GLOBAL MANGROVE ALLIANCE

Including Local Ecological Knowledge (LEK) in Mangrove Conservation & Restoration

A Best-Practice Guide for Practitioners and Researchers

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Experts like Darwin Sosa, a local nature tour guide pictured here, have vital insight into local mangrove forests in the form of LEK. © Jason Houston - WWF-US

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Organizations

Amani Jipange, Asociación de Preservación de Manglares de Bahía Hondita – Asomanglares, AMBAS (Associacion de Mujeres de Barra de Santiago), Asociación Mangle, ASSUREMACATA, ASSUREMAS, ASSUREMAV, AUREMAC, AUREMAP, AUREMAR, AUREMAT, AUREMC-MG, AUREMLUC, Barokah community group of Timbulsloko Village, Blue Ventures Conservation, Bonje Community Forest Association in Mwache, Centro de Estudios Marinos, Ceriops Organization, City of Tacloban, Environment and Natural Resources Office (ENRO), Conservation International, Conservation International (CI) Liberia, CORPOGUAJIRA, Corporación Autónoma regional del Valle del Sinú (CVS), Fundación vigias ambientales Jose Ladeus" DRMI Musichi, GFA Consulting Group / CDM Smith, GIZ, Hô-üt association, Human Environment Connections, Indian Ocean Water Body BMU Network, International Union for Conservation of Nature (IUCN), IUCN French National Committee, JALA S.A., Kenya Marine and Fisheries Research Institute, Konservasi Indonesia, Lamu County BMU Network, Latian Internasyonal Pilipinas Inc. (Wetlands International Philippines), Leibniz-Centre for Tropical Marine Research (ZMT), Mangrove Action Project, Marine and Coastal Research Institute (INVEMAR), Matondoni Beach Management Unit (BMU), Ministerio de Ambiente (Panamá) - Chiriquí Regional, Ministerio de Ambiente (Panamá) - DICOMAR (Coasts and Seas Division), Ministerio de Ambiente (Panamá) - West Panamá Regional, MOCAJUIM, Nailaga District Representative, Omacha Foundation, Organization for Marine Conservation Awareness and Research (OMCAR), Pattimburak Village, Penn State University, Rare, Red Cross Vietnam, Seacology Foundation, Sido Makmur Community Group, Smithsonian Environmental Research Center, Tavua District, The Nature Conservancy, TUARISBA, University of Cambridge, Vida Manglar, Wetland Ranger, Wetlands International, Wetlands International Indonesia, WWF Mexico, WWF Pacific Office.

Audience

This guide is designed as a starting point to help researchers and practitioners working in mangrove conservation and restoration who want to engage with and include LEK in their projects. This applies to, but is not limited to, members of the Global Mangrove Alliance, their collaborators, and the broader conservation community.

DOI: https://doi.org/10.5479/10088/118227

Cover Image

A fisherman practicing his trade, perfected through generations of knowledge, in the waters of a mangrove forest in Myanmar. © Teo Chin Leong / TNC Photo Contest 2023

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1. Introduction

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Local communities know the geography of their mangroves better than anyone else. © IUCN - MFF

1.1

Mangroves

Mangroves are trees and shrubs that grow in saline and brackish tidal waters across tropical and subtropical regions of the world.[1]

People have lived with mangroves for millennia, making use of their many goods and benefits, and often holding a key place for them in local cultures and traditions.

Mangroves support rich biodiversity spanning both marine and terrestrial environments. Their roots anchor to the sediment, providing shelter for an array of marine fauna including fish, invertebrates, and mammals. Their canopy provides habitat, food, and shelter for many terrestrial organisms, including mammals such as tigers and monkeys, birds, reptiles, and insects. Mangroves often show close ecological linkages to adjacent ecosystems, including coral reefs, seagrass beds, salt marshes, and mudflats, supporting a vast network of communities and ecological interactions.[2]

Mangroves also provide many benefits directly to people,[3] and humans have utilized and benefitted from these ecosystems for millennia, especially the numerous local and traditional communities who live adjacent to, or even within, mangroves. Mangroves form a natural buffer reducing storm damage and erosion. Their wood is harvested for timber and fuel. They support fisheries by providing breeding and nursery grounds for many fish and invertebrates.

Through these services, mangroves provide food security, jobs, building materials, and critical protection from extreme events. Many mangrove areas also provide cultural value as places of recreation, tourism, solace, or traditional or religious importance.

1 Spalding, M. D., M. Kainuma, and L. Collins. 2010. *World Atlas of Mangroves*. Earthscan, London

2 Van Lavieren, H., M. Spalding, D. Alongi, M. Kainuma, M. Clüsener-Godt, and Z. Adeel. 2012. *Securing the Future of Mangroves*. A Policy Brief. UNU-INWEH, UNESCO MAB with ISME, ITTO, FAO, UNEP WCMC and TNC, Hamilton, Canada.

3 Ellison, A. M., Felson, A. J., & Friess, D. A. (2020). Mangrove Rehabilitation and Restoration as Experimental Adaptive Management. *Frontiers in Marine Science*, 7.

Local knowledge, combined with local engagement – a group of women in India (see Case Study 9) have been using traditional methods to build biodegradable containers for mangrove saplings. © OMCAR

There has been a surge of interest in the role of mangroves in relation to climate change.[4] Mangroves are among the most effective ecosystems for both carbon storage and sequestration. This, along with their role in protecting coastal communities from climate change impacts (e.g., sea level rise, increased storm intensity), ensures that they can play a key role in mitigation and adaptation strategies to ongoing climate change, putting them at the heart of potential nature-based solutions.

Despite these benefits, mangroves have been at risk since early colonial times. Some historical European and other "outside" observers associated mangroves with negative services, or disservices. In Florida, from the 1700s to the 1900s, mangrove destruction was widely used to control mosquito populations.[5] Mangroves have continued to decline in more recent times as they are cleared for development, tourism, urban expansion, and aquaculture.[6]

Recent years have seen dramatic changes in the perception of mangroves, as their value has been identified, calculated, and supported. The increase in awareness extends well beyond the conservation community and has led to a host of international efforts striving towards halting the loss of, restoring, and protecting mangrove ecosystems - for biodiversity, people, and sustainability.

4 Friess, D. A., Yando, E. S., Abuchahla, G. M. O., Adams, J. B., Cannicci, S., Canty, S. W. J., . . . Wee, A. K. S. (2020). Mangroves give cause for conservation optimism, for now. *Current Biology*, 30(4), R153-R154.

5 Rey, J. R., Walton, W. E., Wolfe, R. J., Connelly, C. R., O'Connell, S. M., Berg, J., ... & Laderman, A. D. (2012). North American wetlands and mosquito control. *International Journal of Environmental Research and Public Health*, 9(12), 4537-4605.

6 Spalding, M. D., & Leal, M. (Eds.). (2021). *The State of the World's Mangroves 2021*: Global Mangrove Alliance.

1.2

Local ecological knowledge (LEK)

With growing interest in conserving and restoring mangroves, it is important to understand the local context where this work occurs, as ecological, social, and economic settings are unique.

Only local people can provide the local context crucial for a holistic view of the mangrove ecosystem.

Local-scale data may be hard to find and include. However, local ecological knowledge (LEK) can play a critical role, providing greater understanding of the local ecological and social context.

In this guide, LEK is defined as "the knowledge, practices, and beliefs gained through extensive personal observation of, and interaction with, local ecosystems, and shared among local resource users".[7]

Over longer periods, such knowledge can accrue and develop between generations, and may be referred to as traditional ecological knowledge (TEK) or Indigenous knowledge (IK) when the local people are Indigenous (Table 1). Here, we consider both TEK and IK to be types of LEK. Holders of LEK typically live locally, but can also include people who have spent extended time within an area.

LEK is often contrasted with academic ecological knowledge (AEK), which has been described as information developed through research-based enquiry, typically using forms of data collection and hypothesis testing learned in academic settings.[8] In reality, distinctions between types of knowledge may not be absolute, and the differences that do exist can be highly complementary.

7 Charnley, S. (2008). *Traditional and local ecological knowledge about forest biodiversity in the Pacific Northwest*. US Department of Agriculture, Forest Service, Pacific Northwest Research Station.

8 Within the literature, AEK is also sometimes referred to as Scientific Ecological Knowledge, Western Ecological Knowledge, or Western Scientific Knowledge. We avoid these other terms as LEK can also be scientific, while much AEK is derived from regions and expertise that is not from the so-called "Western world."

Table 1: Definition of diverse knowledge types.

Local Ecological Knowledge

"The knowledge, practices, and beliefs gained through extensive personal observation of, and interaction with local ecosystems, and shared among local resource users".[7]

Local villager Jeffrey Laia in Kimbe Bay, Papua New Guinea. The knowledge compounded over generations and held by local people is an invaluable asset. © Mark Godfrey

Traditional Ecological Knowledge

"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".[9]

Indigenous Knowledge

Also referred to as Indigenous Ecological Knowledge

"Knowledge and know-how accumulated across generations, which guide [Indigenous] human societies in their innumerable interactions with their surrounding environment".[10]

Academic Ecological Knowledge (AEK)

Also referred to as Conventional Scientific Knowledge, Scientific Ecological Knowledge, or Western Scientific Knowledge

"Driven by theoretical models and hypothesis testing and generated using the scientific method".[11]

"Generated through a strict and universally accepted set of rules informed by academic disciplines (e.g., ecology, biology, or forestry) and by the scientific method".[12]

9 Berkes, F., Colding, J., and Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecol. Appl.* 10, 1251–1262.

10 Thaman, R. R. (2013, September). The contribution of indigenous and local knowledge systems to IPBES: building synergies with science. *Report of the international expert workshop on the contribution of indigenous and local knowledge systems to the Platform*. UNESCO.

11 Charnley, S. (2008). *Traditional and local ecological knowledge about forest biodiversity in the Pacific Northwest*. US Department of Agriculture, Forest Service, Pacific Northwest Research Station

12 Cebrián-Piqueras, M. A., Filyushkina, A., Johnson, D. N., Lo, V. B., López-Rodríguez, M. D., March, H., ... & Plieninger, T. (2020). Scientific and local ecological knowledge, shaping perceptions towards protected areas and related ecosystem services. *Landscape Ecology*, 35(11), 2549-2567.

The inclusion of Indigenous and local communities should be a guiding principle of ecosystem management, with LEK helping to inform planning, implementation, and monitoring associated with restoration and conservation projects.[13]

To do so, researchers and practitioners can look to knowledge co-production, which can inform multiple steps throughout the process, from consultation to dissemination of findings.[14] Knowledge coproduction is the co-creation of knowledge by different groups, such as scientists, managers, communities, or policy-makers. Sharing knowledge and learning from others creates more holistic understanding, and counters conventional one-way knowledge transfer by researchers or project leaders.

By treating LEK as an equal knowledge system from which researchers and practitioners can learn, they will open themselves to an expanse of knowledge that they might be missing. However, this requires an openness to the diversity of LEK that exists. Many focus their attention on LEK relating to ecosystem services (i.e., uses, benefits) or threats, neglecting wide areas of other knowledge.

LEK can help fill knowledge gaps, for example, in data-poor areas that have no historical baseline of quantitative science data such as conditions, biodiversity, or ecosystem uses. LEK can share details about species that live in mangroves, and spatial information about the location of the mangroves and

LEK extends over space and time, and encompasses ecology, hydrology, climate, sociology and more

specific mangrove species, which might be required for reforestation efforts. **Without being aware of such information, scientists or managers may default to low resolution or inaccurate modelling studies, or use global or regional estimates to quantify potential local values.** LEK can also provide deep understanding of the community's relationship to mangroves, historical uses, and current needs. By engaging with this information, local concerns and interests can be better addressed, while community-centered approaches have also been shown to be more effective for restoration and conservation.

The push to include LEK within conservation and restoration has been echoed in multiple policy conventions. However, this is an area that many researchers and practitioners can find challenging. Understanding LEK can require novel approaches and methods and its use comes with ethical responsibilities.

13 Reyes-García, V., Fernández-Llamazares, Á., McElwee, P., Molnár, Z., Öllerer, K., Wilson, S. J., & Brondizio, E. S. (2019). The contributions of Indigenous Peoples and local communities to ecological restoration. *Restoration Ecology*, 27(1), 3-8.

14 Grimm, K.E., Thode, A. E., Satink Wolfson, B., & Brown, L.E. 2022. Scientist engagement with boundary organizations and knowledge coproduction: A case study of the Southwest Fire Science Consortium. *Fire 5* (43).

1.3

Why this guide?

Effective conservation and restoration of mangroves requires a shift in conventional thinking to recognize and engage with the diverse sources of knowledge held by local communities.

In La Guajira, Colombia (Case study 3) mangrove management and access agreements have been developed by Indigenous and Afro-descendant communities, building on traditions, ancestral knowledge and spiritual practices. © Maria Camila Parra

By including LEK in the work of researchers and practitioners, we stand a far greater chance of slowing the loss and degradation of mangroves, and of ensuring stable and long-term outcomes.

This guide explores the need and opportunity for engaging with LEK and approaching it as complementary to other existing ecological, economic, and social science data. It explores the diversity of LEK about mangroves with the aim of expanding awareness and supporting both researchers and practitioners in knowing what they might ask local community members, how to do so, and how such knowledge could help in shaping conservation and restoration projects.

Through discussion of research and case studies of conservation and restoration projects, this guide shows examples from which people can be inspired, while also providing insights on how to improve efforts in ethically and genuinely engaging with LEK.

Accounting for local communities, including subsistence needs, traditions and perceptions has a critical role in designing sucessful restoration and conservation.[15] Although people might struggle to know where to start or how LEK can inform and improve their conservation and restoration projects, the case studies demonstrate there are a multitude of ways to do so.

15 Bosire, J. O., Dahdouh-Guebas, F., Walton, M., Crona, B. I., Lewis III, R. R., Field, C., . . . Koedam, N. (2008). Functionality of restored mangroves: A review. *Aquatic Botany, 89*, 251-259.

Passing on local knowledge, cultural practices and traditional regulations has been central to mangrove conservation in West Papua, Indonesia (Case study 11). © Orlin Ozora Yowei/Konservasi Indonesia

Aims

This guide is intended to encourage wider inclusion of LEK in mangrove research and projects worldwide. Specifically, this guide aims to:

1. **Raise awareness of the variety and scope of LEK** in mangrove ecosystems.
2. **Highlight the value that LEK can bring** to mangrove conservation and restoration.
3. **Encourage increased engagement of LEK** in conservation and restoration projects.
4. **Highlight the importance of equitable collaboration,** in terms of knowledge coproduction, engagement of local people, and working across disciplines.
5. **Provide recommendations and guidance** for practitioners and researchers on whom to engage and how to include LEK in research or projects in ethical and inclusive ways.

1.4 Layout

The guide has four main sections, examining LEK more broadly and then focusing on mangroves.

It begins with a brief background to LEK and highlights the relevance and importance of including LEK in mangrove research and management. Also discussed are increasing policy commitments to LEK in the context of mangrove conservation, and ethical considerations important for any work involving human participants, including holders of LEK.

The next section (Local Ecological Knowledge) contains a synthesis of past research that studied or engaged with mangrove LEK. These studies were identified through a systematic review of peer-reviewed literature. Mangrove LEK is categorized and described along with a synthesis of research methods and approaches towards community engagement. This synthesis provides a greater understanding of the diversity of mangrove LEK; methods for conducting such research; and ways to include community members and their LEK into the research project. Although focused on research studies, this section aims to provide greater understanding of the existing knowledge and approaches that have been used to not only help other researchers, but also help practitioners gain greater insight into mangrove LEK.

This is followed by a series of case studies detailing practical mangrove conservation and restoration projects that engage with and are informed by LEK. Examples from around the world demonstrate the diversity of ways that multiple types of LEK are already informing projects, and ways that communities and their LEK can be included in various stages of a project.

Finally, the guide provides a set of "how to" practical tools to help guide researchers and practitioners looking to include LEK, but unsure of the best approaches.

Figure 1: The main report sections. These icons and headings can be found on the top left of each double page spread, and can be used to navigate to those sections.

2. Local ecological knowledge (LEK)

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Members of the Pate Women's Association in Lamu, Kenya, know the best time and conditions for collecting propagules. © Sarah Waiswa

2.1

Why is LEK important in management and research?

LEK can be a critical information source for natural resource management, even, or perhaps especially, at times when such resources are threatened with change.

Fishing village in Berau Delta, Indonesia. Local knowledge comes from a proximity and familiarity with a place, and often includes a deep understanding of history, ecology and human interactions. © Mark Spalding

Approaches to research or management that do not consider the full and complex array and history of processes in any ecosystem are vulnerable to significant inaccuracies. Bringing in local information can inform broader understanding in research or influence management decisions and implementation. LEK can provide a solid basis and even a check on assumptions and hypotheses. It can also offer insights beyond the limits of conventional scientific analyses.

Part of this holistic approach includes the role LEK can play in providing a historical perspective. LEK can provide unique information on past conditions, including impacts of storms, patterns of seasonality, flooding, human exploitation of resources, and past species and ecosystem functions. LEK can also help to fill gaps in primary data collection, for example, building species lists, resource mapping, or documenting human uses. This can save time, reduce costs, and avoid critical oversights.

