, there are technological managers, management systems, laws and regulations, intellectual property management guidelines, and notions of safety and efficacy of technologies. There are no equivalent entities within the traditional realm. In conventional systems, there are incentives to use innovations through enterprise. In traditional situations, the incentives are centered on survival rather than wealth creation. At best, the traditional technologies are regarded as novelties that may offer cheap possibilities in conventional markets. How these affect food security, water, biodiversity, energy, and waste remain relatively unknown.

9. **Information systems in modern societies are usually well developed, especially where Internet connectivity is pervasive.** This is in contrast to the information and communication systems in traditional communities where oral communication is the main source of transmission. This is slowly changing as more people are being empowered by access. The Kenyan model of internet banking is a good example. New technologies and new insights can be easily spread in modern societies enabling quick uptake of new developments. If the connections are made between both systems, then the possibilities for innovation due to a cross pollination of ideas will give rise to the possibility of novel approaches and products. The International Maize and Wheat Improvement Centre is one such organization that is using sophisticated genetic technologies to identify genetic markers for strains that can be deployed for special circumstances and needs. This has implications for policy promulgation and implementation. Some traditional systems are also well structured having been passed on from generation to generation, but they are not documented and disseminated the same way modern science and technical knowledge.

Bibliography

Aalbersberg, W. (1988). Food preservation in the Pacific using acid fermentation. The Journal of Pacific Studies 14, 59–67.

Abram, David (2007). The Spell of the Sensuous: Perception and Language in a More-than-Human World. New York: Vintage.

Abram, David (2010). Becoming Animal: An Earthly Cosmology. New York: Random House.

Adams, M. (2013). Indigenous knowledge and climate change in Australia: Can the traditional knowledge of Australia's indigenous communities keep pace with climate change. University of Wollongong.

Advisory Committee on Climate Change and Natural Resource Science. (2015). Report to the Secretary of the Interior.

Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. Development and change, 26(3), 413-439.

Ajibade, L. T., & Shokemi, O. O. (2003). Indigenous approach to weather forecasting in ASA LGA, Kwara State, Nigeria. Indilinga: African Journal of Indigenous Knowledge Systems, 2(1).

Alexander, C., N. Bynum, E. Johnson, U. King, T. Mustonen, P. Neofotis, N. Oettlé, C. Rosenzweig, C. Sakakibara, V. Shadrin, M. Vicarelli, J. Waterhouse, and B. Weeks. (2011). Linking Indigenous Knowledge and Observed Climate Change Studies.

Ali, A. (1999). Climate change impacts and adaptation assessment in Bangladesh. Climate research, 12(2-3), 109-116.

Amend, T., Brown, J., & Kothari, A. (2008). Protected landscapes and agrobiodiversity values (Vol. 1). Kasparek Verlag.

Anderson, J. (2010). Indigenous/Traditional Knowledge and Intellectual Property. Center for the Public Domain Issues Paper, Duke University.

Asseng, S., Ewert, F., Rosenzweig, C., Jones, J. W., Hatfield, J. L., Ruane, A. C., ... & Brisson, N. (2013). Uncertainty in simulating wheat yields under climate change. Nature Climate Change, 3(9), 827-832.

Audefroy, J.F., Cabrera Sánchez, N. (2017). Climate Change: Incorporating traditional practices to cope with climate change in the area of Río Lagartos – Yucatán Peninsula. https://www.sciencedirect.com/science/article/pii/S2212609016301042

Australian Governemnt (2016). Indigital - Helping communities tell stories in new ways. Department of the Prime Minister and Cabinet. March. Indigneous.gov.au

Balée, W. (2006). The research program of historical ecology. The Annual Review of Anthropology, 35, 75-98.

Balée, W. (2013). Cultural forests of the Amazon: a historical ecology of people and their landscapes. University of Alabama Press.

Balée, W. and C. Erickson (2006). Time and Complexity in Historical Ecology: Studies in the Neotropical Lowlands. New York, NY: Columbia University Press.

Barnes, Jessica, and Michael R. Dove (2015). Climate Cultures: Anthropological Perspectives on Climate Change. Yale University Press.

Basher, R. (2006). Global early warning systems for natural hazards: systematic and people-centred. Phil. Trans. R. Soc. A 364, 2167–2182.

Beniston, M. (2003). Climatic change in mountain regions: a review of possible impacts. In Climate variability and change in high elevation regions: Past, present & future (pp. 5-31). Springer Netherlands.

Benson, C., & Clay, E. J. (1998). The impact of drought on sub-Saharan African economies: a preliminary examination (Vol. 401). World Bank Publications.

Berkes, F. (1993). Traditional Ecological Knowledge in Perspective, in J.T. Inglis, ed. Traditional Ecological Knowledge: Concepts and Cases. Ottowa, Ontario: International Development Research Centre, pp. 1-9.

Berkes, F. (1999). Sacred ecology: traditional ecological knowledge and resource management Taylor and Francis. London Science and the St Elias, 203.

Berkes, F. (2012). Sacred ecology. 3rd Edition. New York, NY: Routledge.

Berkes, F., Folke, C., & Colding, J. (2000). Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge University Press.

Berlin, B., Breedlove, D., & Raven, P. (1968). Covert Categories and Folk Taxonomies. American Anthropologist, 70(2), 290-299.

Bishop, P., Sanderson, D., Hansom, J., Chaimanee, N. (2005). Age-dating of tsunami deposits: lessons from the 26 December 2004 tsunami in Thailand. The Geographical Journal 171 (4), 379–384.

Black, R., Bennett, S. R., Thomas, S. M., & Beddington, J. R. (2011). Climate change: Migration as adaptation. Nature, 478(7370), 447-449.

Blaser, M., De Costa, R., McGregor, D., and Coleman, W. D. (eds.) (2010). Indigenous Peoples and autonomy: Insights for a global age. UBC Press.

Brooks, N. (1999). Dust–climate interactions in the Sahel-Sahara zone with particular reference to late 20th century Sahel drought. Ph.D. Dissertation, University of East Anglia, available online at http://www.cru.uea.ac.uk/*e118/thesis/thesis.html

Brush, S. B. (1996). Whose knowledge, whose genes, whose rights? Valuing local knowledge: Indigenous people and intellectual property rights, 1-21.

Bubela, T., & Gold, E. (2012). Genetic Resources and Traditional Knowledge: Case Studies and Conflicting Interests. Edward Elgar Publishing Limited.

Burr, J. (2013) Burning Across Boundaries: Comparing Effective Strategies for Collaboration between Fire Management Agencies and Indigenous Communities in the United States and Australia. Retrieved from ARCADE: http://arcade.stanford.edu/occasion/burning-across-boundaries-comparing-effective-strategies-collaboration-between-fire

C. Kamau, E., & Winter, G. (2009). Genetic Resources, Traditional Knowledge and the Law: Solutions for Access and Benefit Sharing. Earthscan.
Cajete, G. (1994). Look to the mountain: An ecology of indigenous education. Kivaki Press, 585 E. 31st St., Durango, CO 81301.

Campbell, J.R. (1984). Dealing with Disaster: Hurricane Response in Fiji. Pacific Islands Development Program, Honolulu.

Campbell, J.R. (1990). Disasters and development in historical context: tropical cyclone response in the Banks Islands, Northern Vanuatu. International Journal of Mass Emergencies and Disasters 8 (3), 401–424.

Campbell, J.R. (2009). Islandness: vulnerability and resilience in Oceania. Shima: the International Journal of Research into Island Cultures 3(1):85-97.

Cervantes, S. R. (2000). Report on the UNCTAD Expert Consultation on National Experiences and Systems for the Protection of Traditional Knowledge, Innovations and Practices

Chen, C-C., McCarl, B. & Adams, R. (2001). Economic implications of potential ENSO frequency and strength shifts. Climatic Change **49,** 147–159.

Cleveland, D.A. and S.C. Murray (1997). The World's Crop Genetic Resources and the Rights of Indigenous Farmers, Current Anthropology vol. 38, no. 4: 477-514.

Conklin, Harold C. (1955). Hanunóo Color Categories. Southwestern Journal of Anthropology, Vol. 11, No. 4. pg. 339-344.

Cosentino, G. (2016). Indigenous Peoples are the real climate experts. So why aren't we listening to them? Retrieved from https://www.weforum.org/agenda/2016/11/indigenous-peoples-are-the-real-climate-experts/

Cox, M.P., R. A. Betts, M. Collins, P. P. Harris, C. Huntingford, and C. D. Jones (2004). Amazonian forest dieback under climate-carbon cycle projections for the 21st century. Theoretical and Applied Climatology 78: 137–156.

Cox, P.M., R.A. Betts, C.D. Jones, S.A. Spall, and I.J. Totterdell (2000). Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. Nature 408: 184 – 187.

Crate, S.A., and M. Nuttal, eds. (2009). Anthropology and Climate Change: From Encounters to Actions. Walnut Creek, CA: Left Coast Press.

Crate, S.A., and M. Nuttal, eds. (2016). Anthropology and Climate Change: From Actions to Transformations. 2nd edition. Walnut Creek, California: Routledge.

Cronin, S.J., Gaylord, D.R., Charley, D., Alloway, B.V., Wallez, S., Esau, J.W. (2004). Participatory methods of incorporating scientific with traditional knowledge for volcanic hazard management on Ambae Island, Vanuatu. Bulletin of Volcanology 66, 652–668.

Crutzen, Paul J. (2002). Geology of mankind. Nature 415, 23 (3 January).

Cunningham, A.B. (1996). People, park and plant use: Recommendations for multiple-use zones and development alternatives around Bwindi Impenetrable National Park, Uganda. UNESCO, Paris, People and Plants working paper no.4.

Dahl, A.L. (1989). Traditional environmental knowledge and resource management in New Caledonia. In: Johannes, R.E. (Ed.), Traditional Ecological Knowledge: A Collection of Essays. The World Conservation Union, pp. 45–53.

Dai, A., Lamb, P. J., Trenberth, K. E., Hulme, M., Jones, P. D., & Xie, P. (2004). The recent Sahel drought is real. International Journal of Climatology, 24(11), 1323-1331.

Davies, S. (1996). Adaptable livelihoods: coping with food insecurity in the Malian Sahel. Macmillan Press Ltd.

Denevan, W. M., & Mathewson, K. (eds.). (2009). Carl Sauer on culture and landscape: Readings and commentaries. LSU Press.

Descola, P. (2013). Beyond nature and culture. University of Chicago Press.

Diamond, Jared (2005). Collapse: How societies choose to fail or succeed. New York City: Viking Press.

Durbar, S. & Kathmandu, N. (2010). National Adaptation Programme of Action (NAPA).

Dutfield, G. (2003). Protecting Traditional Knowledge and Folklore. UNCTAD-ICTSD.

Dybas, C.L. (2005). Native lore tells tale. Oceanography 18 (4), 12.

ELLA: Evidence and Lessons from Latin America (2012). How traditional knowledge and technologies are contributing to climate change adaptation in Latin America's mountains. https://assets.publishing.service.gov.uk/media/57a08a5d40f0b64974000574/120625_ENV_AdaMouEnv_BRIEF2.pdf

Ellen, R. F., Parkes, P., & Bicker, A. (eds.) (2000). Indigenous environmental knowledge and its transformations: critical anthropological perspectives (Vol. 5). Oxford, UK: Psychology Press.

Emanuel, K. (2005). Increasing destructiveness of tropical cyclones over the past 30 years. Nature,

436(7051), 686-688.

Enabling policy environments. (2017). Retrieved from Climate Frontlines: http://climatefrontlines.org/work-1

Ericson, J. P., Vörösmarty, C. J., Dingman, S. L., Ward, L. G., & Meybeck, M. (2006). Effective sea-level rise and deltas: causes of change and human dimension implications. Global and Planetary Change, 50(1), 63-82.

Ewell, K.C. and R.R. Twilley (1998). Different kinds of mangrove forests provide different goods and services. Global Ecology and Biogeography Letters 7(1): 83–94.

Fischer, P.H., B. Brunekreef, and E. Lebret. 2004. Air pollution related deaths during the 2003 heat wave in the Netherlands. Atmospheric Environment 38:1083-1085.

Fiske, S. J., et al. (December 2014). Changing the Atmosphere. Anthropology and Climate Change. Final Report of the AAA Global Climate Change Task Force. Arlington: American Anthropological Association.

Food and Agriculture Organization (FAO) (1998). Report on the development of food insecurity and vulnerability information and mapping systems (FIVIMS). Committee On World Food Security, Rome, Italy, available at: http://www.fao.org/docrep/meeting/W8497e.htm

Ford, J. D., Berrang-Ford, L., King, M., & Furgal, C. (2010). Vulnerability of Aboriginal health systems in Canada to climate change. Global Environmental Change, 20(4), 668-680.

Fritz, Angela (2015). Freak storm pushes North Pole 50 degrees above normal to melting point. The Washington Post. December 30.

Galloway McLean, K. (2009). Advance Guard: Climate Change Impacts, Adaptation, Mitigation and Indigenous Peoples – A Compendium of Case Studies. https://i.unu.edu/media/ourworld.unu.edu-en/article/1148/Advance_Copy-Advance_Guard_Compendium.pdf

G.P. Reddy, S.Z. Ali, P. Kumar. (2015). Traditional knowledge and sustainable agriculture: the strategy to cope with climate change. In Envisioning a future without food waste and food poverty (pp. 109 - 118).