LEK is so widely present that many people utilize LEK at some level without being aware of it. At the same time, it is important that such information is properly acknowledged if it is being used beyond the local "owners" of such knowledge.

Despite the importance of considering LEK in research and management, practical guidance on how to do so is often lacking. There are also concerns that the breadth and complexity of LEK can make engaging with it in a meaningful way more challenging.[16]

Examining the different knowledge systems involved in management, as well as places where they overlap, can help in conducting holistic research and generating sustainable and equitable management approaches (Figure 2).

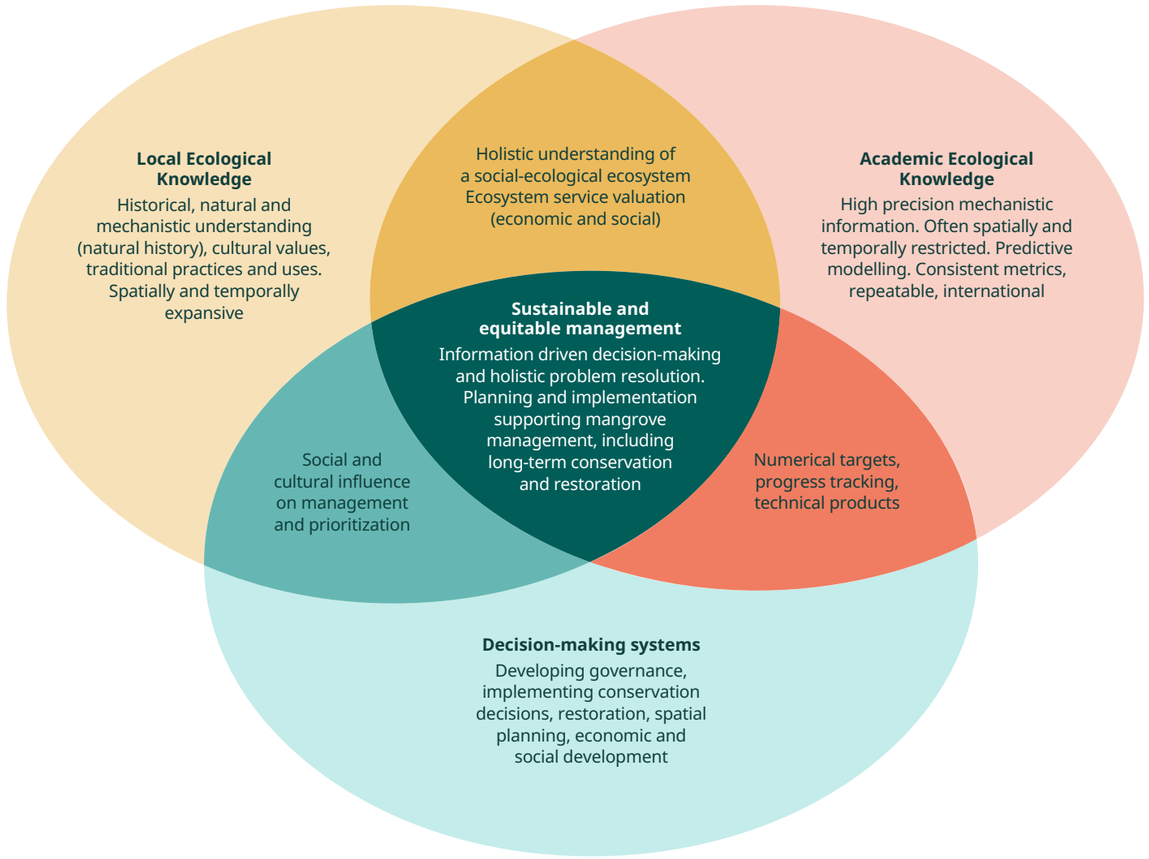

Figure 2: Shared information among LEK, AEK, and decision-making systems. Adapted from Albuquerque et al. 2021.[16]

16 Albuquerque, U. P., Ludwig, D., Feitosa, I. S., de Moura, J. M. B., Gonçalves, P. H. S., da Silva, R. H., ... & Ferreira Junior, W. S. 2021. Integrating traditional ecological knowledge into academic research at local and global scales. *Regional Environmental Change, 21*(2), 1-11.

Ignacia de la Rosa, a leader of the San Antero community in the Cispatá region of Colombia, ensuring Indigenous voices are meaningfully represented and heard during decision-making sessions at the recent United Nations Climate Change Conference in Dubai, United Arab Emirates in December 2023. © COP28 Presidency

2.2

International recognition of LEK

The important links between nature and people have been a key feature of the international policy agenda for many decades.

Even so, there has been increasing awareness of such co-dependence, and particularly on the close connection between local and Indigenous people and their environment. Local knowledge can be seen as a key part of achieving the UN's 17 Sustainable Development Goals.[17] There is thus growing recognition of the importance of LEK and the inclusion of such knowledge into practical action, which is called for in a number of key international policy tools (Table 2). Under the UN Decade on Ecosystem Restoration, for example, *"Integrating Indigenous knowledge & traditional practices into ecosystem restoration initiatives"* is seen as one of the ways to overcome barriers and achieve the vision of preventing, halting, and reversing environmental degradation.[18]

Local villager Ko Myo Naing places crab traps in the mangroves near his village, Wae Ma Gite. Wae Ma Gite and three other villages in the Tha Kyet Taw area in Myanmar depend on the mangroves. © Minzayar Oo - WWF-US

17 Kumar, A., Kumar, S., Komal, Ramchiary, N., & Singh, P. (2021). Role of traditional ethnobotanical knowledge and indigenous communities in achieving Sustainable Development Goals. *Sustainability, 13*(6), 3062.

18 The United Nations Decade on Ecosystem Restoration. Strategy. United Nations. https://wedocs.unep.org/bitstream/handle/20.500.11822/31813/ERDStrat.pdf?sequence=1&isAllowed=y

Table 2: Examples of global policy instruments and frameworks, their purpose, and the key components related to local ecological knowledge.

Policy Instruments & Frameworks	Purpose	Key components relevant to Local Ecological Knowledge	Reference
UN Convention on Biological Diversity	**"...**the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources..." (Article 1)	"...respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge innovations and practices." (Article 8j)	Text of Convention – Article 8 In-Situ Conservation
United Nations The United Nations Decade on Ecosystem Restoration (2021-2030)	"To prevent, halt and reverse the degradation of ecosystems"	Technical capacity pathway: "Integrating indigenous knowledge and traditional practices into ecosystem restoration initiatives." "Using appropriate institutional mechanisms, to increase the upscaling of ecosystem restoration globally by strengthening the role of science, indigenous knowledge and traditional practices and applying best technical knowledge and practice". "Importantly, comprehensive assessments of local and indigenous knowledge, as well as traditional practices, are likely to be critical starting points for many restoration initiatives".	The United Nations Decade on Ecosystem Restoration Strategy Strategy document
UNEP Convention on Biological Diversity. Kunming-Montreal Global Biodiversity Framework	"an ambitious plan to implement broad-based action to bring about a transformation in our societies' relationship with biodiversity by 2030... and ensure that, by 2050, the shared vision of living in harmony with nature is fulfilled."	Target 21: "Ensure that the best available data, information and knowledge, are accessible... to guide effective and equitable governance, integrated and participatory management of biodiversity, and to strengthen communication, awareness-raising, education, monitoring, research and knowledge management and, also in this context, traditional knowledge, innovations, practices and technologies of indigenous peoples and local communities should only be accessed with their free, prior and informed consent...". Target 22: "Ensure the full, equitable, inclusive, effective and gender-responsive representation and participation in decision-making, and access to justice and information related to biodiversity by indigenous peoples and local communities, respecting their cultures and their rights over lands, territories, resources, and traditional knowledge, as well as by women and girls, children and youth, and persons with disabilities and ensure the full protection of environmental human rights defenders."	CBD/COP/15/L.25
Ramsar Convention on Wetlands	"Conservation and wise use of all wetlands".	"The traditional knowledge, innovations and practices of indigenous peoples and local communities relevant for the wise use of wetlands and their customary use of wetland resources are documented, respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention, with a full and effective participation of indigenous peoples and local communities at all relevant levels".	Goal 3, Wisely using all wetlands. Target 10. The 4th strategic plan

2.3

Ethical awareness, understanding, and responsibility

Conservation and restoration activities always involve people, and therefore, ethics must be considered at all stages.

LEK can be a core component through all project stages and inform a variety of activities in which the community is engaged including consultation, data collection, and education and outreach.

Villagers on their way to a restoration site. Through participatory mapping, community members designated areas to be restored. Read more in Case Study 16. © Cicelin Rakotomahazo

When conducting any project that includes local participants, there are ethical and legal obligations that must be understood and followed. Successful, responsible engagement with local people requires that planners, researchers, and practitioners follow clear ethical standards, even though these can be challenging and time-consuming.[19]

Such standards and obligations can take on further meaning when working with Indigenous peoples, given a history of unethical behavior toward them and their lands. In September 2007, the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) called for the recognition of the rights of Indigenous peoples to their lands. Such areas include a significant proportion of natural areas around the planet.[20] They are important

19 Brittain, S., Ibbett, H., de Lange, E., Dorward, L., Hoyte, S., Marino, A., ... & Lewis, J. (2020). Ethical considerations when conservation research involves people. *Conservation Biology, 34*(4), 925-933.

20 Garnett, S.T., Burgess, N.D., Fa, J.E. et al. A spatial overview of the global importance of Indigenous lands for conservation. *Nature Sustainability* 1, 369–374 (2018). https://doi.org/10.1038/s41893-018-0100-6

Working with local people requires collaboration and equitable approaches, generating outputs where all participants feel engaged and can benefit, as exemplified in Case Study 16. © Cicelin Rakotomahazo

for carbon storage, global biodiversity conservation, and many other benefits, but they are also intertwined with important cultural heritage and traditional uses.

Working within local and Indigenous peoples' lands requires building collaborative and equitable approaches. **While many past conservation actions excluded and removed Indigenous or local people from their land,[21] their rights and needs are now widely recognized and highlighted in international law and agreements.**[22] In some cases, such ethical approaches are enshrined in law and many countries require permits for working with local or Indigenous people. Similarly, funders and participating organizations often have specific ethical policies that must be considered as part of project planning. On the ground, this requires all those hoping to study or work on natural resources at local scales to engage more directly, building up a knowledge base to be able to understand the background of the local community, local requirements, and expectations before beginning any project. See Section 5 for more about ethical concerns; resources; and ways to approach research, conservation, and restoration projects ethically.

21 Colchester, M. 2004. Conservation policy and Indigenous peoples. *Environmental Science & Policy 7*:145-153.

22 United Nations Declaration on the Rights of Indigenous Peoples. *www.un.org/development/desa/Indigenouspeoples/wp-content/uploads/sites/19/2018/11/UNDRIP_E_web.pdf accessed 1st July 2022*

3. Local ecological knowledge in mangrove research

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On route to visit mangroves on Lembongan Island, Indonesia. Approximately 30 miles from Bali. Mangrove forests are "fish factories" that support fishing jobs and food security. © Kevin Arnold

3.1

Introduction

A growing body of literature shows that there is considerable interest in learning from the people who live in, rely on, and hold extensive knowledge about mangroves.

Local people in Indonesia providing information on crab fisheries. © Orlina Yowei

However, to our knowledge, no reviews have examined research that has studied or engaged with LEK of mangrove ecosystems. Therefore, we undertook a systematic review specifically targeting LEK in mangrove research. This includes research learning about the LEK of communities as well as the inclusion of LEK in data collection or project planning. From the findings of this review, we have categorized the LEK discussed (e.g., causes of degradation, mangrove identification, ecosystem services), as well as identified methods used to gather such knowledge, the approaches to including local people and their knowledge, and adherence to ethical guidelines.

The review provides a greater understanding as to how researchers have engaged with LEK and what local knowledge has been studied, which can provide guidance towards best practices, encourage further engagement with LEK by other researchers, and illuminate existing knowledge gaps and areas for improvement.

3.2

Approach

The review process involved four main steps:

Step 1:

A systematic review, undertaken in July 2021, used keywords to identify 1158 peer-reviewed conservation or restoration papers that were mangrove-focused, and studied or engaged with LEK.

Step 2:

This full list was reviewed at the title and abstract level to filter out less relevant studies, leading to a shortlist of 520 studies.

Step 3:

The shortlist of 520 studies were then read as full texts using pre-determined accept/reject criteria to identify 90 studies with sufficient information for data extraction.

Step 4:

A database was developed describing standardized details for each of the 90 studies including location, purpose, methodology, types of LEK, inclusion and engagement approaches, and study results.

For the identification of types of LEK, a classification was developed during the data extraction. At the highest level, knowledge types were broadly grouped into three main themes: ecosystem, biodiversity, and human-mangrove interactions (Figure 5, Appendix 2). Within these themes, LEK was classified into nine categories (e.g. ecosystem change, endangered species, ecosystem services) and further categorized into 40 types of LEK.

3.3

Findings

The 90 studies reviewed here contain a diverse array of research topics and approaches.

Most are recent and point to an accelerating interest in LEK in the research community (Figure 3). Geographically, they are also widespread, representing research from all five mangrove continents (Figure 4).

The following sections describe and categorize the LEK-related research from these 90 studies, considering first the types of LEK examined, and then approaches used in LEK research and engaging with communities. While much of the research describes an academic approach to assessing or using such knowledge, the value of LEK for conservation and management is nonetheless a common area of focus in many of these studies.

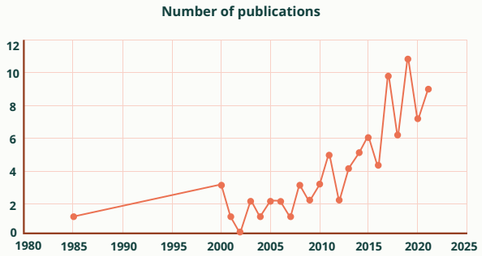

Figure 3: The identified studies covered 1985 through 2021, with the number of papers increasing notably since 2010.

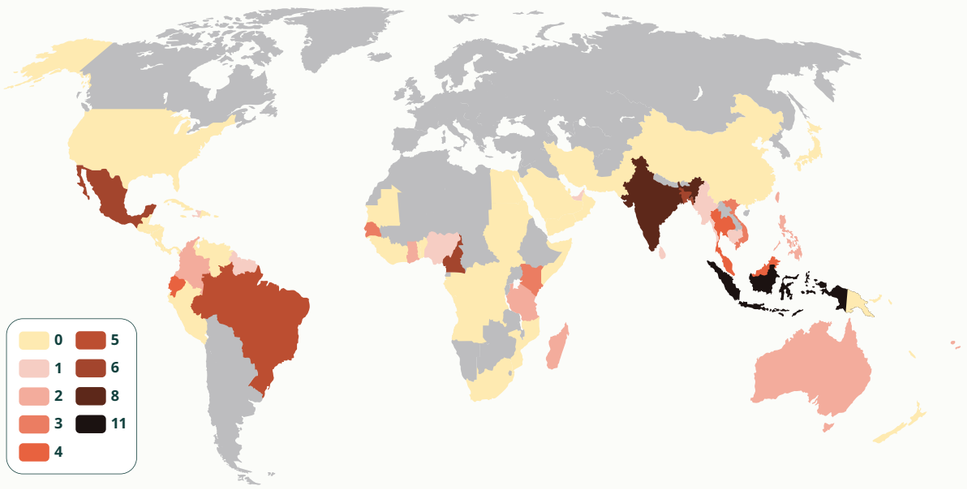

Figure 4: A total of 30 countries from all five continents are represented in the 90 studies. Studies in Asia (n=43) predominate, followed by Africa (n=22).

3.3.1 Mangrove LEK

Understanding the diversity of mangrove LEK that exists can help both researchers and those involved with on-the-ground projects increase efforts to engage more with this knowledge.

Although the LEK described across the studies is highly varied in scope and context (Figure 5, Appendix 2), clear trends existed that allowed us to create a classification. Most of the studies (77%) discussed multiple types of LEK across the three main themes. Ecosystem-level LEK included information on ecosystem state, ecosystem change, or ecosystem function. Biodiversity LEK topics included mangrove species, endangered species, and other faunal species in mangroves. Most common was research examining LEK on human-mangrove interactions, which included ecosystem impacts, ecosystem services, and applied management. To increase understanding of the diverse LEK that exist about mangroves, we provide practical examples that illustrate each mangrove LEK type.

For those seeking additional information about these examples or other studies that examine specific types of LEK, please see the reference list (Appendix 1) or table illustrating the type or LEK present in each paper (Appendix 2).

Mangroves expanding into grassland in Pemba Island, Tanzania. Although initially invisible on satellite images, such changes are quickly noted by local people. © Mark Spalding

Figure 5: Mangrove LEK themes, categories, and types found in the 90 reviewed papers. Numbers correspond to the number of studies that included LEK about that topic.

Ecosystem:

Local communities will often know more about the **extent and location of the mangrove ecosystem** than outsiders, and that knowledge is widely cited in many studies.