Gessas, Jeff (2015). Indigenous knowledge on the Marshall Islands: A Case Study for Recognition Justice. Master's thesis, University of North Texas.

Giles, B.G. et al. (2007). Integrating conventional science and aboriginal perspectives on diabetes using fuzzy cognitive maps. Social Science and Medicine. 64 (3). pp. 562–76.

Glahn, D. v. (2011). Indigenous Wisdom and Biomathematics: Amazonians Tackle Climate Change. WIPO.

Godde, P., Price, M.F. and Zimmermann, F.M. (eds.) (2000). Tourism and Development in Mountain Regions. CABI Publishing, Wallingford.

Godoy, R., Jacobson, M., De Castro, J., Aliaga, V., Romero, J., & Davis, A. (1998). The role of tenure security and private time preference in neotropical deforestation. Land Economics, 162-170.

Goldman, Mara, Paul Nadasdy, and Matthew D. Turner, eds. (2011). Knowing Nature: Conversations at the Intersection of Political Ecology and Science Studies. Chicago: University of Chicago Press.

Gombrich, E.H. 1966. The Renaissance Theory of Art and the Rise of Landscape. In E.H. Gombrich, Norm and Form: Studies in the Art of the Renaissance. London: Phaidon, 107–21.

Gómez-Baggethun, E., Reyes-García, V., Olsson, P., & Montes, C. (2012). Traditional ecological knowledge and community resilience to environmental extremes: A case study in Doñana, SW Spain. Global Environmental Change, 22(3), 640-650.

González, A. H., Aristizábal, A. B., & Díaz, R. M. (2009). Micro Hydro Power Plants in Andean Bolivian communities: impacts on development and environment. In International conference on renewable energies and power quality, Valencia.

Governors' Climate and Forests Task Force(2018). New alliances for people and the planet, How unexpected partnerships between Indigenous Peoples and state and provincial governments are delivering for communities, conservation, and climate.
https://static1.squarespace.com/static/5896200f414fb57d26f3d600/t/5b98280b88251b2a09be1730/1536698424833/GCF+New+Alliances+for+People+and+the+Planet+Report+2018.pdf

Gray, L.C. & Morant, P. (2003). Reconciling indigenous knowledge with scientific assessment of soil fertility changes in Southwestern Burkina Faso. Geoderma 111, 425–437.

Green, D. & Raygorodetsky, G. (2010). Indigenous knowledge of a changing climate. Climatic Change, 100(2), 239-242.

Green, D. (2006). How Might Climate Change Affect Island Culture in the Torres Strait? Australia Commonwealth Scientific and Industrial Research Organization.

Griffiths, Jay (2006). Wild: An Elemental Journey. New York: Penguin Group.

Guardians of the Forest. (2018). Guardians of the Forest. A Solution to Climate Change.
https://guardiansoftheforest.me/
Gyampoh, B.A., Amisah, S., Idinoba, M., Nkem, J. (2008). Using traditional knowledge to cope with climate change.
http://www.fao.org/3/i0670e/i0670e14.htm

Harinarayana, T., Hirata, N. (2005). Destructive earthquake and disastrous tsunami in the Indian Ocean, what next? Gondwana Research 8 (2), 246–257.

Hedberg, O. (1961). The phytogeographical position of the afroalpine flora. pp. 914-19). Rec. Adv.

Bot. Univ. Toronto Press.

Heidegger, Martin (1927). Sein und Zeit, Gesamtausgabe Volume 2. Being and Time, translated by John Macquarrie and Edward Robinson. London: SCM Press.

Henriksen, John B. (2007). Report on Indigenous and Local Communities highly vulnerable to Climate Change inter alia of the Arctic, Small Island States and High Altitudes, with a focus on causes and solutions. Convention on Biological Diversity 2007.

Hinzman, L. D., Bettez, N. D., Bolton, W. R. et al. (2005). Evidence and implications of recent climate change in northern Alaska and other arctic regions. Climatic Change, 72(3), 251-298.

Hiwasaki, L., Luna, E., & Marçal, J. A. (2015). Local and indigenous knowledge on climate-related hazards of coastal and small island communities in Southeast Asia. Climatic Change, 128(1-2), 35-56.

Holcombe, S and Janke, T. (2012). Patenting the Kakadu Plum and the Marjarla Tree: Biodiscovery, Intellectual Property and Indigenous Knowledge. Retrieved from SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2239519
http://digital.library.unt.edu/ark:/67531/metadc822739/m2/1/high_res_d/thesis.pdf

Huffman, M. R. (2013). The many elements of traditional fire knowledge: synthesis, classification, and aids to cross-cultural problem solving in fire-dependent systems around the world. Ecology and Society. Retrieved from http://dx.doi.org/10.5751/ES-05843-180403

Hulme, M., Doherty, R., Ngara, T., New, M., & Lister, D. (2001). African climate change: 1900-2100. Climate research, 17(2), 145-168.

Hunn E (1993). What is traditional ecological knowledge? In Williams, N. M., & Baines, G. (eds). Traditional ecological knowledge: wisdom for sustainable development. Centre for Resource and Environmental Studies (CRES), Australian National University.

Hunn, E.S., Johnson, D.R., Russell, P.N. and Thornton, T.F. (2003). Huna Tlingit traditional environmental knowledge, conservation and the management of a "Wilderness" Park. Current Anthropology, 44 (Supp): 167-194.

Hurley, Andrew (1994). Creating Ecological Wastelands: Oil Pollution in New York City, 1870-1900. Journal of Urban History, V. 20, Issue: 3.

IFAD. (2016). The Traditional Knowledge Advantage. Indigenous Peoples' knowledge in climate change adaptation and mitigation strategies.

IIED. (2011). Adapting agriculture with traditional knowledge.

Indigenous knowledge and climate change. An International Conference contributing to the COP22 climate conference. (2016). Marrakesh, Morocco.

Inter-Agency Support Group on Indigenous Peoples' Issues. (2014). The Knowledge of Indigenous Peoples and Policies for Sustainable Development: updates and trends in the Second Decade of the World's Indigenous People.

Intergovernmental Panel on Climate Change (IPCC; 1998). The regional impacts of climate change. Cambridge University Press, Cambridge and New York, 517 pp.

IP Australia (2016). Nanga Mai Arung Dream Shield, A guide to protecting intellectual property for Aboriginal and Torres Strait Islander People.
https://www.ipaustralia.gov.au/tools-resources/publications-reports/dream-shield
https://www.ipaustralia.gov.au/sites/default/files/reports_publications/dream_shield.pdf

IPCC (2001). Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 1032p.

IPCC. (2007). IPCC Fourth Assessment Report: Climate Change 2007. Retrieved from https://www.ipcc.ch/publications_and_data/ar4/wg2/en/xccsc4.html

IPMPCC. (2017). IPMPCC: Vulnerability, Adaptation and Traditional Knowledge. Retrieved from Climate Frontlines: http://climatefrontlines.org/blog/ipmpcc-vulnerability-adaptation-and-traditional-knowledge

Irfanullah, H. M., Adrika, A., Ghani, A., Khan, Z. A., & Rashid, M. A. (2008). Introduction of floating gardening in the north-eastern wetlands of Bangladesh for nutritional security and sustainable livelihood. Renewable agriculture and food systems, 23(02), 89-96.

Irfanullah, H. M., Azad, M. A. K., Kamruzzaman, M., & Wahed, M. A. (2011). Floating gardening in Bangladesh: a means to rebuild lives after devastating flood. Indian Journal of Traditional Knowledge, 10(1), 31-38.

Irfanullah, H. M., Nishat, A., & Ahmed, R. (2005). Baira: The Floating Gardens for Sustainable Livelihood. IUCN-The World Conservation Union, Bangladesh Country Office.
Johann G. Goldammer . (n.d.). Example of best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation to climate change.

Johannes, R. E., & Neis, B. (2007). The value of anecdote. Fishers Knowledge in Fisheries Science and Management. Paris: UNESCO, 41-58.

Johannes, R.E. (1978). Traditional marine conservation methods in Oceania and their demise. Annual Review of Ecological Systems 9, 349–364.

Johnson, L. M., and Hunn, E. S. (eds.). (2010). Landscape ethnoecology: concepts of biotic and physical space. Berghahn Books.

Kakissis, J. (2010). Environmental refugees unable to return home. New York Times, 3.

Kapos, V., Rhind, J., Edwards, M., Ravilious, C., and Price, M., (2000). Developing a map of the world's mountain forests. In: Price, M.F., and Butt, N. (eds.), Forests in a sustainable mountain environment. CAB International, Wallingford.

Karki, M., Pokhrel, P., Adhikari, J.R. (2014). Climate Change: integrating indigenous and local knowledge into adaptation policies and practices: a case study from Nepal https://www.cabi.org/Uploads/CABI/OpenResources/91797/Finished%20A10%20Karki.pdf

Kathryn Norton-Smith et al. (2016). Climate Change and Indigenous Peoples: A Synthesis of Current Impacts and Experiences. USDA. Retrieved from National Park Service: https://www.nps.gov/subjects/tek/climate-change.htm

Keener, V. W., J. J. Marra, M. L. Finucane, D. Spooner, and M. H. Smith (Eds. 2012). Climate change and Pacific Islands: indicators and impacts. Report for the 2012 Pacific Islands regional climate assessment (PIRCA). Island Press, Washington, D.C., USA.

Kingsford, R. T., and S. D. Jupiter (2014). Conservation lessons from the Pacific Islands. Pacific Conservation Biology 20 (2):134-135.

Knowlton, K., Kulkarni, S. P., Azhar, G. S., Mavalankar, D., Jaiswal, A., Connolly, M., ... & Sanchez, L. (2014). Development and implementation of South Asia's first heat-health action plan in Ahmedabad (Gujarat, India). International journal of environmental research and public health, 11(4), 3473-3492.

Kronik, J., & Verner, D. (2010). Indigenous Peoples and Climate Change in Latin America and. World Bank Group.

Lacy, S. M., Cleveland, D. A., & Soleri, D. (2006). Farmer choice of sorghum varieties in southern Mali. Human Ecology, 34(3), 331-353.

Ladefoged, T. N. (1993). Evolutionary process in an oceanic chiefdom: intergroup aggression and political integration in traditional Rotuman society. UMI Dissertation Services.

LaDuke, W. (1999). All our relations: Native struggles for land and life. South End Press.

LaDuke, W. (2005). Recovering the sacred: The power of naming and claiming. South End Press.

Lenton, T. M. (2011). Early warning of climate tipping points. Nature Climate Change, 1(4), 201-209.

Leung, R. (2005). Sea gypsies saw signs in the waves: How Moken people in Asia saved themselves from deadly tsunami. 60 Minutes, 20 March 2005, updated 10 June 2007. http://www.cbsnews.com/stories/2005/03/18/60minutes

Lewis, J. (2000). The Batwa pygmies of the Great Lakes region (Vol. 209). London: Minority Rights Group International.

Lewis, M. P., G. F. Simons, and C. D. Fenning, editors (2014). Ethnologue: languages of the world. Seventeenth edition. SIL International, Dallas, Texas, USA. [online] URL: http://www.ethnologue.com

Ligare, M. (2015). The Nagoya Protocol: Its impact on access & benefit sharing, patent applications and the utilization of genetic resources.

Long, S. (2010). Traditional Knowledge is Facilitating Climate Change Adaptation in Torres Strait.

Lyons, O. (1984). Spirituality, equality and natural law. Pathways to Self-Determination: Canadian Indians and the Canadian State, 5, 5.

Lyons, O. (1991). An Iroquois Perspective. Learning to Listen to the Land, 202.

Macchi, M. (2008). Indigenous and Traditional Peoples and Climate Change.

Maldonado, J., Colombi, B., & Pandya, R. (2014). Climate Change and Indigenous Peoples in the United States. Springer International Publishing. Retrieved from http://www.springer.com/us/book/9783319052656

Malley, Z. J., Mzimbiri, M. K., & Mwakasendo, J. A. (2009). Integrating local knowledge with science and technology in management of soil, water and nutrients: implications for management of natural capital for sustainable rural livelihoods. International Journal of Sustainable Development & World Ecology, 16(3), 151-163.

Marti, N. and Pimbert, M. (2005). Barter Markets: Sustaining People and Nature in the Andes. IIED. London.

Mathiesen, Karl (2015). Tasmania's bushfires: a human-made calamity on par with the razing of Palmyra's temples. The Guardian. February 25.

McAdoo, B.G., Dengler, L., Prasetya, G., Titov, V. (2006). How an oral history saved thousands on Indonesia's Simeulue Island during the December 2004 and March 2005 tsunamis. Earthquake Spectra 22 (3), 661–669.

McClain, M.E. (2001). The Relevance of Biogeochemistry to Amazon Development and Conservation. In The biogeochemistry of the Amazon Basin. McClain, M.E., Victoria, R.L., and Richey, J.E. (eds.). London, Oxford University Press.

McCorkle, C.M. (1989). Towards a Knowledge of Local Knowledge and its Importance for Agricultural RD and E. Agriculture and Human Values vol. 6, no. 3: 4-12.

McManis, C., & Terán, Y. (2011). Trends and scenarios in the legal protection of traditional knowledge. In Intellectual Property and Human Development. PIIPA.

McMichael, A.J., M. Ando, R. Carcavallo, P. Epstein, A. Haines, G. Jendritzky, L. Kalkstein, R. Odongo, J. Patz, and W. Piver. (1996). Human population health.