> *Residents from three coastal sites in Busuanga, Philippines participated in a mapping activity where they identified the location of 353.67 ha of mangroves in the study area, which contributed to increasing the accuracy of existing maps (Francisco et al. 2019).*

Local knowledge about the ecosystem **state**, or the current condition of the ecosystem, including its physical, chemical, and biological characteristics, are reported in many of these studies.

> *Fishers from three villages near Pak Phanang Bay rated the state of the mangroves from degraded to healthy, which allowed for differences between villages to be identified (Jumnongsong et al. 2015).*
>
> *Interviewees informed Griffin et al. (2013) about the destruction of mangrove forests in Aceh, Indonesia after the 2004 tsunami and how this led to fewer fish and invertebrates collected.*

Most discussions of ecosystem recovery focused on restoration efforts and were classified under human-mangrove interactions; however, a few papers explored people's knowledge about the **recovery of the ecosystem** due to natural factors.

> *Local people in Bobaneigo Bay, Indonesia reported to Amin (2019) that there was significant improvement in mangrove forests over the past 15 years, which they attributed to decreased firewood collection and the reappearance of crocodiles.*

Many studies explored LEK about **ecosystem change**, especially **spatial** and **temporal change**. These often overlapped, as locals shared how the size (spatial) of the mangrove ecosystem had changed over the years (temporal).

> *Fishers interviewed by Kovacs (2000) were able to describe in detail the changes in mangrove extent and differential responses by species, while also reporting abiotic changes such as increased salinity.*
>
> *Local fishers reported perceived increases in mangrove cover in parts of the Godovari Delta. Although this observation ran counter to remotely sensed observations, it highlights the differences in scale and location, with fishers noting increases into the channels, and probably focused near their villages, while remote-sensing imagery was noting losses away from channel margins (Dahdouh-Guebas et al. 2006).*

A flamingo in Mexico foraging in a mangrove forest decimated by a hurricane. © Miguel Diaz / TNC Photo Contest 2023

Less common were studies that included local knowledge about **seasonal or climatic changes in the ecosystem**. Seasonal changes included changes in tides or flowering patterns, whereas climatic changes were often those associated with events related to climate change, such as increased storm and flooding frequency.

The importance of particular areas within the mangroves as nursery grounds is often well known to local fishing communities. © Mark Spalding

> *In Cameroon, local knowledge informed researchers that seasonal flood risk was greatest July-October. Over half the respondents believed this risk was increasing due to heavier rainfalls (Munji et al., 2014).*
>
> *Marschke et al. (2014) recounted climatic changes locals had observed in the weather and tides, and the impacts these had on fishers and mangrove ecosystems in Cambodia.*

Fewer studies reported LEK about **ecosystem function**. Most often these studies involved information about **connectivity** or **nurseries.**

> *Zapelini et al. (2017) used fishers' observations to understand the distribution and movements of goliath groupers between mangroves and offshore ecosystems in Brazil, while Berkström et al. (2019) undertook similar studies to study fish migrations in Zanzibar, Tanzania.*

A small number of studies included information about **community dynamics,** or changes in the community structure and composition over time, often following environmental disturbances.

> *Respondents on Nijhum Dwip Island, Bangaldesh, said that after a 1991 cyclone, they observed many large uprooted trees and wild animals killed. They also reported recent conflicts with deer, especially on farms, which they attributed to population increases due to lack of predators, reduction in natural food sources, and increasing siltation leading to decreased water availability (Iftekar & Takama, 2008).*

Biodiversity:

Local knowledge about the species within their mangrove area represents another highly valuable type of information source, often informed from extensive presence within the mangroves and by knowledge over considerable time periods.

Participants shared their knowledge about **mangrove species**. Often, this involved **identifying specific mangrove species** or understanding the level of knowledge locals had about the different species. LEK included different uses for specific mangrove species, thereby indicating awareness of species' unique properties.

> *Dahdouh-Gueba et al. (2006) found that 83% of respondents had good or very good knowledge about the 13 mangroves species in the area.*
>
> *Nfotabang et al. (2009) surveyed loggers and villagers about different mangroves species and their uses, as well as preferred commercial species. For example, Avicennia germinans had numerous uses including fuelwood for cooking and smoking fish, timber poles for banda (table-like construction to smoke fish) construction, and fishing traps. Meanwhile, the leaves of Nypa fruticans were used as thatching material for house walls and roofs.*

In other instances, LEK holders provided information on the **state,** such as degradation or declines in specific mangrove species, or the **presence/absence of mangrove species**. This differs from the state or location of mangrove ecosystems, as these respondents focused on specific mangrove species.

> *Local plantation owners shared with Hassan et al. (2018) their sources of propagules that they collected from local tree sources, indicating the presence of those species in the area.*
>
> *Locals in three Indonesian villages identified their preferred uses for each mangrove species (e.g., Rhizophora mucronata for construction, craft, and fuel). They then shared which uses of certain species had declined indicating a decrease in the availability of these species (Furukawa et al. 2015).*

Roots of Rhizophora *and* Pelliciera *mangroves in a Colombian forest – local community members often know a great deal about the distribution of different species. © Mark Spalding*

A few studies included LEK **about mangrove growth,** which could include either discussions of regrowth after planting efforts or general growth patterns of a species. Along with growth, some studies discussed respondents' knowledge about the **height of mangrove species**, which often was in relation to harvesting practices.

> *Older residents shared with Walters (2005) that some mangrove trees once stood 30 m tall, which is twice as high as the tallest remaining trees.*
>
> *Community members from Vietnam's Vam Ray coastal area shared daily observations of natural growth and regeneration of mangrove species in the project (Nguyen et al. 2017).*

Proboscis monkeys are an endangered species, only found in the mangrove forests of Borneo. Coastal communities are well-placed to know about their distribution, status, and about changes in populations through time. © Donny Sophandi / TNC Photo Contest 2021

In addition to mangrove species, community members held much LEK about **faunal species** that lived in or relied on mangrove ecosystems. Species discussed often included types of crabs, fish, shellfish (e.g., Carney 2017, Treviño & Murillo-Sandoval 2021)**.**

Many researchers have engaged with LEK holders in fauna **species identification,** and to a lesser extent **species range,** or the distribution of species across an area. Identification sometimes occurred by showing respondents pictures of species, but in other cases, respondents initiated the identification by pointing out the species.

> *In Bali, Indonesia, different resource user groups identified the distributions of various fish species, which informed Seary et al.'s (2021) map of species ranges in the Perancak Estuary.*

A local community member in northern Pemba Island, Tanzania describing local mollusk species. © Mark Spalding

Other researchers turned to local knowledge to assist with gathering information about **species presence/absence** or **abundance –** the total number of individuals present in the ecosystem. Abundance was often described as general trends rather than specific numbers, such as a lot of oysters encountered in a certain location.

> *Concheras in Ecuador's Esmeraldas province carried GPS trackers, recording the routes they traveled and locations they visited to collect cockles. Interviews also revealed that cockles were present in mangroves, but men were more likely to access these locations because they did not have the same safety concerns (Treviño & Murillo-Sandoval 2021).*

Information on the **size of individuals** usually related to species collected or caught in a fishery. Size was often asked to understand resource users' perceptions as to whether the size of individuals of that species had changed over time.

> *Fishers in three villages around Colombia's Ciénaga Grande de Santa Marta had different perceptions of the size of the fish they caught. The majority of respondents in two villages viewed the size of individuals caught in 2015 similar to those caught in 2010, but over half of respondents surveyed in a third village reported smaller individuals (Carrasquilla-Henao et al. 2019).*

Species change focused on changes that local participants had observed concerning species that live in or rely on mangrove ecosystems. Often, species change was discussed in relation to size, abundance, or presence of species, usually as declines observed in fisheries species such as fish, mollusks, and crustaceans.

> *Local people in Sri Lanka had observed decreased fish in mangrove water channels (Satyanarayana et al. 2013).*
>
> *Fishermen in the India's Godavari mangroves reported declines in fish catch (Dahdouh-Guebas et al. 2006).*
>
> *Crab fishers shared how Lethargic Crab Disease was decimating Ucides cordatus crabs and impacting the Brazilian crab harvesting community in Bahia State (Firmo et al. 2011).*

When LEK holders were asked about **endangered species**, it was often about the **presence/absence** of such species. The most commonly discussed endangered species included sawfish (Hossain et al. 2015, Leeney & Downing 2016) or manatee (e.g., De Thoisy et al. 2003, Choi et al. 2009, Mayaka et al. 2013).

Researchers asked local people to share information about **identification**, **population size,** or **distribution** of these endangered species. Relying on local knowledge and observations is crucial especially for endangered species, as their smaller numbers can pose challenges for a researcher trying to make accurate counts during a short field season.

> *Given that participants often use local names for sawfish, Hossain et al. (2015) showed an image when asking people in Bangladesh if they had encountered a sawfish to ensure they were speaking about the same fish; if they had, participants were asked about their most recent encounter (e.g., time and location of encounter, estimated length and weight of species).*
>
> *Responses from resource users about manatee viewings in various locations and trends in population numbers helped Mayaka et al. (2013) gain a better understanding of the species' distribution in Cameroon.*

Human-mangrove interactions:

LEK holders were often asked to share their knowledge about **ecosystem services**. As with much research on ecosystem services, participants were usually asked about uses of or benefits received from the mangrove ecosystem. The types of ecosystem services shared by local respondents could be categorized as provisioning, regulating, cultural, or supporting ecosystem services.

Provisioning ecosystem services were the focus of most ecosystem services studies. These refer to benefits that can be extracted from nature, in other words, products that are provided to people. Given the numerous products from mangroves and the broader ecosystem, we focus on major trends rather than create an exhaustive list of all uses and benefits shared by local respondents. The bulk of the studies focused on LEK about subsistence or commercial benefits, such as **fisheries, forest food products** (e.g., honey), fuelwood, and **timber** (typically as poles for construction). Mangroves also provided resources for **medicines, dyes, and crafts.**

Ecotourism is a cultural ecosystem service being developed in many communities and typically highly dependent on local knowledge and guides. © Pete Bunting

Respondents in Kerala reported using mangroves for fuel wood, building materials for house construction, and poles for spreading nets or anchoring canoes (Hema & Devi 2014).

Avtar et al. (2021) found that mangrove mud crabs were the most common catch sold in both the Ba and Rewa Deltas in Fiji; other common fauna included fish, mud lobster, and shrimp, although these were of differing importance to communities in the two deltas.

Along Kenya's coast, various parts of mangrove trees provided medicines for different ailments, such as Rhizophora mucronata *roots, which were said to address constipation, infertility, and menstruation discomfort. Respondents also shared that stems of this species were used as a dye or tanning compound, which helps preserve canoes and boats (Dahdoud-Guebas et al. 2000)*

Regulating services refer to the role that mangroves play in the maintenance of the ecosystem. Respondents most often shared their knowledge about **coastal defense, such as erosion control, flood prevention, and storm protection.**

Nyangoko et al. (2020) found that after provisioning services, the communities in Tanzania's Rufiji Delta most often selected regulating services as a benefit of mangroves, which included sediment trapping, climate regulation, and coastal protection.

Cultural services include non-material benefits from the ecosystem. These papers most often described cultural services related to **traditional or religious values**, as well as the role mangroves played in **recreation and tourism.**

Fishing (St Kitts and Nevis), honey production (St Lucia), and boat-building (Kalimantan, Indonesia) are among the many benefits from mangrove forests. © Mark Spalding

The Sundarbans are a center of belief and rituals for local Hindu communities, with festivals and temples occurring there (Islam et al. 2018).

Recreational and ecotourism opportunities shared by local resource users included mangrove walks, wildlife watching, or boat cruises in Bangladesh's Sundarbans (Chakraborty et al. 2020).

Community members from villages near India's Bhitarkanika Conservation Area also indicated that mangroves hold aesthetic values for them (Badola et al 2012).

Supporting services are those that are necessary for the production of other ecosystem services. Most respondents focused on the role that mangroves played in **supporting biodiversity as a wildlife and nursery habitat.**

Fishers in three villages around Ciénaga Grande de Santa Marta in Colombia said that mangroves were critical habitats for fishery resources because they served as nurseries, as well important locations for food and reproduction (Carrasquilla-Henao et al. 2019).

Ecosystem impacts were also discussed in many papers. Most LEK focused on **threats**, or processes and events that can cause negative impacts to an ecosystem or people living there. People shared several threats to mangroves or species living in mangroves, but commonly mentioned were mangrove cutting, pollution, overfishing, and climate change.

More than half the villagers interviewed around Cameroon's Wouri Estuary and the Douala-Edea Reserve said that there was a negative change in mangroves, which they attributed to selective harvesting and uncontrolled deforestation (Nfotabong-Atheull et al. 2009).

Local resource users in Cameroon's Lower Sanaga Basin stated that manatee populations were threatened by pollution, excessive killings, and habitat loss (Mayaka et al. 2013).

In the Sundarbans, the communities believed that climate variability, climate change, and extreme climatic events have had extensive impacts on the resources and their livelihoods (Singh et al. 2019).

The impacts on mangroves from the rapid urbanization in the Persian Gulf have been considerable, and while "local" communities are large, only a few will recall details of the former mangrove areas and their ecology. © Mark Spalding

A flood-prevention embankment affected the hydrology of these mangroves and led to die-off. Researchers are using a combination of LEK and AEK to develop restoration plans. © Dominic Wodehouse, MAP

Often the **impacts**, or effects on organisms and the ecosystem, due to these human or biophysical threats were a reduction of size or degradation of the mangrove ecosystem; fewer species, such as fish, in the ecosystem; or other physical changes, such as erosion and sedimentation.

> *In southeastern Mexico, residents explained that deforestation, burning, channeling of rivers, and pollution has led to mangrove degradation (Reyes-Arroyo et al. 2021)*
>
> *Fishermen in Mexico's Teacapan-Agua Brava Lagoon reported that opening a canal increased salinity that in turn decreased abundance of certain fauna, such as fish and sea turtles (Kovacs 2000).*
>
> *Decreases in fish, fruit, birds, and water quality were seen by residents in the Solomon Islands, which they attributed to declines in mangroves (Warren-Rhodes et al. 2011).*

Although **drivers of loss** can at times overlap with threats, they often can capture indirect causes that are less tangible and more removed from the locale. In terms of mangroves, drivers were often related to global demand for mangroves and other species, especially fish and shrimp; climate change; and international tourism and development interests.

> *In addition to climate impacts, local people in the Sundarbans identified demand for mangrove products on the global markets, major infrastructure development, and governance failure as some of the drivers leading to degradation of mangroves and related ecosystem services (Islam et al. 2018).*

LEK about **applied conservation and management** was included in the papers in a variety of ways. Commonly shared was knowledge about **conservation and restoration strategies**, which were diverse, and

Rapid increases in coastal erosion in this village in Berau, Indonesia were linked to overgrazing of mangroves in coastal areas by free-ranging cattle. © Mark Spalding

included replanting mangroves, building fences for erosion, or awareness campaigns. In many cases, locals were involved or initiated in these strategies. However, other studies sought to understand peoples' awareness of ongoing or past conservation and restoration work in the area.

> *In Ecuador's Association Isla Costa Rica, community members recounted their efforts to plant mangroves because of the role mangrove forests play in supporting commercial and subsistence fisheries (Beitl et al. 2019).*
>
> *Ocampo-Thomason (2014) described a grassroot movement that established a reserve with a strict permitting system in Ecuador's Ecological Mangrove Reserve Cayapas-Mataje (REMACAM).*

Researchers also asked locals about their **conservation attitudes**. This included attitudes about the ecosystem in general, such as needs to protect or conserve mangroves and associated biodiversity, as well as their views of conservation actions that have or should be taken in their area.

> *Badola et al. (2012) reported that 84% of the people surveyed in East India felt responsible for conservation and 93% were in favor of an integrated conservation and development program.*

Community members also shared their knowledge about **community participation in past activities**, such as tree planting efforts or sustainable management approaches, as well as successes and challenges they encountered in engagement.

> *In talking with community members, Nguyen et al. (2016) learned that although a previous project in the Vam Ray coast had been successful and the local community had been involved in project planning and implementation, the implementation and results were poorly documented by agencies largely because there was little local involvement during the reporting process.*

Several studies also reported local respondents' **knowledge about land tenure or laws**, either traditional or modern. For the former, respondents shared information about who traditionally owned land or resources and customary laws guiding use. LEK also included reference to modern day ownership and boundaries, such as national parks or marine reserves, and laws that governed these resources, such as mangrove cutting permits or fishing regulations.

> *Iftekhar & Takama (2008) found that slightly more than half the respondents knew that the nearby forest in Bangladesh was a national park and had heard about the Forest Act.*

Understanding ownership and land tenure may be critical for mangrove protection or restoration, especially in Southeast Asia, where aquaculture, like the shrimp ponds pictured here, may go back generations. Local communities may be the sole holders of such knowledge. © Mark Spalding

> *Local plantation owners on the Solomon Islands explained the traditional mangrove tenure and rules that existed for requesting permission for access or use of mangroves (Warren-Rhodes et al. 2011).*
>
> *Older fishermen who used Fosu Lagoon in Ghana shared taboos that guided their fishing decisions, such as avoiding night fishing so as not to disturb the god Nana Fosu who occupies the lagoon (Darkwa & Smardon 2010).*

Conflicts varied greatly, and included but were not limited to issues around land tenure, outsider pressure on mangrove harvesting or fishing (e.g., Dahdouh-Guebas et al. 2006, Ocampo-Thomason 2014, Damastuti & De Groot 2017), corruption, and policies that disregarded traditional uses.

> *In the Sundarbans, respondents reported paying excessive fees to corrupt forest officials to gain access to the mangrove forest to collect resources (Islam et al. 2019).*
>
> *Artisanal fishers in Ecuador shared conflicts they encountered with shrimp farmers due to ineffective policies around resources and territory. Collective action led to stewardship rights for artisanal fishers and other ancestral user groups in support of mangrove conservation (Beitl et al. 2019).*

Although several studies discuss artisanal fishers, only some described **traditional/artisanal fishing, preservation, or craft** practices they learned from local respondents.

> *From locals in the La-ngu District in Thailand, Kaewploy et al. (2018) learned indigenous serrated mud crab fattening practices, such as pond preparation, rituals, feeding management, and harvesting approaches, all of which had been passed down within families.*
>
> *Women in The Gambia and Senegal paid close attention to the lunar cycles so that they could synchronize journeys to oyster and crab sites with the ebb and flood tides (Carney et al. 2017).*
>
> *Traditional building approaches have also been used in mangrove restoration work; traditional Melaleuca fences used in the Vam Ray coastal area were the foundation for upgraded designs constructed to address erosion (Nguyen 2019).*

Traditional uses of mangroves such as the use of mangrove poles for home-building here in Mtangawanda, Kenya, can only be learned in a local context. © Sarah Waiswa

Engagement with local communities and the benefits derived from sharing their knowledge can have important ethical dimensions which must be considered prior to engagement. © Leo Thom, MAP

3.3.2 Community involvement in LEK research

An ethical approach to engaging with LEK involves equitable and inclusive community engagement and knowledge co-production. Here we discuss the diverse approaches used by authors in our review for engagement with LEK holders.

Consideration of ethics

Before engaging in any research involving people, but especially important when working with Indigenous or marginalized communities who have a long history of poor treatment, it is necessary to consider how these groups and their LEK will be ethically treated and included.

Consideration of ethics might be a formal process, such as the granting of ethical clearance required by an institution or country, or it might consist of discussion and planning ethical approaches prior to including local people in the study. We found only 13% of papers explained how they considered ethics in their research (Figure 6). Only four studies indicated they had conducted a formal ethical clearance, with three of these having in-country authors. However, it is only recently that many journals require proof of ethics approval, and so it is possible that not all studies reported such processes even if they did employ them.

Frequency of engagement

Extended engagement with the community can be important both in generating useful outcomes and for building trust.

"Parachute science", where international researchers arrive, sometimes suddenly and without advanced communication, to gather knowledge from community members and then leave without any meaningful engagement, recognition of local contributions, or sharing of findings or products with local researchers and stakeholders, has been widely criticized.[23]

It is notable that, other than some pre-collection preparation, only about a quarter of the studies specifically indicated meeting with local communities on two or more occasions. For the remainder, most only met once with any particular stakeholder or group from the community (e.g., fishers).

Research needs to be sensitive to local culture and researchers should allow time for full engagement with the community.

Clearly, the research projects and goals are themselves highly varied. Some were based on single site visits, such a gathering data based on one-time survey encounters, preventing the possibility of multiple engagements. Also, in some cases, the paper was part of a larger study that engaged the community more. For example, Treviño & Murillo-Sandoval (2021) resided in the community with a local family during multiple field stays while learning about the community and its use of mangrove resources in Ecuador's Muisne River Estuary.

Studies that included several meetings sometimes involved multiple data collection approaches with the same individuals, such as interviews, observations, and workshops (Deb 2015). Several studies involved multi-step participatory approaches, such as Brown et al.'s (2018) work with traditional knowledge holders in Australia. Rakotomahazo et al. (2019) described validation meetings with participants who had participated in earlier parts of the process, which is discussed in greater detail below.

Regular, sustained engagement by researchers with local people can yield richer and more detailed information than one-off, short-term visits (photo: Mangrove Action Project trainers and members of local associations in El Salvador in 2023, monitoring a restoration project started in 2011. © MAP

23 Stefanoudis, P. V., Licuanan, W. Y., Morrison, T. H., Talma, S., Veitayaki, J., & Woodall, L. C. (2021). Turning the tide of parachute science. *Current Biology, 31*(4), R184-R185.

Many studies hove focused on describing or learning from LEK, but relatively few have actually included LEK as a contribution or source of knowledge integral to their work. (photo: TNC researchers in Papua New Guinea). © Annette Ruzicka

Including LEK in research

The inclusion of LEK in research can take various forms. We categorized these into three classes: studied LEK, learned-from LEK, and included LEK.

Studied LEK involved research where the focus was learning about people's LEK, such as perceived benefits or causes of degradation. This comprised the majority of the studies (n= 62). Studying knowledge is an important first step to including LEK in meaningful ways, and several researchers mentioned in their conclusions that understanding this knowledge could inform policy or conservation actions (e.g., Than et al. 2022, Carrasquilla-Henao et al. 2018, Carney 2017). **However, we encourage researchers to consider more inclusive ways of engaging with LEK.**

A more inclusive approach involved **learning from LEK.** Only ten studies fell into the learned from LEK class. This category involved research that relied on LEK to inform the research question. Examples included working with locals to identify species in field surveys or information in the interviews that helped inform their research. For example, Leeney and Downing (2014) interviewed fishermen to better understand the presence of sawfish in the Gambia River; between historical and present-day interviews with fishermen, the authors could demonstrate that the Gambia River had been a key habitat for freshwater sawfish and therefore it should be considered in future conservation actions. Another common way that researchers learned from community members was how LEK could inform conservation or restoration actions. For example, Deb (2015) learned how the community had incorporated LEK into fishing rules and noted that policy makers would benefit from including this knowledge into policies and management plans.

Even fewer studies (n=8) **included LEK** in their research. In these cases, locals played a significant role in the research process. They include those where LEK holders assisted with ecological data collection by contributing their LEK to the data set, such as bird inventories (e.g., Gardner et al 2017, Salter & MacKenzie 1985) or cases in which their LEK was integral in informing project outcomes, such as planning and resource zonation (e.g., Brown et al. 2018, Mateos-Molina et al. 2020). Many of these examples illustrate the complementary nature of LEK and AEK.

Engagement in knowledge co-production activities

Researchers looking to engage in two-way knowledge sharing with local communities can look to knowledge co-production approaches for guidance.

Knowledge co-production can occur at multiple points in the process, including **consultation, project design/planning, implementation, monitoring/ data collection, data analysis**, and **dissemination** of findings and educational materials. In our review, 11 papers included communities in some of these steps. Although we realize that knowledge co-production may not be feasible for all research projects, we provide some examples below to inspire researchers and practitioners interested in exploring such approaches in their own work.

The most common way projects included knowledge co-production was through **data collection**, such as species identification or inventorying (Gardner et al. 2017), which is discussed in greater detail below. Despite its importance, no studies mentioned **consulting** with local communities to determine what might be researched based on the community knowledge, needs, or concerns. This step can be challenging, however, because funders require clear research questions before awarding funding; it might be more feasible when the researcher is already familiar with the community.

Project design and planning, implementation, and **data analysis** were often present in interactive activities like knowledge-sharing workshops or participatory mapping, where local people are invited to share their knowledge through mapping. In Madagascar, the work of local people was ubiquitous across a project to develop a mangrove payments for ecosystem services initiative and members from 10 coastal communities were involved in several knowledge co-production activities. They helped with **project design and planning** during participatory mapping and concept modelling workshops that developed a spatial and social-ecological understanding for both researchers and the communities (Rakotomahazo et al. 2019).

Knowledge co-production is the co-creation of knowledge, for example by scientists and community members. Here, researchers and community groups share their restoration experiences during a learning exchange in Ecuador. © Laura Michie, MAP

They also engaged in **project implementation** by proposing management approaches that formed the basis of the final zoning and management plan. Community involvement in **data analysis** often included analysis of mapping exercises. Further examples included studies from Indonesia (Damastuti & de Groot 2019) and the United Arab Emirates (Mateos-Molina et al. 2020), where involving participants in analysis not only enhanced the benefits to the research, but also served the local community, building social learning and social capital.

The example in Madagascar provides a powerful example of how LEK can not only be a central component of research, but can also provide opportunities for LEK holders to lead the sharing of co-produced knowledge with their communities. Management committees made of up community members would lead **dissemination** of findings and conduct activities that highlighted the importance of mangroves within the communities. Straddling the boundary between research and management, this same work is described in the next chapter from a practical management perspective (Case Study 16).

Community members organize community gatherings to raise awareness on the restoration activities in Baie de Assassins, Madagascar. © Cicelin Rakotomahazo

Ethics of validating results

An important part of knowledge co-production and ethically engaging with LEK is to validate findings with the participants to ensure that results are accurately interpreted.

In our review, seven studies mentioned that they validated findings with the community. As an example of such validation, Damastuti and de Groot (2019) had all participants and other stakeholders evaluate the maps resulting from the participatory mapping. As they stated, situations in which villagers map their villages and then have the results taken away by outsiders, "not only exploit local communities, but also leave the communities in a powerless situation" and therefore the authors "realized the ethical necessity to ensure that the output resulting from the mapping process can be understood by all stakeholders and that the result is given back to the participants." A less satisfactory approach reported in some studies is to interview additional key individuals to validate the responses shared by other participants in surveys or interviews. Although this can help verify the work and gain insight into community views, it does not ensure that the researchers accurately reported the study participants' views, or allow those participants to know how their information is being recorded and used.

Acknowledgment of LEK holders

Finally, as researchers work on widely sharing their findings, it is important to recognize the contributions of local people who have provided information, time, and energy towards a project. Within this review, 55% of studies acknowledged local people (Figure 5) by highlighting that the data had come from local people and/or recognizing their contribution. This information was most often located in the acknowledgements section at the end of each study. **A further step is to include as co-authors any LEK holders who significantly contributed to the study.**

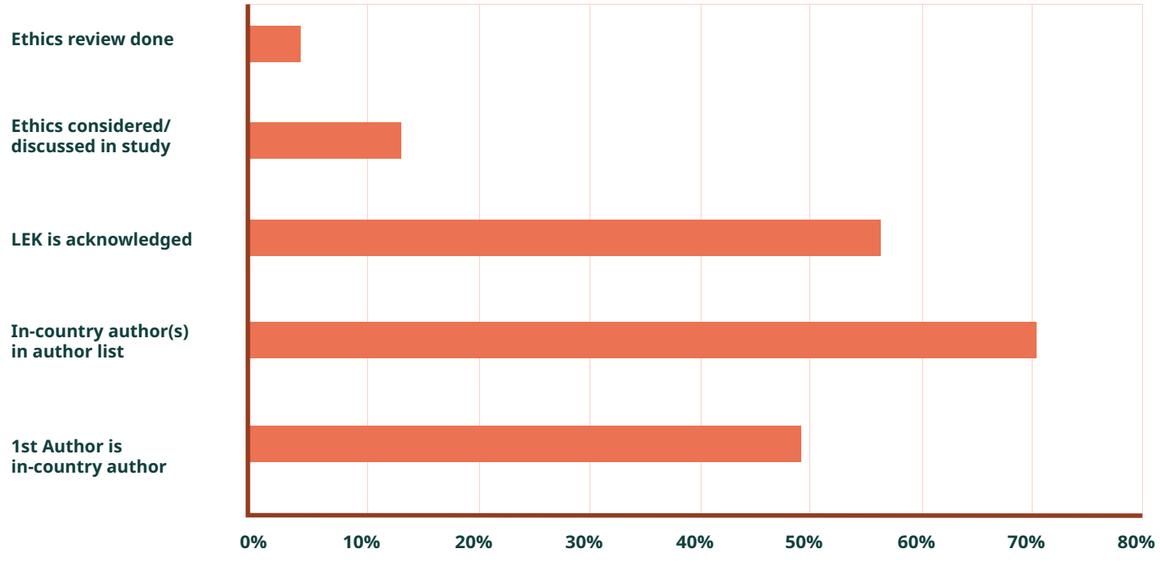

Figure 6: The percentage of mangrove LEK papers that acknowledge LEK holders, consider ethics, indicate an ethics review, or include in country authors.

3.3.3 Data collection methods

Given the diversity of studies, we identified a wide variety of data collection approaches used by researchers. **Understanding these methods can assist not only other researchers with exploring ways to learn from community members, but can also prove useful for planners, managers, and practitioners who could use these methods to research and learn about LEK that can inform conservation and restoration projects.**

Pre-collection preparation

Taking time to build trust prior to working with LEK holders is imperative.

A total of 43% of studies included information on preparatory work within the community/study area before data collection. Preparatory work can help a researcher understand the local context, such as community structure and norms, which can strengthen the research questions and methods. This can help ascertain cultural appropriateness of particular elements of the research and inform participants of the work in an open and transparent manner.

> *In the Sine-Saloum Delta, Conchedda et al. (2011) pre-tested the questionnaire with native speakers and found that it was culturally inappropriate to ask participants about their gender.*

It may be necessary to **work with local guides or translators** to help with the research, including the preparatory work. Local guides/translators were mentioned in 15% of the studies. The help they provided included assistance with introductions to key individuals, data collection, or receiving required permissions. In some cases, these individuals might be identified during early visits to the site.

There are several methods that researchers used for pre-collection preparation. Some of these methods are more time-consuming and immersive, such as conducting **exploratory trips to the area and living within the community.**

> *Carney's (2017) two monthly visits to Senegal/The Gambia allowed them to establish contacts and study the location of villages and mangrove restoration areas prior to the study start.*

Other methods include interactions with different members of the community through **community meetings, informal discussions with the local community,** and when necessary, **asking for permission from local leaders.**

> *Firmo et al. (2011) convened a community meeting with Brazilian crab harvesters in the Mucuri estuary to inform them about the project and ask for participation.*
>
> *In Kerala, India, Hema and Devi (2014) had informal discussions with residents, officials from local self-governments, and elderly people, which helped identify a stakeholder group who depended on the mangrove ecosystem.*
>
> *Before starting surveys in Grand-Popo, Benin, Gnansounou et al. (2021) sought permission to conduct the research from local and traditional authorities in each village.*

Mangrove restoration researchers and trainers meet with local restoration groups and head into the field with several local guides in Bengkalis Island, Indonesia. © Dominic Wodehouse, MAP

Studies can also benefit from planning that includes preliminary data collection to better understand the issues and ecosystem. Some of these might involve interacting directly with community members through **preliminary interviews** or **pilot testing**.

> *Kovacs (2000) conducted preliminary interviews to develop the final interview guide.*
>
> *Hugé et al. (2016) modified the Q methodology set used in the data collection after piloting it with two local researchers to ensure the questions were understandable in English and Malay.*

Other planning might involve activities that do not require being on-site, but involve a variety of information gathering from secondary sources, such as generating base maps (Francisco et al. 2014) and reviewing local data and reports.

Connections made with communities prior to the start of research can help optimize outcomes and encourage greater community support.

> *To gain important background information about the study villages in Fiji's Ba and Rewa deltas, Avtar et al. (2021) reviewed census data and technical reports about the villages.*

Restoration practitioners review a map of a potential project site in Guayaquil, Ecuador. © Laura Michie / MAP

Participant selection and sampling

Another key step before actual data collection is determining the sample population. The overall study aims and objectives determine the target participants (e.g., fishers or other resource users, women, young people, residents of mangrove areas). **It may be important to select people who have lived for an extended period in the area or to consider differences within local populations such as neighboring villages.** This may involve understanding local politics and customs. The number of participants and the time required will typically be determined by the research question, but access may further constrain such decisions.

Once the target participants are determined, **an appropriate sampling protocol can reduce the risk of bias in the selection of individual participants.** **Random sampling** can help to avoid bias (e.g. Than et al. 2022), while **purposive sampling** can be appropriate to select groups or individuals for a specific reason.

> *Duangjai et al. (2004) selected key informants (village seniors, headmen, and fishermen) from villages in Thailand.*
>
> *Hernandez-Cornejo et al. (2005) purposely selected long-term fishers, but then randomly selected participants from within this group.*

Stratified sampling can ensure representation particularly in relatively small samples – here a population is divided into specific groups and samples are randomly taken from each group.

> *Rönnbäck et al. (2005) aimed to have at least 10 males and females in both villages who regularly used mangroves.*

Snowball sampling involves asking individuals if they can identify people to participate in the study, and can be particularly helpful in finding people or information that is rare in a population.

> *Zapelini et al. (2017) asked local fishers to identify people especially knowledgeable about the goliath grouper.*

These methods are not exhaustive, as there are other sampling approaches, nor are they mutually exclusive. For example, purposive sampling can be used for the initial sample, which can then be expanded through snowball sampling.

Research approaches may focus on only a specific area of knowledge, such as fisheries, but having a clear sampling protocol for selecting individual participants can be critical to avoid bias and to ensure representation. (Photo: fishers in Grenada). © Tim Calver

Data collection

Across the 90 studies, a range of data collection methods were employed, with many studies combining multiple approaches.