In: Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change [Watson, R.T., MC. Zinyowera, and R.H. Moss (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 561–584.

McMillen, H. L., Ticktin, T., Friedlander, A., Jupiter, S. D., Thaman, R., Campbell, J., & Apis-Overhoff, L. (2014). Small islands, valuable insights: systems of customary resource use and resilience to climate change in the Pacific. Ecology and Society, 19(4), 44. https://www.researchgate.net/profile/Stacy_Jupiter/publication/269278966_Small_islands_valuable_insights_systems_of_customary_resource_use_and_resilience_to_climate_change_in_the_Pacific/links/54861efa0cf289302e2c058a.pdf

Mercer, J., Dominey-Howes, D., Kelman, I., & Lloyd, K. (2007). The potential for combining indigenous and western knowledge in reducing vulnerability to environmental hazards in small island developing states. Environmental Hazards, 7(4), 245-256. http://www.mtnforum.org/sites/default/files/publication/files/the-potentialforcombining-indige_jessica.pdf

Mercer, J., Kelman, I., Taranis, L. and Suchet-Pearson, S. (2010). Framework for integrating indigenous and scientific knowledge for disaster risk reduction. Disasters, 34: 214–239.

Merleau-Ponty, Maurice (1945). Phénoménologie de la perception (Paris: Gallimard). Phenomenology of Perception translated by Colin Smith. New York: Humanities Press.

Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. Environmental management, 43(5), 804-816.

Meybeck, M., Green, P., and Vörösmarty, C. (2001). A New Typology for Mountains and Other Relief Classes: An Application to Global Continental Water Resources and Population Distribution. Mountain Research and Development, 21, 34-45

Michael A. Gollin. (2005). Intellectual Property and Biodiversity: The Good, the Bad, and the Ugly.

Mollins, J. (2013). Traditional knowledge fuels climate change adaptation in Ghana – study. Retrieved from Forests News: http://blog.cifor.org/19210/traditional-knowledge-fuels-climate-change-adaptation-in-ghana-study?fnl=en

Mora, C., A. G. Frazier, R. J. Longman, R. S. Dacks, M. M. Walton, E. J. Tong, J. J. Sanchez, L. R. Kaiser, Y. O. Stender, J. M. Anderson, C. M. Ambrosino, I. Fernandez-Silva, L. M. Giuseffi, and T. W. Giambelluca. 2013. The projected timing of climate departure from recent variability. Nature 502 (7470):183-187. http://dx.doi.org/10.1038/nature12540

Moreira, C.J.E. 1986. Rainfall and flooding in the Guayas river basin and its effects on the incidence of malaria 1982–1985. Disasters 10(2): 107 – 111.

Mortimore, M. (1998). Roots in the African dust: sustaining the sub-Saharan drylands. Cambridge University Press.

Mortimore, M. (2006). What are the issues? Have the issues changed? Natural Resource Management in Sahel–Lessons Learnt, 10.

Nakashima, D., & Roué, M. (2002). Indigenous knowledge, peoples and sustainable practice. Encyclopedia of global environmental change, 5, 314-324.

Nakashima, D., Galloway McLean, K., Thulstrup, H., Ramos Castillo, A., & Rubis, J. (2012). Weathering Uncertainty. Traditional Knowledge for Climate Change Assessment and Adaptation. United Nations.

Nazarea, Virginia (ed.) (1999). Ethnoecology: situated knowledge/located lives. Tucson: University of Arizona Press.

Nepstad, D. C., Stickler, C. M., Soares-Filho, B., & Merry, F. (2008). Interactions among Amazon land use, forests and climate: prospects for a near-term forest tipping point. Philosophical Transactions of the Royal Society of London B: Biological Sciences, 363(1498), 1737-1746.

Nicholas, G. (2018). Western science is finally catching up to traditional ecological knowledge. https://www.sapiens.org/culture/traditional-ecological-knowledge/

Nicholas, G. (2019). TEK vs Western Science, An uneasy alliance: indigenous traditional knowledge enriches science. https://www.nps.gov/subjects/tek/tek-vs-western-science.htm

Nyong, A., Adesina, F., & Elasha, B. O. (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. Mitigation and Adaptation strategies for global Change, 12(5), 787-797.

Oxfam Novib, ANDES, CTDT, SEARICE, CGN-WUR. (2013). Building on farmers' perception and traditional knowledge: Biodiversity management for climate change adaptation strategies. Briefing paper. The Hague: Oxfam Novib.

PAHO (1998a). Report on the Epidemiological Situation in Central America. SC/XVII/40, Pan American Health Organization, Washington, DC, USA, 2 pp.

PAHO (1998b). Infectious Diseases Posing in the Greatest Epidemiological Risk Following Hurricane Mitch in Central America. Pan American Health Organization Emergency Task Force, Division of Disease Prevention and Control, Washington, DC, USA, 4 pp.

Parajuli, D. R., & Das, T. (2013). Indigenous Knowledge And Biodiversity: Interconnectedness For Sustainable Development. International Journal of Scientific & Technology Research, 2(8). http://www.ijstr.org/final-print/aug2013/Indigenous-Knowledge-And-Biodiversity-Interconnectedness-For-Sustainable-Development..pdf

Pareek, A., & Trivedi, P. C. (2011). Cultural values and indigenous knowledge of climate change and disaster prediction in Rajasthan, India. Indian Journal of Traditional Knowledge, 10(1), 183-189.

Parlee, B., Manseau, M. (2005). Using traditional knowledge to adapt to ecological change: Denésôåiné monitoring of Caribou movements. https://umanitoba.ca/institutes/natural_resources/canadaresearchchair/Parlee%20et%20al%20Arctic%2005.pdf

Parry, M. L., Canziani, O. F., Palutikof, J. P., Van der Linden, P. J., & Hanson, C. E. (2007). Contribution of working group II to the fourth assessment report of the intergovernmental panel on

climate change, 2007. Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability.

Patz, J. A., D. Campbell-Lendrum, T. Holloway, and J. A. Foley (2005). Impact of regional climate change on human health. Nature 438:310-317. http://dx.doi.org/10.1038/nature04188

Patz, J.A., W.J.M. Martens, D.A. Focks, and T.H. Jetten (1998). Dengue fever epidemic potential as projected by general circulation models of global climate change. Environmental Health Perspectives 106(3): 147–153.

Pedersen, M. A. (2001). Totemism, animism and North Asian indigenous ontologies. Journal of the Royal Anthropological Institute, 7(3), 411-427.

Penaskovic, R. (2011). Evening Thoughts: Reflecting on Earth as Sacred Community. By Thomas Berry. Edited by Mary Evelyn Tucker. The Heythrop Journal, 52(2), 360-360.