Interviews, of which there are three main types, are often a primary or sole source of information.

Structured interviews ask set questions, usually close-ended, to all participants with no deviation from the interview guide. This approach can be particularly useful for generating quantitative information from multiple participants to allow comparisons, such as household survey data, and is especially useful when written surveys cannot be deployed for various reasons, such as literacy.

> *Rumahorbo et al. (2020) used structured interviews to derive quantified values for multiple ecosystem services in the Papua Province of Indonesia.*

Semi-structured interviews are typically built around a series of pre-set but usually open-ended questions. Unscripted follow-up questions allow space for expansion and digression.

> *Utilizing semi-structured interviews allowed Berkström et al. (2019) to learn more about habitat use, connectivity of selected species, fish migrations, and how residents gained their knowledge about these topics.*

Interviews with LEK holders can forge connections and facilitate a 2-way knowledge exchange. © Dominic Wodehouse, MAP

Unstructured interviews do not employ a set of interview questions and are characterized by minimum control over the participant's responses. They can be beneficial in exploratory work, especially for more experienced interviewers, or when or when the researcher is more interested in encouraging people to express themselves in their own terms and at their preferred pace.

> *Hernández-Félix et al. (2017) first conducted open (i.e. unstructured) interviews that allowed for identification of emerging themes about mangrove ecosystem services.*

Surveys are similar to structured interviews but can be administered orally or in a written form, whether on paper or online. Surveys include the same set of questions, which are usually close-ended, but might also involve some open-ended questions. Surveys are often shorter than interviews, although this can depend on the type of survey and interview.

> *Longepee et al. (2021) used surveys, informed by previous interviews, to quantitatively gather information about people's knowledge of the mangrove ecosystem, ecosystem services, and mangrove health.*

Drawbacks of written surveys for mangrove LEK research may include lower literacy rates in rural villages, and the logistics of having to carry a large amount of paper and keeping it secure in a wet tropical climate. Online surveys do not address literacy rates and can face challenges associated with internet connectivity. Some online survey programs allow for offline data collection that is then uploaded when the researcher gains connectivity.

One-on-one interviews are an excellent way to learn with LEK holders, and these can vary in level of formality. © Mark Godfrey / TNC

The sharing of knowledge can be facilitated by interviews and surveys, but also by engagement of groups in discussions or practical activities such as mapping.

Focus groups involve several participants sharing information through group discussion around a few specific questions, with the researcher acting more as a facilitator.

> *Nyangoko et al. (2021) used focus groups, during which facilitators interacted with communities to encourage exploration and brainstorming around ecosystem topics and issues. They learned diverse views by holding separate focus groups with local resource beneficiaries (e.g., mangrove cutters, fishers) and representatives from local management institutions in Tanzania's Rufiji Delta.*

Many studies included **observations** of local participants or events and documenting information (e.g., locations, timings, activities). These may include observations made by uninvolved researchers, or can be developed through direct participation by the researcher in activities with the participants, also known as participant observation. Such observations can be particularly effective if the researcher can spend prolonged periods with the community.

> *Ocampo-Thomason (2006) lived in her study area in Ecuador for 11 months and highlighted the importance of participant observation alongside surveys and interviews.*

> *As one method of data collection, Hossain et al (2015) visited dry fish markets and villages in hopes of discovering sawfish to help inform their national-level rapid assessment of sawfish.*
>
> *Hernández-Félix et al. (2017) conducted participant observation when accompanying octopus fishers at sea.*

There are also ways that knowledge can be gained through interactive, participatory methods of data collection.

Participatory mapping involves participants sharing knowledge by adding to or producing maps and documenting important features, such as fishing locations, ecosystem changes, and important sites. Sometimes this method might involve historical mapping, where participants reveal past uses, species, and features, which can be especially helpful in restoration efforts.

> *In the United Arab Emirates, Mateos-Molina et al. (2020) included participatory mapping, interviews, working groups, ground-truthing, and satellite imagery and data to produce a coastal habitat map with high accuracy for conservation and management in an area that was data deficient.*
>
> *Brown et al. (2018) conducted participatory mapping of Australia's Maroochy River, identifying how the mangrove had changed over time, drivers of these changes, and how changes in mangrove extent affected ecosystem services; this allowed an understanding of changes dating back to European colonization (~1860), far beyond what remote sensing methods are capable of showing.*

Participatory mapping involves knowledge sharing through the medium of maps where local people can share knowledge of key locations or activities. (Photo of village leader Venantius Barrier in Madang Province, Papua New Guinea). © Annette Ruzicka

A walking transect, as its name implies, involves walking a transect, often while conducting interviews and collecting data in the mangroves. This can allow participants to share applied information, such as planting techniques or areas of degradation, or be a method for in-situ gaining knowledge about the ecosystem or species.

To gather a full bird diversity inventory and understand mangrove utilization by birds, Gardner et al. (2017) carried out walking interviews with 1-4 local participants during survey transects in Ambanja and Ambaro Bays in northwest Madagascar. These locals shared the names of birds seen and/or heard, which added an additional 18 species to the researchers' total and provided a complementary dataset more complete than a rapid inventory alone.

3.3.4 Increasing connections between LEK and AEK

In combining widely used academic approaches in the natural sciences with LEK, it is important to avoid an assumption that LEK should be, or even can be, fully integrated or subsumed into AEK.

These knowledge types are distinct, although they may be similar, and are complementary.[24] Many studies identified in this strategic review involve some combination of local and academic knowledge sources. In most cases, studies focused on the generation of complementary data, illustrating how the two knowledge systems can strengthen the study. This was sometimes through active participation methods, some of which were described in the previous section (e.g., walking transects, participatory mapping), while others involved working with existing data sources.

Combining data sources provided a more holistic and historic view of the landscape and mangrove cover changes. For example, Beitl et al. (2019) identified spatiotemporal patterns of mangrove cover change in Isla Costa Rica, Ecuador from 1985-2014 by combining remote sensing with ethnographic research (e.g., interviews, focus groups, observation), thereby providing a better understanding of how mangrove cover had changed and the drivers of these changes.

Combining LEK and AEK can also be used to understand habitats and assist in planning efforts. For example, to help inform the potential design of a manatee wildlife refuge in Brazil, Choi et al. (2009) combined field surveys and mapping with fisher surveys about manatee presence/absence, spatial range, habitat use, and potential feeding areas.

Across these studies are a small number that describe methods to compare and assess accuracy of LEK versus AEK. In some cases, information from the two approaches is aligned (Cormier-Salem et al. 2017). In other cases, there is weaker agreement. For example, in Hernandez-Cornejo et al. (2005) local perceptions differed from satellite observations or in Francisco et al. (2019) locals had better awareness of small patches of mangrove than remotely sensed imagery. LEK represents the lived experience and perceptions of local residents, while AEK may represent the highly focused observations and measurements of outsiders. In almost all cases, it is likely that both will contain knowledge that the other cannot see.

While technology can be a considerable help in contemporary surveys, local knowledge may be the only means to understand historical change and drivers of current conditions (photo in Haiti with boat owner Jackson Pierre and his son Baldwen). © Tim Calver

24 Albuquerque, U. P., Ludwig, D., Feitosa, I. S., de Moura, J. M. B., Gonçalves, P. H. S., da Silva, R. H., ... & Ferreira Junior, W. S. (2021). Integrating traditional ecological knowledge into academic research at local and global scales. *Regional Environmental Change, 21*(2), 1-11.

3.4

Summary

LEK represents a critical resource for the research community, and particularly for those working in conservation and restoration centered research.

Local and Indigenous communities are uniquely placed to know "their" mangroves in a more detailed and holistic manner than external visiting researchers, even those researchers who may be from relatively nearby cities or research establishments.

The sharing of knowledge between local people and others requires collaborative and equitable approaches in which all partners are heard, recognized and respected. © Frisnar Paysal / TNC

This review highlights a great variety of LEK that has enhanced research and our wider understanding of mangroves. LEK has helped inform basic geospatial and ecological information – where mangrove forests and specific species are located, seasonal patterns, and hydrodynamics. It has provided a historic context, identifying the patterns of change and past impacts from storms or human activities. It has been critical in helping to understand the social and economic context of mangroves – how they are used for benefits such as fisheries or timber; their importance in local culture or traditions; or past restoration or conservation actions, including local involvement or the benefits derived from management interventions.

Many studies in our review have focused more on understanding the types of knowledge held by local communities, and while they do not directly engage with such knowledge in the context of conservation, they are important in further highlighting the scope and potential for inclusion of LEK into more practical research.

In addition, as seen in the next section, several data collection methods used by researchers can also be used by planners, managers, or practitioners to assist with conservation or restoration projects.

Local knowledge covers many different areas, from endangered species (here a Bengal tiger in the Sundarbans © Sandipan Ghosh, TNC Photo Contest 2023), local ecological processes (a woman in Kenya collecting mangrove propagules © Sarah Waiswa), to understanding impacts on mangroves (here the aftereffects of a hurricane in Jamaica. © Tim Calver)

For example, focus groups and workshops can be valuable methods for learning LEK that can inform a project. Sampling techniques discussed in this section can help projects ensure a variety of stakeholder groups and demographics are invited to share their knowledge.

It is also of great importance to ensure that the gathering and sharing of such information is undertaken with sensitivity that it is equitable and properly acknowledged and, where applicable, supported or funded.

Looking beyond these examples, there is considerable potential for greater inclusion of LEK. We located only 90 studies that had sufficient detail to inform our review and classification. It is likely that many others are studying or engaging with LEK, but may not be clearly highlighting it in their findings. Equally, however, it is probable that many researchers are failing to consider the potential of LEK as an expansive data source that could greatly enhance their understanding of mangroves as social-ecological systems.

LEK can provide depth and context to our understanding of mangrove ecosystems and represents a powerful resource for all mangrove research.

4. Local ecological knowledge in mangrove management

Traditional honey collectors of the Sundarbans
© Tanmoy Badhuri - WWF International

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4.1

Introduction

Mangroves are in need of protection and restoration, and LEK can – and in many cases, already does – play a pivotal role in these efforts.

Mangroves have faced large changes and wholescale losses over the last century, which have largely been driven by national or even international policy and commercial demands, be that through urbanization, development of tourism infrastructure, industrial timber or charcoal production, or conversion to aquaculture ponds or oil palm plantations.

Despite these external pressures, mangrove conservation and restoration tend to occur on a local level, and even when larger scale-projects occur, many conduct work in individual villages with community members. Although it might not be included in projects, it can be assumed that people living near the mangroves hold local knowledge of those mangroves, ranging from a simple awareness of location and extent to profound cultural/traditional linkages or detailed understanding of ecological processes. Much of this knowledge is practical – mangroves as fishing grounds or sources of timber or fuelwood, mangroves as places of spiritual connection, or simply mangroves as boundaries or spaces to be navigated. Such knowledge, in many cultures, has gone hand-in-hand with traditional management, where ownership, utilization, even clearance and loss, has been determined by local decisions.

An Indigenous fisher in Bocas del Toro, Panama. Local knowledge is often driven by practical need, but can also be deeply embedded in local culture. (C) Mark Spalding

Conservation and LEK come together as fisher groups sign Sustainable Use and Custody Agreements as part of Ecuador's Socio Manglar (Mangrove Partner) program, where local residents are granted access to mangrove forests in exchange for agreeing to protect and maintain them. © Fabián Viteri

LEK can be a potent and vital source of knowledge for mangrove management, but in many areas, connections between local people and mangroves have been lost or undermined by changes in policy, patterns of settlement, or shifting livelihoods. New coastal populations from other areas may have little or no awareness of mangroves. Ownership of mangroves has been formalized, and rarely awarded to the long-time users of the mangroves. In this setting, management decisions, including sustainable use, conservation, and restoration, are now often being enacted or encouraged by non-local agents, such as governments and NGOs.

Bringing LEK into mangrove management is important, and in many cases, this may mean bringing LEK back into management. The study of LEK, described in the previous section illuminates the diversity of LEK that is held around the world. Yet, only a few such studies have directly considered how LEK can inform mangrove restoration and conservation.

At the same time, however, numerous on-the-ground practical projects are already engaging with LEK and developing projects informed by this knowledge. These examples may not be widely shared, so we sought out cases that illustrate how LEK can play a significant role in mangrove restoration and conservation.

These examples can inform and inspire others to engage with LEK. In so doing, they can strengthen mangrove conservation and restoration, while at the same time supporting local communities who interact with mangroves.

4.2

Methods and summary of case studies

To collect case studies, we cast a wide net.

We created clear guidelines (Appendix 4) for selection: LEK had to inform part of the project; projects needed to have continued involvement of the community; and, to ensure best practices, case studies had to include local knowledge contributors as a co-authors **(local authors are indicated by an * next to their names in the case studies).**

We emailed Global Mangrove Alliance (GMA) members and other key contacts asking if they were involved with or knew of relevant projects. Mangrove Action Project (MAP) also shared the request on their 'Community-Based Ecological Mangrove Restoration' Group listserv. We also solicited examples at the 6th International Mangrove Macrobenthos and Management conference (MMM6) held in Colombia in July 2023. This included contacting authors of presentations and posters that seemed relevant, providing information and a sign-up sheet at the GMA table, and making an announcement at the GMA member gathering. In total, we received 21 case studies from around the world that we were able to include in this guide.

Projects focused on restoration, including hydrologic changes and replanting efforts, and/or conservation, which include environmental education, management approaches, and alternative livelihood opportunities. Projects in Honduras, New Caledonia, and El Salvador were initiated by local community members or groups, but even those started by another group illustrate how local members both contributed valuable information that informed the project and were involved at various points of the project.

Local villager fishing in the rich mangrove waters of St Kitts and Nevis. © Mark Spalding

Despite the geographic range and project focus, some broad classes of LEK emerged across the cases. Each class has a corresponding label, which is used to denote its presence in a case study. A complete table of all projects and the classes of LEK they included is found in Figure 7.

BIODIVERSITY

Several projects included local knowledge about biodiversity, including mangroves or other species in the area. For example, near Matadoni Village in Kenya, a prawn fisher recommended which mangroves would be best suited for a restoration project based on his knowledge of prawn presence and their preferred mangrove species (Case Study 12). Other case studies relied on local knowledge to inform them of the locations of mangroves. This information helped in both siting the location of restoration projects in appropriate areas (i.e., where mangroves had existed) such as in Panama (Case Study 19), or including wild stocks of mangrove propagules for nurseries, direct planting, and/or supplementing plantings from nurseries, like wildlings used for planting in a Philippine restoration project (Case Study 20).

PHYSICAL PROCESSES

Several projects asked locals to share knowledge about physical processes, especially those relating to hydrology. This was especially important in projects working to restore previous hydrological systems through digging canals. In Colombia's Morrosquillo Gulf, intergenerational knowledge and daily existence in mangrove systems allowed community members to identify areas experiencing salinization due to insufficient water flow. This information proved vital to mapping the appropriate locations of the channels (Case Study 4).

HABITAT CONNECTIVITY

Several projects also turned to LEK to provide a greater understanding of the connectivity of the ecosystem, such as its connection to other ecosystems, like rivers or the ocean, or how abiotic and biotic factors within the habitat were connected and impacted each other. For example, community members in Honduras noticed poor water quality and fish deaths in the estuary and were able to connect it to the presence of an invasive plant spreading throughout the nearby river (Case Study 8).

THREATS & IMPACTS

Also common in several projects was the inclusion of LEK about causes of mangrove degradation, such as mangrove cutting, oil spills, and dams. Understanding the causes of degradation can support successful management interventions. In Kenya's Tudor Creek, learning from community members that degradation resulted from logging, rather than biochemical or hydrological degradation, indicated that a particular project site may be suitable for replanting (Case Study 14).

RESTORATION APPROACHES

In projects that included planting, several turned to locals for their knowledge on how they have planted or maintained mangroves and what has or has not worked in previous projects. In some of these, the case studies explained how local knowledge and technical knowledge complemented each other for a more effective project. In Bahia Jiquilisco, El Salvador, locals were provided technical training on digging channels, and the community then determined the best place to dig the channels based on their knowledge of where water had previously flowed (Case Study 6).

CULTURAL PRACTICES

Studies also turned to locals to share information about traditional tenure and local rules, which could inform locations of project sites, with whom to talk about permissions, and traditional management systems (e.g., closed seasons, taboos) that could be employed. In Indonesia, the traditional authority of "adat" and Kerakera, or local agreed upon wisdom, was reintroduced to protect and manage mangroves (Case Study 11). Projects also included LEK about rituals, which were then included in their conservation efforts. In Colombia's La Guajira department, this involved engaging in "Yanama", or community work; drinking chirrinichi, a typical Wayuu liquor; and performing "la Yonna," a traditional Wayuu dance (Case Study 3). Cultural calendars, such as in Fiji, also played an important role in determining timing of restoration or conservation activities (Case Study 7).

TRADITIONAL SKILLS

Some projects discussed traditional skills, crafts, or fishing techniques. For example, a traditional weaving approach from palm leaves in India has been used to replace plastic bags in nurseries and provide an alternative livelihood to women in the region (Case Study 9). Beekeepers in Mexico practice traditional beekeeping that relies on inter-generational knowledge about climate, phenology, and ecology (Case Study 17).

LEK IN OUTREACH

Finally, some projects explained how communities are involved in sharing their LEK in education and awareness campaigns or activities. In New Caledonia, the Koé tribe shared traditional knowledge about mangrove names and uses, mangrove fishing techniques, and the history of the mangroves on an interpretative trail (Case Study 18). Brazil's Green July campaign involved the creation of a community written "Maretório Manifesto" that highlighted traditional Brazilian wisdom. Elders teach younger generations how to observe seasonal patterns of mangroves and fisheries (Case Study 1).

In many cultures, mangroves have a spiritual or religious value which can play a critical role in mangrove conservation and management. Here in Benin, communities sanctified their mangroves through the deity, Zangbéto. © PAPBio/ UICN-PACO

Even though overarching trends exist, each case study is unique and provides a greater understanding of how projects can engage with LEK and improve project outcomes. A key takeaway is that LEK can support mangrove conservation and restoration in myriad ways. A common failure of natural resources management can be ignoring or paying minimal attention to local people and the knowledge they hold. **What these case studies show is that local knowledge has the potential to enhance projects and improve success, including the longevity and sustainability of management interventions.**

Enjoy reading about these cases, but take inspiration too! Mangrove conservation will advance more rapidly and more effectively if managers and funders[25] recognize LEK and if local communities are engaged as equal partners and even leaders.

25 Grimm, K. E., Archibald, J. L., Axelsson, E. P., & Grady, K. C. (2023). Follow the money: Understanding the Latin America and Caribbean mangrove restoration funding landscape to assist organizations and funders in improved social-ecological outcomes. *Conservation Science and Practice, 5*(5), e12815.

4.3

Case studies

The 21 case studies that follow describe how, all around the globe, very different kinds of LEK are informing and strengthening mangrove conservation and management (Figure 7), and how local communities are being engaged in such efforts (Figure 8).

Case study	1 Brazil	2 Colombia	3 Colombia	4 Colombia	5 El Salvador	6 El Salvador	7 Fiji	8 Honduras	9 India	10 Indonesia	11 Indonesia	12 Kenya	13 Kenya	14 Kenya	15 Liberia	16 Madagascar	17 Mexico	18 New Caledonia	19 Panama	20 Philippines	21 Vietnam	Total
Biodiversity - Mangrove species		■	■		■	■	■	■				■	■	■		■		■		■	■	12
Biodiversity - Other species				■	■	■	■			■	■	■		■	■	■	■					10
Biodiversity - Location of mangrove/seed source		■	■			■	■			■		■	■	■	■	■			■	■		11
Physical processes		■	■	■	■					■						■						6
Habitat connectivity	■		■	■			■	■			■	■			■		■					8
Threats and Impacts	■	■	■					■				■	■			■				■	■	10
Restoration Approaches - Hydrological			■	■				■		■		■										4
Restoration Approaches - Planting/maintenance practices		■	■	■			■	■							■	■					■	8
Cultural Practices - Traditional tenure/rules			■				■				■				■	■						5
Cultural Practices - Rituals			■				■								■	■						4
Traditional Skills							■		■								■	■				4
LEK in outreach	■														■	■		■				4

Figure 7: Table showing the different classes of LEK that are included in each of the case studies, with many relying on several types of LEK.

A Carimbó traditional culture concert celebrates mangroves during Green July in the Brazilian state of Pará as part of a campaign to promote mangrove protection. © Bianca Araújo

A member of the Berkah Alam community group from Surodadi Village in Indonesia, conducting monitoring of mangrove growth and water quality. © Wetlands International

Community members work together to construct a permeable sediment trapping structure in Timbulsloko Village, Indonesia. © Kuswantoro

Figure 8: Map with locations of the projects represented in the subsequent case studies. Click on the project to jump straight to a case study.

CASE STUDY 1 | BRAZIL

Green July: Building community pride for Mangroves

Contributing authors

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THREATS & IMPACTS | LEK IN OUTREACH | RESTORATION APPROACHES

Location

Amazon Coastal Zone of Pará State, Brazil.

Project Size

1,677 km² of mangrove coverage along 3,905 km² of protected areas.

Mangrove species

White mangrove *(Laguncularia racemosa),* red mangrove *(Rhizophora mangle),* black mangrove *(Avicennia germinans).*

Project Duration

2021 - ongoing

Green July 2022 São João da Ponta. © Enrico Marone

Project goals and objectives

Due to socio-economic and political challenges, the coastal territories of Pará State have been neglected in the past. Green July is a grassroots campaign supported by Rare where local people celebrate the importance of the vast mangrove ecosystems along Brazil's Amazon Coast. It awakens and strengthens the role of local community members as guardians of the mangroves.

Methods/approaches used

During Green July, local leaders and communities across the Pará region host cultural activities like parades, fisher games, live concerts, and radio broadcasts to build excitement for mangrove protection and promote sustainable behaviors that benefit nature and coastal communities. Young children learn the ecological value of mangroves, while fishers learn new strategies for sustainably managing shared natural resources. Each lesson contributes to a "wave" of awareness, creating a larger social transformation. World Mangrove Day on July 26 provides a narrative arc, driving momentum for the activities of Green July.

Groups involved and roles

Green July is a grassroots initiative growing in attention and momentum. With support from Rare, currently over 30 local institutions and hundreds of community members across Pará State join in the campaign. Local Indigenous and community leaders organize weekly campaign activities, uniting their respective community members. Youth, women, and community members of all ages mobilize friends and families to participate. Local NGOs and state agencies provide technical support for fishers and increase campaign visibility through social marketing.

Local Knowledge

All messaging and actions provided by the Green July campaign build upon native Afro-Amazonian knowledge and encourage pride in coastal communities' ancestral connection to the mangroves. Indigenous wisdom and intergenerational lessons are incorporated into conservation games and community events. **Each year, participating communities collectively write a "Maretório Manifesto" that highlights traditional Brazilian wisdom on topics like rainfall cycles, human-wildlife relationships, and the impact of human activities on mangroves. Elders teach younger generations how to observe the seasonal patterns of mangroves and fisheries and combat anthropogenic disturbances like coastal development, pollution, wood harvesting, and overfishing.** As part of the manifesto, community leaders pledge their commitment to mangrove maintenance, reinforcing their community's pride as guardians of the mangroves.

Outcomes

Green July may be the world's largest community-led movement to protect mangroves, bringing visibility to Brazilian communities from local to international levels, helping to showcase how mangroves offer nature-based solutions for healthy fisheries, community well-being, and climate resilience. Since 2021, the campaign has reached 200 communities and 3,000 members. Twelve local associations representing 18,000 families along the Amazon coast that use the mangrove resources have joined in partnership to sustainably manage the coastal ecosystems along with Green July's efforts. In the words of local Pará State leader Laercio Amoras, "Green July is becoming a tradition in our territory." This sentiment reflects the awakening of a culture where individuals take pride and collective action to protect their shared resources and build a brighter future for people and nature.

CASE STUDY 2 | COLOMBIA

Searching for solutions for carbon-sequestration in coastal ecosystems (sea4soCiety)

Contributing authors

Martin Zimmer – project coordinator. **Mondane Fouqueray** – doctoral candidate. **Camilo A. Arrieta-Giron** – knowledge exchange officer. **Juan Carlos Cuadro*** – Communitarian Council. **Wilmer Gomez*** – Communitarian Council.

BIODIVERSITY | PHYSICAL PROCESSES | THREATS & IMPACTS | RESTORATION APPROACHES

Location

Villages Ararca (10°15'49.4"N 75°33'21.8"W), Santa Ana (10°14'17.0"N 75°33'07.5"W) and Barú (10°08'24.5"N 75°41'14.1"W), Barú Peninsula, Bolívar.

Project Size

The project is still in a development phase and the final size is yet to be determined.

Mangrove species

Rhizophora mangle, Avicennia germinans, Laguncularia racemose, Pelliciera benthamii, Conocarpus erectus

Project Duration

Phase 1: 2021-2024
Phase 2: 2024-2027

Mangrove (*Rhizophora*) expansion carried out by a fishers association from Santa Ana, Colombia. © Mondane Fouqueray

Project goals and objectives

sea4soCiety aims to enhance carbon sequestration in coastal ecosystems using innovative, ecologically feasible, environmentally sound, and ethical approaches. It supports innovations that fit with societal requirements, which may provide benefits beyond carbon, and have economic viability. On a local scale, sea4soCiety is looking at the ecological and societal feasibility of mangrove expansion on the peninsula of Barú, Colombia, with a deep engagement with a diverse group of local stakeholders.

Methods/approaches used

To assess societal desirability and feasibility , the project conducted individual interviews with the communities in 2022, followed by focus group interviews with mangrove nursery managers, ecotourism operators, and fishermen from the three villages, in 2023. Subsequently, a workshop involving community members, governmental organizations, and the academic sector was organized to understand stakeholder needs, interests, and challenges related to mangrove (re-)establishment and recognize their roles and knowledge in resource management. The methods for (re-)establishing mangroves will be based on the outcomes of the discussions with the communities.

Groups involved and roles

- **Academic partners** including leaders from Universidad Nacional de Colombia (Bogotá), Universidad del Sinú (Cartagena), and Pontificia Universidad Javeriana (Bogotá).
- **Parque Nacional Natural Islas Corales del Rosario y san Bernardo (PNN):** Jurisdiction over mangroves within park limits on the Western side and tip of the peninsula.
- **Corporación Autónoma Regional Del Canal del Dique (CARDIQUE)**: Jurisdiction over mangroves on the Eastern side of the peninsula, distributes permits for cutting and building.
- **Wilmer Gomez**: Environmental leader of the Communitarian Council of the village of Barú. Founder of the mangrove nursery and a youth environmental group.
- **Juan Carlos Cuadro**: Part of the Communitarian Council. Founder of Tuarisba, a local ecotourism and mangrove nursery cooperative in the village of Ararca, that works with a women's collective.

Local knowledge

The peninsula of Barú is under special jurisdiction due to the presence of Afro-Colombian communities, governed by their Communitarian Council. This grants them legal protection and governance authority over their land.

Considerable local knowledge on mangroves and the area was gathered through interviews, workshops, and group discussions. This included mangrove species, locations, and management; historical and current uses for different species; threats affecting mangrove ecosystems; replanting efforts; climate change perceptions; mangrove health status; views on mangrove expansion; and community needs. For example, **the communities have knowledge of sedimentation and salinity changes over time, which informs areas experiencing fast accumulation of sediment that might need frequent dredging or areas suffering from high salinity.** The community uses specific channel-building techniques to reduce the salinity. This knowledge comes from a variety of sources: empirical practice; ancestral and neighbor community practices; and through trainings conducted by environmental institutions.

CASE STUDY 2 | COLOMBIA

Group presentation during the multi-stakeholder workshop held in Barú, Colombia. © Mondane Fouqueray

Some community members shared information about mangrove planting, such as different planting techniques, substrate types (where to find them, which ones are more suitable for mangroves, how to combine different substrates to use in nurseries), life cycle and optimal planting time, and the necessary acclimatization steps between nursery and planting.

The community works on the recovery of their 'Ancestral Memory,' where the understanding between the environment and culture, and the union of these two spheres, would be the way to generate ecosystem equilibrium. The community practices knowledge-sharing among elderly members (called "sabedores" or knowledge-holders) and children through, for instance, the mangrove nurseries. Information about social and economic problems arise as well from the different stakeholders, for whom land tenure, food security, and lack of interinstitutional cooperation are the main factors to highlight.

These communities participate in ecosystem recovery, driven by the private and governmental sectors, through nursery maintenance, species selection, and locating planting sites. Their holistic understanding of the area is essential in identifying parallel activities crucial to long-term success of mangrove expansion (dredging, solid waste management, and environmental education). The future phases will need a comprehensive knowledge of the area and an understanding of the needs of the communities and the ecosystem.

The project will rely on local knowledge to inform where to plant, where to create channels for freshwater input, and how to address the existing pressures on mangrove forests.

Outcomes

The engagements with the local community since 2021 have built trust and increased the visibility of mangroves and their importance for climate change mitigation and adaptation. A positive impact of the project thus far is the successful gathering of a wide variety of actors (government, community, academia) in the same discussion space. This has allowed for networking and improved communication between actors who seldomly interact.

To learn more about this case study visit:

https://www.leibniz-zmt.de/en/research/research-projects/sea4society.html

https://sea4society.cdrmare.de/en/

Focus group discussion in the village of Ararca, with members of the "consejo communitario" or community council. © Mondane Fouqueray

CASE STUDY 3 | COLOMBIA

Multi-scale mangrove governance for the traditional and Indigenous communities in the department La Guajira, Colombia

Contributing authors

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Location

The Department of La Guajira, Colombia, including 30 Wayuu indigenous and Afro-descendent communities. Three projects are described here: **Bahia Hondita** (12°24'25"N -71°41'34"W) at most northern part of the province (Alta Guajira), the regional protected area **Musichi** (11°44'52"N - 72°33'14"W) in the center (media Guajira), and all other mangrove areas in the province spread along the coastline.

Project Size

Musichi – Regional protected area – 42.34 hectares

Bahia Hondita – 363.07 hectares

Mangrove areas for voluntary agreements along the coastline – 587.66 hectares

Mangrove species

Rhizophora mangle, Avicennia germinans, and Laguncularia racemosa

Project Duration

2021 - 2023

BIODIVERSITY | PHYSICAL PROCESSES | THREATS & IMPACTS | RESTORATION APPROACHES | CULTURAL PRACTICES | HABITAT CONNECTIVITY

Signing mangrove management agreements. © Andrés García, Fundación Omacha

Project Goals and Objectives

The arid Caribbean peninsula of La Guajira in northern Colombia is inhabited by numerous ethnic communities such as Afro-descendent; Wayúu; and Indigenous groups of the Sierra Nevada de Santa Marta, including some populations of Kogui-Malayo-Arhuaco resguardo. They all have close symbolic and material ties to coastal marine ecosystems such as mangroves. However, the ecosystem and adjacent communities are vulnerable to impacts such as hurricanes, hyper salinization, floods during the rainy season, and coastal erosion. Firewood harvesting is also a major threat in this region where there are few alternative fuel sources.

The regional environmental agency, CORPOGUAJIRA, is responsible for monitoring and managing the mangroves within its jurisdiction. CORPOGUAJIRA has developed voluntary management agreements with communities that regulate mangrove access and use. These agreements are based on a previous participatory zoning concept in which Indigenous communities participated. This work is part of the Ecosystem based Adaptation to Prevent Coastal Erosion in a Changing Climate project, executed by Ministry of Environment and Sustainable Development of Colombia, financed by the International Climate Initiative (IKI) through the Kreditanstalt für Wiederaufbau (KfW). Complementary to the agreements, the project included the installation of eco-efficient stoves to reduce pressure on mangrove use and reduce greenhouse gas emissions, as well as fencing and hydrological rehabilitation of a mangrove wetland.

Methods and approaches

Central to this project was the co-development of voluntary agreements with Indigenous and Afro-descendant communities aimed to improve mangrove management. These agreements included the Wayúu ethnic group's and the Afro-descendant communities' worldviews of the mangrove ecological system.

In contrast to the Western approach of signing a physical document, the fulfillment of these voluntary agreements has a binding nature for the Wayúu communities; **in the Wayúu cosmovision, observance of oral agreements reflects a fundamental socio-cultural principle.** To develop these agreements, a translator facilitated a multi-stage negotiation process that included workshops, field work, and discussion circles.

The interrelationship between traditional life patterns, ancestral knowledge, spiritual practices, and the mangrove ecosystem provided the project with the opportunity to develop environmental education strategies. These strategies, created by CORPOGUAJIRA based on local knowledge, mainstream the environmental education approach for the whole department (La Guajira), addressing all stakeholders involved in interactions with mangroves. Another important approach of this work was including **traditional rituals and cultural practices** depending on the importance of the activity. These **included the offering of a goat; meal preparation; drinking chirrinchi, a typical Wayuu liquor; playing musical instruments; or performing "la Yonna," a typical Wayuu dance.**

Specific restoration activities were implemented in two areas of the project:

Bahia Hondita: Multiple activities included rehabilitation of the water flow by the digging of channels in three sectors of the bay using traditional practices (Yanama); the implementation of nurseries and seed sowing; the introduction of an alternative economic opportunity in ecotourism "The Mangroves Route"; the registration of the initiative as one of the Blue Carbon initiatives in Colombia; and the installation of eco-efficient cooking stoves. **"Yanama" refers to "community work" within the Wayuu culture; people come together to accomplish a job and at the end of the day have a meal together. In this case, "Yanama" was implemented as a collective**

CASE STUDY 3 | COLOMBIA

work for the maintenance of canals that favor water circulation to the mangroves.

Musichi: Two key activities were undertaken. To mitigate identified threats to the mangrove forest, specifically cattle ranching and logging, this project constructed a 6,240-meter fence around the mangrove restoration areas. To improve natural flooding and drainage and to regulate salinity in areas threatened by coastal erosion, in turn helping mangrove rehabilitation, 1.5 km channels were excavated.