Penn, M., & Lukermann, F. (2003). Chorology and landscape: An internalist reading of 'The Morphology of Landscape.' In Culture, Land, and Legacy: Perspectives on Carl O. Sauer and Berkeley School of Geography, edited by K. Mathewson and M.S. Kenzer. Oxford: Blackwell. Pp. 233-259.

Perez-Brito, C. T. (2018). Mexico Dedicated Grant Mechanism for IP and LC. WIPO.

Pfadenhauer, M. (2005). Ethnography of scenes. Towards a sociological life-world analysis of (post-traditional) community-building. In Forum Qualitative Sozialforschung/Forum: Qualitative Social Research (Vol. 6, No. 3).

PIIPA. (2011). Traditional Knowledge & Biopiracy: The Peruvian Maca Root. In Public Interest IP Case Study Series.

Posey, D. A. (1982). Keepers of the forest. New York Botanical Garden Magazine, 6(1), 18-24.

Posey, D. A. (1985). Indigenous management of tropical forest ecosystems: the case of the Kayapo Indians of the Brazilian Amazon. Agroforestry systems, 3(2), 139-158.

Posey, D. A. (1988a). The Declaration of Belem. In Proceedings of the First International Congress of Ethnobiology. Posey, D. A. and W. Overal (eds.). Museu Paraense Goeldi. Belem.

Posey, D. A. (1988b). Kayapó Indian natural resource management. In J. S. Denslow & C. Padoch (eds.), People of the Tropical Rain Forest (pp. 89–90). Berkeley: Smithsonian Institution Traveling Exhibition Service & University of California.

Posey, D. A. (1992). The relation between cultural diversity and biodiversity. In S. Bilderbeek (Ed.), Biodiversity and International Law (pp. 44–47). Amsterdam: IOS Press.

Posey, D. A. (1998). Safeguarding traditional resource rights of Indigenous Peoples. In V. D. Nazarea (Ed.), Ethnoecology: Situated Knowledge/Located Lives (pp. 217–230). Tucson: Arizona University Press.

Posey, D. A. (2002). Upsetting the sacred balance: can the study of indigenous knowledge reflect

cosmic connectedness? In P. Sillitoe, A. Bicker & J. Pottier (eds.), Participating in Development: Approaches to Indigenous Knowledge (pp. 24–42). New York: Routledge.

Posey, D. A. (2003a). Fragmenting cosmic connections: converting nature into commodity. In S. A. Vertovec & D. A. Posey (eds.), Globalization, Globalism, Environments, and Environmentalism: Consciousness of Connections (The Linacre Lectures) (pp. 123–140). Oxford: Oxford University Press.

Posey, D. A. (2003b). Insects, foods, medicines and folklore in Amazonia. In E. Motte-Florac & J. M. C. Thomas (eds.), Les "Insectes" Dans La Tradition Orale - Insects in Oral Literature and Tradition (pp. 221–237). Paris: Peeters Publishers.

Poumadere, M., Mays, C., Le Mer, S., & Blong, R. (2005). The 2003 heat wave in France: dangerous climate change here and now. Risk analysis, 25(6), 1483-1494.

Prinz, D. (1996). Water harvesting—past and future. In Sustainability of irrigated agriculture (pp. 137-168). Springer Netherlands.

R. D. K. Herman. (2016). Traditional knowledge in a time of crisis: climate change, culture and communication. Sustain Sci , 163–176.

Raygorodetsky, G. (2011). Why Traditional Knowledge Holds the Key to Climate Change. Retrieved from United Nations University: https://unu.edu/publications/articles/why-traditional-knowledge-holds-the-key-to-climate-change.html

Raygorodetsky, G. (2012a). Conversations with the Earth: Indigenous Voices on Climate Change. Origin Magazine. November/December 2012 Issue.

Raygorodetsky, G. (2012b). The Key to Addressing Climate Change – Indigenous Knowledge. Published online February 6, 2012. Washington, DC: National Geographic NewsWatch.

Raygorodetsky, G. et al. (2012c). Recognition and Support of Indigenous and Community Conserved Areas in Canada.
In Recognizing and Supporting Territories and Areas Conserved By Indigenous Peoples And Local Communities. A Kothari et al. (Eds.) Technical Series no. 64. Secretariat of the Convention on Biological Diversity. Montreal, Canada.

Reed, Richard (1996). Forest Dwellers, Forest Protectors: Indigenous models for International Development. Part of the Cultural Survival Studies in Ethnicity and Change series, edited by David Maybury-Lewis and Theodore Macdonald, Jr. of Cultural Survival, Inc., Harvard University.

Reed, Richard (2000). Forest Developers, Forest Protectors: Commercial Agroforestry by the Chiripá of Paraguay. Journal of Culture and Agriculture. Spring.

Reed, Richard (2005). Indigenous Peoples, Tropical Reserves, and Anthropology. General Anthropology, published by a division of the American Anthropological Association. Spring.

Reed, Richard (2006). Two Rights Make A Wrong: Indigenous Groups in the Environmental Movement. Applying Anthropology, Podolefsky, A. and Brown, P. (eds.).

Reed, Richard (2008). Cultivating the Tropical Forest: Using Indigenous Knowledge to Halt Tropical Deforestation. In Conformity and Conflict, J. Spradley and D. McCurdy (eds.).

Reed, Richard (2009). At the Intersection of Academics and Scholarship. Anthropological Quarterly. 82(4) 1065-1069. Nov.

Resources. (2017). Retrieved from Guidelines for Considering Traditional Knowledges in Climate Change Initiatives: https://climatetkw.wordpress.com/resources/

Riedlinger, D., & Berkes, F. (2001). Contributions of traditional knowledge to understanding climate change in the Canadian Arctic. Polar Record, 315-328. Retrieved from Cambridge University Press.
Rimmer, M., & McLennan, A. (2012). Intellectual Property and Emerging Technologies: The New Biology. Edward Elgar Publishing. Inc.

Rist, L., Uma Shaanker, R., Milner-Gulland, E.J., Ghazoul, J. (2010). The use of traditional knowledge in forest management: an example from India.
https://www.ecologyandsociety.org/vol15/iss1/art3/

Rival, L. (2006). Amazonian historical ecologies. In Ethnobiology and the science of humankind. A retrospective and a prospective (ed.) Roy Ellen, 97-116. Special Issue of the Journal of the Royal Anthropological Institute, #1.

Rival, L. (2009). Towards an understanding of the Huaorani ways of knowing and naming plants. Mobility and migration in indigenous Amazonia, 47-68.

Robinson, D., Abdel-Latif, A., Roffe, P. (2017). Protecting traditional knowledge: the WIPO intergovernmental committee on intellectual property and genetic resources, traditional knowledge and folklore.
https://www.ictsd.org/themes/innovation-and-ip/research/protecting-traditional-knowledge-the-wipo-intergovernmental

Robinson, J. B., & Herbert, D. (2001). Integrating climate change and sustainable development. International Journal of Global Environmental Issues, 1(2), 130-149.