Local Knowledge

Although a Mangrove Restoration Guide was adopted by the central government, differences in the biophysical, socioeconomic, and ethnic characteristics of local settings make it important to include the traditional knowledge and the beliefs of the communities in the mangrove restoration processes.

In Guajira, mangroves have unique meanings for the different groups. For the Wayúu ethnic group, mangrove ecosystems are sacred sites. The four mangrove species have special meanings and uses and are associated with traditional production activities. The Afro-descendants consider the mangroves as a refuge for their ancestors, a source of fishing, and a supply of fruits.

For the Arhuaca people, the Sierra Nevada Mountain at the western end of this region represents a sacred body and the heart of the world; the mangroves act as eyebrows and are the first barriers to protect coastal erosion.

Thus, the coastal lagoons, estuaries, and mangroves are considered part of the sacred spaces that constitute the ancestral territory of these Indigenous people.

These sacred beliefs, as well as knowledge of land use, mangrove species and locations, hydrological patterns, and causes of degradation helped inform this project.

To begin, the participatory zoning concept guiding the overall project was informed by mangrove mapping by drones and local knowledge of current and past land use patterns. Specific knowledge informing the work in each area included:

Bahia Hondita: Ethnic, ancestral knowledge was central to the work conducted in this area. Besides inclusion of "Yanama", this involved **knowledge of seasonal changes of winds, tides, and currents and how they influence the mangrove ecosystem.** It also included appropriate times for planting and seed collection and species to be planted depending on the site location. For example, artisanal on-site nurseries were implemented using the seeds that fell in the environment.

Musichi: Wayuu knowledge was instrumental in sharing information about ecosystem services, threats, and conservation approaches. The mangrove ecosystem of Musichi protected area supports important fishing and nursery grounds for the Wayuu clans. The Wayuu also identified threats to mangroves, such as firewood and fodder for goats and cows. Traditional knowledge informed the fencing of the mangroves and helped to prioritize the zones most relevant to the ecosystem services mentioned. In addition, ancestral knowledge informed where and how to dig the canals to ensure water supply to the mangroves. This included understanding of changing tides and wind directions during the year and dimensions needed to ensure water availability for mangroves and to reduce soil salinity.

Outcomes

Overall, 14 agreements with 30 communities were signed for 588 hectares that includes 6.3 km of channels dug, 180 eco-efficient stoves installed, 42 hectares mangrove protected with 6.4 km of fencing, and activities such as nurseries and planting mangrove seeds.

Local and ancestral knowledge informed the process of digging channels to secure water flows to and from the mangroves in Musichi. © Adriana Daza

Bahia Hondita: Around 500 mangroves have been planted by the community and visitors and 500 m of channels have been rehabilitated. Twenty eco-efficient cooking stoves have been installed in four communities. Since in Wayuu tradition one stove is used by three families, this measure reaches 60 families. Substrate sampling occurred in nine plots to measure blue carbon. To strengthen local governance, members of four Wayuu communities were involved in the creation an Indigenous mangrove guardians group "ASOMANGLARES" and CORPOGUAJIRA supported the effort. These results show that climate actions based on the management of marine and coastal biodiversity at the local level are more efficient than efforts that simply follow high-level national public policies.

Musichi: The project duration was one year and ended in October 2023. Monitoring in the subsequent months will inform whether a reduction of cattle ranching and logging resulted from the fencing. The physical and chemical conditions of the soil that enable the development of the mangrove have been improved by opening 3.8 km of channels. Additionally, within that area 4000 seedlings were planted.

Mangrove areas within Indigenous or Afro-descendant communities: 14 voluntary management agreements have been signed by 30 communities, covering 630 of the 995 hectares of mangrove ecosystems in the province. Among the prioritized topics in the 14 agreements are restoration of mangroves, management of solid waste, nature tourism initiatives, and formation of environmental groups. The agreements will last one year and CORPOGUAJIRA will carry out two follow-ups a year. In addition, there were 14 environmental education workshops and four workshops related to participatory mapping and zoning of the mangrove areas, which was based upon current quantitative and qualitative information. The above constitutes a very valuable social cartography input for the management processes of the mangrove ecosystem in the department of La Guajira.

To learn more about this case study visit:

https://www.youtube.com/watch?v=2SMfe2jzd5A

https://www.international-climate-initiative.com/en/iki-media/news/using-caribbean-ecosystems-to-protect-against-the-impacts-of-climate-change/

CASE STUDY 4 | COLOMBIA

Vida Manglar, blue carbon program in the Morrosquillo Gulf

Contributing authors

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BIODIVERSITY | PHYSICAL PROCESSES | RESTORATION APPROACHES | HABITAT CONNECTIVITY

Location

Morrosquillo Gulf, Colombia.
The protected area covers 7,561 ha.
(9°19'27.04" - 9°26'46.10" N and 75°43'32.08" - 76°0'15.43").

Project Size

7561 ha in the Cispatá Bay

Mangrove species

Rhizophora mangle (red mangrove), *Laguncularia racemosa* (white mangrove), *Conocarpus erectus* (button mangrove), *Pelliciera rhizophorae* (piñuelo), *Avicennia germinans* (black mangrove).

Project Duration

2015 - ongoing

Artisanal transportation of harvested mangrove wood to the "Caño Lobo" collection site in San Antero, Córdoba. © Vida Manglar

Project goals and objectives

"Vida Manglar" is a local community and institutional initiative. The project seeks certification of actions related to the reduction of carbon emissions due to forest degradation or deforestation and the conservation of coastal wetlands in 7,561 ha of mangrove forests. The grouped blue carbon project was approved by Verra under VCS and CCB standards and began May 15, 2015. Over 30 years, an estimated reduction of 939,296 tCO_2e is expected through the execution of activities related to the Integrated Management Plan (PMI) of the protected area (PA) of Cispatá Bay. These activities include strengthening local governance, promoting alternative livelihoods projects with local communities, recovery and rehabilitation of mangrove areas, and monitoring the associated biodiversity. During the first monitoring period, a net reduction of 69,027 tCO_2e was certified; credits were completely sold in the international voluntary market.

Methods/approaches

Vida Manglar uses the following methods for mangrove conservation and restoration, many of which are informed by local ecological knowledge (LEK) and are described in more detail below.

- Opening and maintaining channels.
- "Assisted regeneration" using methods developed together with local communities and learning from many years of activities in the region.
- Conducting research and monitoring about vegetation, fauna, and real-time threats, which is used to inform proposed solutions.
- Extraction of wood through a community-based sustainable use rotation system, which is based on their detailed knowledge of the forest.
- In exchange for making specific commitments that limit the amount of mangrove wood extracted and the active participation in monitoring and scientific activities, community members receive benefits, such as wages for opening channels to avoid high salinity levels, capacity building opportunities and training sessions, and economic alternatives (e.g., ecotourism, local orchards, bee products).

Groups involved and roles

Vida Manglar is led by a coalition of public and private organizations — including 14 community-based associations of mangrove workers, CVS, INVEMAR, the local NGO Fundación Omacha, and Conservation International. Communities living around the project area have a high economic dependence on the natural resources associated with the mangrove forests. Historically, they have promoted different sustainable management initiatives together with CVS to improve their economic welfare and maintain the environmental quality of the ecosystem. They are also part of the governance structure of the project and a key partner for decision-making processes.

Local knowledge

Vida Manglar relies on the local community's knowledge of the ecosystem, which is rooted in generations of utilizing and benefiting from the forest and its associated fauna. **The grandparents of the Cispatá mangrove community relied on mangrove wood for their livelihoods and the community's intimate familiarity with the system and its species is derived from their local knowledge and continual presence in the area.**

CASE STUDY 4 | COLOMBIA

Local communities and institutions on a site visit to monitor an area being restored in the mangrove ecosystem of the DRMI Cispatá protected area, Córdoba. © Vida Manglar

Community members participate in the baseline measurement of physicochemical variables before the start of restoration interventions in the mangrove ecosystem of DRMI Cispatá, Córdoba. © Vida Manglar

LEK as a way of selecting channels to be maintained: Traditionally, **the grandparents recognized the importance of maintaining open water channels, not only for accessing the interior of the forest, but also for ensuring the health of the trees.** This valuable knowledge has been passed down through generations. Through daily immersion in the forest, community members identify areas experiencing salinization due to insufficient water flow. They communicate this information to CVS and map the channels. After creating the map, the channel's length is verified in the field. The system's hydrodynamics are examined, and in collaboration with the community, a decision is made on the appropriate intervention based on the channel conditions (e.g., restoration, maintenance, opening). An agreement is signed between CVS and the community associations so they may carry out the activities autonomously, but accompanied by an official from CVS and experts from Vida Manglar (NGOs and the Research Institute).

Assisted regeneration and active restoration: Local communities possess a keen understanding of tidal changes and effects of rising sea levels. This awareness prompted them to adopt the mounding methodology for tree planting, which prevents seeds from being constantly submerged, enabling seed survival. The success of this approach, tested in the early 2000s, led to its adoption by Vida Manglar. The other method used, also adopted by Vida Manglar, is "broadcast planting", where mangrove seeds are thrown randomly in the area to be restored. Learned from local agricultural practices, mangrove farmers have been using this method for decades with high effectiveness.

Active participation on research and monitoring processes: **The local communities play a crucial role in all scientific research conducted in the area, contributing significantly to data collection on various species.** (e.g., caimans, migratory birds, manatees, otters, dolphins). For example, **the grandparents observed that due to sea level rise, caiman eggs laid on the shores would perish due to submersion.** This led local members to create artificial nests in the forest to ensure the health of the deposited eggs. Initially done to sustain hunting, over time, communities established an association dedicated to the care and monitoring of caiman. The local population of needle-nosed caimans has significantly increased and the methodology used was adopted by Vida Manglar.

Rotating forest management mechanism: One unique characteristic of Vida Manglar is the existence of a community-based sustainable use rotation system, which is based on detailed local knowledge of the forest. In Colombia, the use of mangrove wood is prohibited for any purposes except in the Cordoba Department because of the extensive mangrove monitoring conducted with communities since 1990. Local communities can extract mangrove wood based on permits granted by CVS on a yearly basis. The entire mangrove forest is divided into 13 different subzones, which are harvested on a yearly rotation basis; after 14 years, harvesting returns to subzone 1.

Outcomes

The following are some key outcomes from the first monitoring period (2015-2018):

- 297 hectares restored in the Regional Management District (DRMI) Cispatá, La Balsa, Tinajones and Sectors bordering the Sinú River Delta.
- With community participation of those from San Antero and San Bernardo del Viento, 23,343 meters of canals have been restored, prioritizing the natural regeneration of the mangrove ecosystem.
- Community production and planting of 209,000 mangrove seedlings for coastal erosion mitigation.
- Community capacity building for the management and sustainable use of the mangrove ecosystem and its natural resources for more than 337 local community members.

To learn more about this case study visit:

www.vidamanglar.co

Community delivery of the products of traditional rice agriculture as an alternative livelihood strategy in the municipality of San Bernardo del Viento, Córdoba. © Vida Manglar

CASE STUDY 5 | EL SALVADOR

Restoration and monitoring of four mangrove species in El Zaite, Barra de Santiago

Contributing authors

Eder Caceros*, Coordinator of Environmental Projects for the local NGO "Women's Association for Community Development of Barra de Santiago, El Salvador" (AMBAS[26])[27]. **Luis Roberto Quintanilla Guerra***, Technician for the AMBAS. **Karla Evangelista**, IUCN, site coordinador. **Zulma Ricord de Mendoza**, Regional Coastal Biodiversity Project IUCN-USAID.

BIODIVERSITY | PHYSICAL PROCESSES

Location

13°42' N and 90°00' W

Project Size

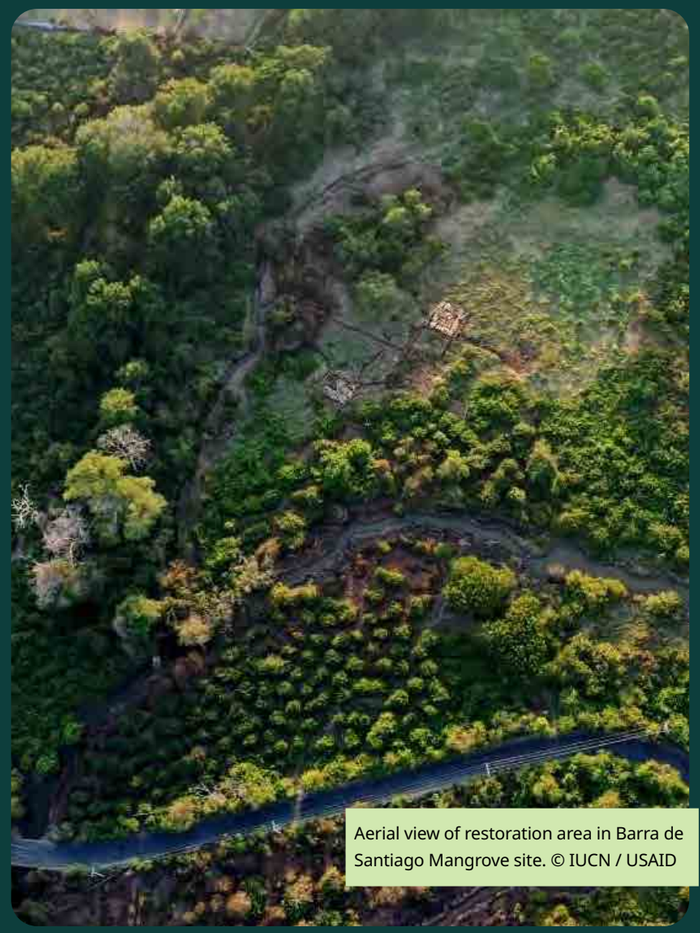
The goal is to expand beyond the 81 ha currently protected.

Mangrove species

Four species are used in the restoration process: white mangrove (*Laguncularia racimosa),* red mangrove (*Rhizofora mangle*), black mangrove (*Avicennia germinans),* and the button mangrove (*Conocarpus erectus*).

Project Duration

2020 - 2024



Aerial view of restoration area in Barra de Santiago Mangrove site. © IUCN / USAID

26 AMBAS (Associacion de Mujeres de Barra de Santiago) is a local women's non-governmental organization established in 2005, which is currently made up of 50 members. The board is led by Doña Rosa, the NGO's founder and leader.

27 Barra de Santiago, Women Association AMBAS.

Additional location details

On July 23, 2014, The Barra de Santiago became an internationally recognized Ramsar site covering 11,519 ha at the western boundary of El Salvador. The site includes coastal and marine areas as well as terrestrial zones up to 5 to 9 meters of elevation. The site is the main forested area with mangroves in the western part of the country and is inhabited by species such as the caiman *(Caiman crocodylus)*; the crocodile *(Crocodylus acutus)*; the tropical gar fish, known locally as the "machorra" *(Atractosteus tropicus)*, otters *(Lontra longicaudis)*, and various migratory and resident birds that are threatened or endangered. The mangrove forests continue beyond the border with Guatemala, where protected areas and wetlands in Hawaii, Monterrico, and the Las Lisas Multiple Use Area, among others, can also be found. The area is one of the implementation sites for the Regional Coastal Biodiversity Project, IUCN-GOAL/USAID (2017-2024).

Project goals and objectives

Local knowledge highlighted that mangroves in this area have undergone considerable deterioration in recent decades, having been damaged by two powerful hurricanes (Hurricanes Fifi in 1974 and Mitch in 1998), as well as by fire. Parallel to these events, a native liana species, "devil's rib" *Dalbergia brownei*, colonized former mangrove areas, preventing recovery. Thus, an area of rich biodiversity that in the 1980s was known as *"El Colegio de Aves" (the Bird School)* underwent considerable declines.

This project, known as the "El Zaite, 81 ha", aims to restore a part of this site with vegetative cover; increase carbon dioxide (CO_2) fixation; and eradicate *Dalbergia brownei*. Until 2016-2017, only water rehabilitation activities occurred at the Ramsar site, based on guidelines from the Ministry of Environment and Natural Resources (MARN). Yet, AMBAS (a local women's non-governmental organization) and others in the communities observed that these interventions were not enough. To make better decisions, they sought out the knowledge of their elders, verified that information, and prepared a review on the state of the resources in the site, after which AMBAS developed their intervention plan.

Methods/approaches

AMBAS, with the support of others in the community, created demonstration plots and focused on the eradication of the *Dalbergia brownei*. Through a process of trial and error, they successfully transplanted seedlings in the demonstration plots. Although they are currently working in an area of 5.5 hectares with the Regional Project, their goal is to restore a total of 25 hectares by 2025. They also provided training for communities on the dangers, benefits, and commitment required to restore the mangrove ecosystem. The restoration efforts supported temporary work for 50 local people hired under a "cash for work" program, where they earned a rate of USD $7 per 4-hour workday. AMBAS measures the effectiveness of the interventions by monitoring mangrove species size and noting the appearance of fauna in restoration sites. AMBAS has donated seedlings from its nursery to be used in other restoration sites.

Groups involved and roles

The project is supported by the Regional Coastal Biodiversity Project, a coordinated restoration started in 2020. The project also works in coordination with MARN as the governing authority for mangroves; UNES[28];

28 Unidad Ecológica de El Salvador UNES local implementation member of the IUCN consortium for the Project implementation.