Rosegrant, M. W., Msangi, S., Ringler, C., Sulser, T. B., Zhu, T., & Cline, S. A. (2008). International model for policy analysis of agricultural commodities and trade (IMPACT): Model description (p. 42). Washington, DC, USA: International Food Policy Research Institute.

Ross, A., Pickering Sherman, K., G. Snodgrass, J., D. Delcore, H., Sherman, R. (2016). Indigenous Peoples and the collaborative stewardship of nature: knowledge binds and institutional conflicts.
https://books.google.co.in/books?id=Y94YDQAAQBAJ&pg=PT38&lpg=PT38&dq=Berkes+(2009)&source=bl&ots=KEv2BHxajP&sig=ACfU3U1Tau0c4Eh70WMTqrLrYrDF3KO4Pw&hl=en&sa=X&ved=2ahUKEwiK3o6M6MXgAhXEbX0KHalYBQ0Q6AEwDXoECAEQAQ#v=onepage&q=Berkes%20(2009)&f=false

S. von Lewinski. (2003). Indigenous Heritage and Intellectual Property: Genetic Resources, Traditional Knowledge and Folklore. Kluwer Law International.

Salmon, E. (1996). Decolonizing our voices. Winds of Change, 11(3), 70-72.

Salmon, E. (2000). Kincentric ecology: indigenous perceptions of the human–nature relationship. Ecological Applications, 10(5), 1327-1332.

Sandhya, V., Reddy, G.P., Ali, S.Z., Kumar K.L., P. (2015). Traditional knowledge and sustainable agriculture: the strategy to cope with climate change. https://www.wageningenacademic.com/doi/pdf/10.3920/978-90-8686-820-9_12

Sauer, Carl O. (1925). The morphology of landscape. University of California Press.

Sauer, Carl O. (1963). Land and life. University of California Press.

Schwartzman, S. and Zimmerman, B. (2005). Conservation alliances with Indigenous Peoples of the Amazon. Conservation Biology, 19(3), 721-727.

Secretariat of the Convention on Biological Diversity. (2009). Indigenous Peoples and Traditional Knowledge Related to Biological Diversity and Responses to Climate Change in the Arctic Region. Ministry of the Environment of Finland.

Shepard, Glenn H, Yu, Douglas W., Lizarralde, Manuel, & Italiano, Mateo (2001). Rain forest habitat classification among the Matsigenka of the Peruvian Amazon. Journal of Ethnobiology, 21(1), 1-38.

Sillitoe, P., A. Bicker and J. Pottier (2002). Participating in Development: Approaches to Indigenous Knowledge. ASA Monographs 39. London and New York: Routledge.

Sohani, G. G., et al. (1998). Conjunctive use of water resources in Deccan trap, India. BAIF Development Research Foundation (Research Report), Pune. 134p.

South Pacific Applied Geo-Science Commission (2004). Implementing the Yokohama strategy and plan of action: Pacific Islands Regional Progress Report (1994–2004). South Pacific Applied Geo-Science Commission, Fiji.

Spainhower, K. (2011). Traditional Knowledge is the Prescription for Environmental land Management. WIPO.

Spennemann, D. H. (1996). Nontraditional settlement patterns and typhoon hazard on contemporary Majuro Atoll, Republic of the Marshall Islands. Environmental Management, 20(3), 337-348.

Sponsel, Leslie (2001). Is Indigenous Spiritual Ecology Just a New Fad? Reflections from the Historical and Spiritual Ecology of Hawaii' in Indigenous Traditions and Ecology. Cambridge, Massachusetts: Harvard University, pg. 159-174.

Sponsel, Leslie and Casagrande, David (Ed.) (2007). Ecological anthropology. Cleveland, C.J. (Ed.). Encyclopedia of Earth. Environmental Information Coalition, National Council for Science and the Environment. Washington, D.C.

Stern, N. H. (2006). Stern Review: The economics of climate change (Vol. 30). London: HM treasury.

Strauss, Sarah, ed. (2003). Weather, Climate, Culture. Oxford: Berg.

Subsidiary Body for Scientific and Technological Advice. (2014). Report on the meeting on available tools for the use of indigenous and traditional knowledge and practices for adaptation, needs of local and indigenous communities and the application of gender-sensitive approaches and tools for adaptation . United Nations.

Sumner, Thomas (2014). West Antarctic Ice Sheet Is Collapsing. Science Magazine. May 12.

T.M. Bull Bennett & Nancy G. Maynard. (n.d.). Indigenous Peoples, Lands, and Resources. Retrieved from National Climate Assessment: http://nca2014.globalchange.gov/report/sectors/indigenous-peoples

Tarhule, A., & Lamb, P. J. (2003). Climate research and seasonal forecasting for West Africans: perceptions, dissemination, and use? Bulletin of the American Meteorological Society, 84(12), 1741.

The British Broadcasting Corporation News (2016). Pakistan floods kill at least 53 after heavy rains. April 4: http://www.bbc.co.uk/news/world-asia-35957186

The Institute for Tribal Environmental Professionals. (2017). ITEP Tribes & Climate Change Program. Retrieved from Northern Arizona University: http://www7.nau.edu/itep/main/tcc/

The United Nations Educational, Scientific and Cultural Organization (UNESCO) (2005). A world of science. Natural Sciences Quarterly Newsletter 3 (2), 1–24.

Thomson Reuters Foundation (2018). Fight fires with indigenous knowledge, researchers say. https://www.reuters.com/article/us-global-wildfire-climatechange/fight-fires-with-indigenous-knowledge-researchers-say-idUSKBN1KY0XP

Thornton, Thomas F. (2008). Being and Place among the Tlingit. Seattle, WA: University of Washington Press.

Torre, A., Fajnzylber, P., & Nash, J. (2009). Low Carbon, High Growth Latin American Responses to Climate Change. World Bank Group.

Townsend, R. F. (2015). Ending Poverty and Hunger by 2030: An Agenda for the Global Food System. The World Bank.

Twarog, S., & Kapoor, P. (2004). Protecting and Promoting Traditional Knowledge: Systems, National Experiences and International Dimensions. United Nations.

Uganda Population Secretariat (2008). State of the population report: The role of culture, gender and human rights in social transformation and sustainable development. Kampala, Uganda.

UNCTAD. (2000). Systems and national experiences for protecting traditional knowledge, innovations and practices. United Nations.

UNCTAD. (2005). Report of the UNCTAD-Commonwealth Secretariat Workshop on Elements of National Sui Generis Systems for the Preservation, Protection and Promotion of Traditional Knowledge, Innovations and Practices and Options for an International Framework. United Nations.

UNESCO (2012). Traditional knowledge for climate change assessment and adaptation. http://www.climatefrontlines.org/

UNESCO, National Museum of Natural History of France, Tebtebba (2015). Resilience in a time of uncertainty, Indigenous Peoples and climate change. http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IPCC_2015_summaries_bios.pdf

UNESCO/ICHCAP. (2013). Traditional Knowledge for Adapting to Climate Change.

UNISDR (2015). Weather Disasters Report. http://www.unisdr.org/2015/docs/climatechange/COP21_WeatherDisastersReport_2015_FINAL.pdf

United Nations Conference on Environment and Development, (UNCED, 1992). Earth Summit: Agenda 21. Rio de Janeiro, Brazil. 294 pp.

United Nations Declaration on the Rights of Indigenous Peoples (2007). New York, NY: United Nations.

United Nations Framework Convention on Climate Change (UNFCCC) (1992). Intergovernmental Negotiating Committee for a Framework Convention on Climate Change. A/AC.237/18, 9 May. http://www.un-documents.net/unfccc.htm

United Nations Framework Convention on Climate Change (UNFCCC) (2015). Adoption of the Paris Agreement. Conference of the Parties (COP) 21. https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf

UNFCC Change (2013). Best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation, and the application of gender-sensitive approaches and tools for understanding and assessing impacts, vulnerability and adaptation to climate change. http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/UNFCCC-TP-2013-11.pdf

United Nations Framework Convention on Climate Change (2016). A compilation of good practices, tools and available data collection initiatives for the use of local, indigenous and traditional knowledge and practices for adoption. http://unfccc.int/files/adaptation/application/pdf/compilation_litkp.pdf

United Nations Framework Convention on Climate Change (n.d.). Example of best practices and available tools for the use of indigenous and traditional knowledge and practices of adaptation https://unfccc.int/files/adaptation/application/pdf/gfmc.pdf

United Nations Human Rights Council (UNHCR) (2014). Promotion and protection of the rights of Indigenous Peoples in disaster risk reduction, prevention and preparedness initiatives. http://www.ohchr.org/Documents/Issues/IPeoples/EMRIP/Session7/A-HRC-EMRIP-2014-2_en.pdf

United Nations Office for Disaster Risk Reduction (UNISDR) (2006). Global survey of early warning systems: An assessment of capacities, gaps and opportunities toward building a comprehensive global early warning system for all natural hazards. Platform for the promotion of early warning (UNISDR—PPEW), UN: p, 46.

United Nations University. (2009). Traditional indigenous fire management techniques deployed against climate change. Retrieved from ScienceDaily: https://www.sciencedaily.com/releases/2009/11/091129125133.htm

United Nations. (2013). Best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation, and the application of gender-sensitive approaches and tools for understanding and assessing impacts, vulnerability and adaptation.

UNU-IAS. (2007). Traditional Knowledge Initiative. Retrieved from United Nations University: https://unu.edu/projects/traditional-knowledge-initiative.html#outline

V. Sandhya, G.P. Reddy, S.Z. Ali and P. Kumar K.L. (2015). Traditional knowledge and sustainable agriculture: the strategy to cope with climate change

Vanuatu Traditional Knowledge Project. (2016). Retrieved from Pacific Climate Change Portal: https://www.pacificclimatechange.net/news/vanuatu-traditional-knowledge-project

Veitayaki, J. (2002). Taking advantage of indigenous knowledge: the Fiji case. International Social Science Journal 54 (3), 395–402.

Verran, H., Christie, M., Anbins-King, B., Van Weeren, T., & Yunupingu, W. (2007). Designing digital knowledge management tools with Aboriginal Australians. Digital Creativity, 18(3), 129-142.

Vincent, K. (2007). Uncertainty in adaptive capacity and the importance of scale. Global Environmental Change, 17(1), 12-24.

Vinyeta, K., & Lynn, K. (2013). Exploring the Role of Traditional Ecological Knowledge in Climate Change Initiatives. USDA.

Walker, N., Willmett, N., & Dr. Rose, M. (2016). Dream Shield. Retrieved from Australian Government. IP Australia: https://www.ipaustralia.gov.au/tools-resources/publications-reports/dream-shield

Warren, D.M., L.J. Slikkerveer and D. Brokensha, (eds.) (1995). The Cultural Dimension of Development: Indigenous Knowledge Systems. London: Intermediate Technology Publications.

Whiteman, D. (2000). Mountain Meteorology: fundamentals and applications. Oxford University Press, 355 pp.

Whyte, K. (2015). What Do Indigenous Knowledges Do for Indigenous Peoples? In Keepers of the Green World: Traditional Ecological Knowledge and Sustainability, edited by M. K. Nelson and D. Shilling. Available for access at http://ssrn.com/abstract=2612715

Williams, T., & Hardison, P. (2013). Culture, law, risk and governance: contexts of traditional. Climatic Change, pp. 531–544.

Williams, T., & Hardison, P. (2013). Culture, law, risk and governance: contexts of traditional knowledge in climate change adaptation. Climatic Change, 120(3), 531-544.

Willoughby, H. E., Rappaport, E. N. & Marks, F. D. (2007). Hurricane forecasting: the state of the art. Nat. Hazard. Rev. **8,** 45–49.

WIPO. (2015). Intellectual Property and Genetic Resources, Traditional Knowledge and Traditional Cultural Expressions.

Woodroffe, C. D., Nicholls, R. J., Saito, Y., Chen, Z., & Goodbred, S. L. (2006). Landscape variability and the response of Asian megadeltas to environmental change. In Global change and integrated coastal management (pp. 277-314). Springer Netherlands.

World Bank Group (2013). Acting on climate change and disaster risk for the Pacific. Washington, DC. http://documents.worldbank.org/curated/en/2013/01/18530985/acting-climate-change-disaster-risk-pacific

World Bank Group (2014). Turn Down the Heat: Confronting the New Climate Normal. Potsdam Institute for Climate Impact Research and Climate Analytics. Washington, DC.

World Bank Group (2016). Climate Change Action Plan 2016-2020. Washington, DC: World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/24451/K8860.pdf
World Bank Group (2016). World Development Report 2016: Digital Dividends. Washington, DC.

World Resources Institute (2016). Protecting indigenous land rights makes good economic sense for climate protection. https://www.wri.org/blog/2016/10/protecting-indigenous-land-rights-makes-good-economic-sense

Yarris, L. (2004). Samoa's Gift to the World. Retrieved from Berkley Lab: http://newscenter.lbl.gov/2004/11/05/samoas-gift-to-the-world/

Yue, X., Mickley, L. J., Logan, J. A., Hudman, R. C., Martin, M. V., & Yantosca, R. M. (2015). Impact of 2050 climate change on North American wildfire: consequences for ozone air quality. Atmospheric Chemistry and Physics, 15(17), 10033-10055. http://acmg.seas.harvard.edu/publications/2015/yue_acp_2015.pdf