CASE STUDY 5 | EL SALVADOR

FIAES[29]; FUNDEMAS,[30] a private NGO; DAVIVIENDA Bank[31]; other cooperation agencies such as the Green Fund (GIZ); local schools and national universities; and local communities. AMBAS has also participated in learning exchanges.

Local knowledge

Elders identified the areas where there had been mangroves in the past, the types of mangrove species found, and the vertebrate species that existed in those areas. This procedure is included in the REM Ecological Mangrove Restoration methodology according to MARN (Ministry of Environment and Natural Resources) and IUCN guidelines, which recommend in the guidelines to consider gathering information from community elders. Afterwards, AMBAS visited sites and verified the evidence of the past hurricane and fire damage. From that knowledge, it was possible to derive the original location of tidal inundation and the original mangrove species.

Outcomes

To date, a total of 11.7 hectares have been restored, representing an economic value of USD 18,000 per year[32]. The restoration of the area and the elimination of the "devil's rib" has resulted in the return of species such as the river otter, caimans and crocodiles, wildcats (not reported before), and some six to seven species of shore herons. In addition, due to their restoration work, AMBAS has learned that the white mangrove has greater adaptability as a pioneer species, allowing the red mangrove species to develop in its shade. The rest of the community is committed, experiencing a change in attitude as they increased their awareness about the restoration process. There has been an increase in small-scale fishing and improved water rehabilitation practices in the area.

To learn more about this case study visit:

https://focostv.com/las-mujeres-que-restauran-el-manglar-de-la-barra-de-santiago-hectarea-a-hectarea/

Dredging channels on mangrove sites in Barra de Santiago. © IUCN / USAID

29 Environmental Investment Fund of El Salvador: FIAES

30 FUNDEMAS: Business Foundation for Social Action.

31 Davivienda is a bank of Colombian origin that has agencies throughout the national territory of El Salvador.

32 According to a chart managed by MARN

El Zaite area to be restored in Barra de Santiago. © IUCN / USAID

AMBAŚ women participating in dredging in El Zaite, Barra de Santiago. © IUCN / USAID

CASE STUDY 6 | EL SALVADOR

Harnessing local knowledge for mangrove restoration in the Bay of Jiquilisco

Contributing authors

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BIODIVERSITY

Location

Bay of Jiquilisco, El Salvador.
13°12'00.9"N 88°28'57.6"W

Project Size

62 hectares

Mangrove species

Rhizophora racemosa, Avicennia germinans, Avicennia bicolor, Laguncularia racemose, Conocarpus erectus

Project Duration

2011 - ongoing

El Salvador site assessment Feb 2023. © Mangrove Action Project

Project goals and objectives

Along the Pacific coast of El Salvador, lies the Bay of Jiquilisco, home to one of the region's most extensive and diverse mangrove forests. Covering over 63,000 hectares, this invaluable ecosystem earned its designation as a UNESCO Biosphere Reserve and Ramsar Wetland of International Importance due to its unique biodiversity and global significance.

However, the mangroves in the Bay of Jiquilisco face an array of threats, including upstream flooding, sedimentation, uncontrolled tourism development, large-scale agricultural expansion, and exploitation of mangrove resources. The aim of this project was to restore the degraded mangroves in the bay by implementing a community-based restoration project.

Methods

The methods employed a distinctive blend of expertise, integrating the insights of the local community with technical scientific knowledge. The restoration efforts were rooted in the principles of Community-Based Ecological Mangrove Restoration (CBEMR), which entailed a comprehensive assessment of both biophysical and social factors at the restoration sites. Due to sedimentation blocking many of the channels, hydrological restoration was deemed necessary at all sites to restore the natural flow of water. Leveraging the invaluable local knowledge of the ecosystem discussed below, former mangrove channels were carefully re-excavated, while new channels were strategically created to enhance water flow in inundated regions. Asociación Mangle, a regional non-profit focusing on community development in the Bay of Jiquilisco, coordinated community groups in restoration activities, which consisted of removing sediments and extracting fallen trees and other debris that blocked the channels. After several months of concerted effort, over 4 km of channels were opened, allowing the standing water to drain and the mangroves to naturally regenerate.

Groups involved and roles

Seven communities were involved in the project, namely Isla Montecristo, Las Mesitas, La Chacastera, La Canoita, Los Calix, Los Lotes, and La Babilonia. Asociación Mangle; the Ministry of Environment; the inter-governmental agency, Fondo de Inversión Ambiental de El Salvador (FIAES); and two international NGOs, Mangrove Action Project and EcoViva, were also key partners.

Local knowledge

A fundamental aspect of this project was acknowledging and harnessing the local knowledge present within the communities. The residents, whose lives and livelihoods are intricately connected to the mangroves, possess an innate understanding of these ecosystems. To determine where to dig the channels to reestablish water flow, the local communities provided essential knowledge about the site history, including the position of past tidal drainage channels and specifics of the hydrological dynamics that defined the sites. Furthermore, local community members shared their knowledge about past assemblages of flora and fauna within the study areas. This **local understanding of the ecosystems' historical composition helped formulate the project's biodiversity goals, with an aim of restoring all species that were historically present**, contributing to the long-term sustainability of the mangrove areas.

CASE STUDY 6 | EL SALVADOR

Community Restoration Group Bay of Jiquilisco. © Asociación Mangle

Outcomes

An estimated 62 hectares of mangroves across the project sites have been restored through natural regeneration. The benefits of restoration using this methodology is that it brings back a mangrove ecosystem consisting of all five mangrove species. Since the mangroves have been restored, the overall health of the ecosystem has improved. The bay has seen an increase in the number of animal species dependent on this habitat, including migratory and wading birds, mammals, crabs, fish, and mosquitoes.

Today, the project continues to evolve and expand its scope, incorporating mangrove management and monitoring. The local knowledge, combined with structured technical training, has made the communities not just beneficiaries but active participants in mangrove conservation. Furthermore, the Ministry of Environment in El Salvador has adopted CBEMR as the national policy for best mangrove restoration practices.

To learn more about this case study visit:

http://mangroveactionproject.org/wp-content/uploads/2023/11/Mangrove-Restoration-Impact-Assessment-Report-2023.pdf

https://bit.ly/ElSalvadorVideo

El Salvador CBEMR Photo Sequence - Before and After Restoration. © Mangrove Action Project

Community Restoration Group Bay of Jiquilisco. © Asociación Mangle

CASE STUDY 7 | FIJI

Living with change – Resilient mangroves, fisheries and people of Fiji

Contributing authors

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BIODIVERSITY | RESTORATION APPROACHES | CULTURAL PRACTICES | TRADITIONAL SKILLS | HABITAT CONNECTIVITY

Location

Ba Province
- Western Division of Fiji - in the mainland districts of Tavua and Nailaga
- Maritime District of Nacula

Project Size

Nacula District – 205.4ha
Nailaga District – 5527.12 ha
Tavua District – 3153.25 ha

Mangrove species

Rhizophora stylosa, Rhizophora samoensis, Rhizophora selala, Bruguiera gymnorrhiza, and Mangrove Associated species.

Project Duration

2019 - 2022

We all have a role to play in building our resilience to climate change. © WWF Pacific

Project goals and objectives

The overall goals of this project were to restore and protect mangroves, rivers, forests, coral reefs, and fisheries, as well as increase community capacity and resilience. To address community resilience, the project aimed to improve livelihoods, food security, and economic security, as well as eradicate poverty. One way was through trainings and workshops aimed at capacity building and awareness. Another goal was to create Mangrove Community Business Development and Nature Based Solutions. This holistic approach to mangrove management combines protection efforts with community-led business development, recognizing the importance of both ecological conservation and sustainable livelihoods. Future plans envision expanding economic initiatives by integrating ecotourism into the framework. This strategic move aims to not only boost local economies but also raise awareness about the importance of mangrove ecosystems.

Methods/approaches

To achieve these goals, the project collaborated with the community and included their knowledge. Community consultation occurred with local leaders to develop District Sustainable Development Plans. The community helped with resource mapping and was involved in workshops for creating Fisheries Management Plans. The project also held several training and capacity building and awareness sessions to formulate Disaster Risk Reduction and Response Plans for community resilience, sustainable farming and fishing techniques, food preservation, livelihood enhancement, governance and leadership, committee administration, and responsible ecotourism practices. The project worked to provide financial opportunities for the community. In addition, the project involves mangrove restoration through the planting of mangroves raised in nurseries started by the project.

Groups involved and roles

Ministry of Fisheries, Provincial Councils, District Councils, Village Women and Youth Groups, Traditional Leaders.

Local knowledge

Actively participating in decision-making processes, the community drew from generations of mangrove knowledge and practices, ensuring informed and culturally sensitive project decisions. This project blends the old with the new by combining traditional ways with modern methods, as well as including traditional rules and governance systems.

The local communities have a deep connection with mangroves, both culturally (e.g., seeing mangroves as totems) and practically (e.g. fishing spots). Their generational knowledge about the different mangrove species, their habitats, and the whole ecosystem forms the backbone of how these resources are managed sustainably. **Project activities (e.g., fishing, planting) are aligned with the community's cultural calendars.** For example, early mornings of the third and fourth week of the month are believed to be the best time for catching crabs. In addition, replanting mangroves and setting up nurseries aligns with the flowering and fruiting period, which are well known by the communities.

Oral histories provide insights into how mangrove ecosystems have changed over time, helping the project make better decisions. For example, in selecting restoration sites, the collaboration with community elders played a crucial role. With their valuable support, priority sites were discerned, encompassing locations of historical significance such as old village sites, some situated near mangrove areas. Additionally, the identification process took into account key fishing hotspots.

CASE STUDY 7 | FIJI

The insights provided by the community elders were instrumental not only in pinpointing potential restoration sites but also in discerning changes that have transpired in the mangrove areas and their associated ecosystems.

Collaboratively, the project and the community explored alternative livelihoods that can ease pressures on mangroves and tap into local wisdom, such as crab farming and fattening (bai ni qari) and fish preservation methods (Ika sigani - sun drying, Ika Vesa - smoked drying). **Recognizing the cultural and spiritual ties that people have with mangroves, the project includes traditional ways of managing and restoring mangroves, such as setting areas on temporary taboo (Tabu) or creating out of bound areas to provide recovery period and using specific planting methods.**

For instance, the selection of healthy propagules and the timing of planting are considered crucial knowledge shared by the community. Planting mangroves in groups, rather than as individual plants, is believed to result in a higher survival rate. **It is also believed that when restoration efforts are carried out at the communal level and with a high and positive spirit, success is more likely to be achieved.** In essence, the success of the project is intricately connected with the rich local knowledge, practices, and active participation of the community, surpassing a mere consultative role to establish a genuine partnership. Saving mangroves is not the only objective; rather, the focus is on implementing conservation efforts in alignment with the traditional practices that have been passed down through generations.

This matriarch ensuring the homes of her grandchildren are not only protected from the waves but fishes also have nurseries to multipl for food security. © WWF Pacific

Nacula villagers actively support the replanting of mangroves along their barren coastline. © WWF Pacific

Outcomes

- Protection and preservation of 16,000 ha of mangroves across the three districts through community management and restoration.
- 10 Fisheries Management Plans and Mangrove Management Plans established with its committee, incorporating traditional knowledge and practices and climate smart strategies.
- Establish community-based enterprises which link to a Trust Fund to support the Sustainable Fisheries Management and operations within the district.
- Enhanced local ownership of resources and co-management with government agencies.
- Promote sustainable use of resources and its preservation through implementation of management strategies and traditional practices that enhance proper management of mangrove resources, including: traditional medicine, arts and crafts, and fishing practices.
- Knowledge exchange and enhancement. Integrating traditional knowledge and scientific data on trends and projections in climate data. Consultation and awareness sessions provide great opportunities for sharing lessons and traditional knowledge from the elder community members to the younger generations and project team.
- Livelihood diversification – alternative sources and improved finance in each household. Capacity building to ensure high quality of harvest and proper management of household finance was part of the project activity. Facilitate market access for locally produced goods to increase income opportunities.
- Set up community savings and microfinance initiatives to support local entrepreneurs Cultures and traditions are acknowledged, respected, and preserved through traditional governance systems and leadership.
- Mangrove Protected Areas and Mangrove Community Business Development. In communities engaging in mangrove management, the focus extends beyond conservation to also include economic enhancement initiatives. Through proper management practices, including the integration of traditional knowledge for optimal harvest timing, these communities have experienced an increase in mangrove harvests.

CASE STUDY 8 | HONDURAS

Restoring the mangroves of Estero Prieto, Omoa

Contributing authors

Sandra Cardenas*, Centro de Estudios Marinos, *co-founder of the restoration committee*. **Sara Bonilla**, Penn State University, *technical support*. **Hannah Morrissette**, Smithsonian Environmental Research Center, *technical support*. **Steven Canty**, Smithsonian Environmental Research Center, *technical support.*

BIODIVERSITY | THREATS & IMPACTS | RESTORATION APPROACHES | HABITAT CONNECTIVITY

Location

Las Flores Estero Prieto, Cortés, Honduras Community (N 15.777; W -88.038)

Project Size

7.97 hectares

Mangrove species

Rhizophora mangle - red mangrove

Project Duration

2015 - ongoing

Youth participating in a planting event. The boys were using one of the committee's boats to row to the Estero's banks and plant mangrove seedlings. © Sandra Cardenas

Project goals and objectives

To restore and protect the mangroves and improve the water quality within the estuary of Estero Prieto.

Methods/approaches

Methods used include cleaning the river channel of invasive species, such as water lettuce to increase water flow and planting red mangroves along the banks of the channel, which the community raises in nurseries that they created and maintain. In addition, the committee carries out environmental education activities highlighting the importance of mangroves and the benefits they provide. The environmental education activities are aimed at adults and youth.

Groups involved and roles

A protection and surveillance committee, established in 2015, is made up of leaders and members of Las Flores Estero Prieto community. Since its creation, the committee has had the advice and support of community member and co-founder Sandra Cardenas, who has accompanied the committee members in each cleanup and reforestation activity. In addition, the committee has had the support of the Municipality, the Navy, and the Center for Marine Studies, institutions that have been key to the creation of the nurseries and execution of the cleaning and planting activities.

Local knowledge

The project was initiated by the community of Las Flores Estero Prieto and relied on their observations within the estuary. Community members noticed the poor water quality and the deaths of fish and other species in the estuary. Fishers and families who lived near explained that some plants were growing too fast and covering the entire surface of the river, not allowing fish to breathe. **Community members canoed up and down the creek documenting the problem of invasive species with photographs and videos to convince other members of the community to join their initiative to clean the creek and plant mangroves. Being the first to raise awareness about the threats and the need to remove invasive species, the community group created a committee** consisting of people from the municipal government and local organizations to address these issues. All activities carried out by the committee are designed by them according to their goals and priorities. In addition, local people's presence in the ecosystem enabled them to understand optimal seasons for harvesting and planting propagules and identify optimal areas for these activities. In the words of Sandra Cardenas,

> *"We have learned by trial and error…by observing the mangroves very closely, times when there are many propagules, areas where regeneration was better… seeing what worked and what didn't. Now some of us have received training and **people who know about mangroves have come and taught us different restoration techniques and how to monitor these areas. We have come to mix our knowledge with theirs and we have seen better results."***

Outcomes

Although not yet reaching the goal, the main achievements so far are: (i) the involvement of men, women, and youth in the restoration of the ecosystem; (ii) clearing half of the estuary of the invasive water lettuce, allowing better oxygenation of its waters; (iii) planting 17,952 mangroves, which will be important spawning and refuge sites for various species; and (iv) being an example and motivating nearby communities, as people from other communities and educational centers visit to learn from this experience.

CASE STUDY 9 | INDIA

Reviving mangroves: Sustaining traditional knowledge and using eco-friendly Palmyra nursery bags

Contributing authors

Sumantha Narayana – *project design*. **Balaji Vedharajan** – *project conception and design*. **Murugesan Govindarajan** – *set up mangrove nursery and planting work*. **Rajendran Magalingam*** – *set up mangrove nursery and planting work.* **K. Sathya***, *managed Palmyra bag making, training, production and procurement*. All are from the Organization for Marine Conservation Awareness and Research (OMCAR).

Location

Adirampattinam (Keelathotham, Agni estuary) Thanjavur District, Tamil Nadu India) (10°17'50.7"N 79°22'10.9"E)

Project Size

14 sites were selected along the coast of Thanjavur district, Tamil Nadu, as the location also has settlements with high human populations, and is important for fisheries and other activities. Planting locations were spread out in suitable areas where minimal disturbances to mangroves occurs. Sites include 4 km linear planting along the coast and ranging from 0.5 to 1.5 hectares along the shoreline.

Mangrove species

Rhizophora mucronata, *Avicennia marina*.

Project Duration

2022 - ongoing

TRADITIONAL SKILLS

Local community members sowing Avicennia marina propogules © OMCAR

Project goals and objectives

The primary focus of this project was the restoration and conservation of mangroves in this region, while reducing plastic usage in mangrove nurseries and simultaneously empowering the traditional craft of Palmyra bag-making to foster sustainable livelihoods for the local community. Palmyra bags are meticulously hand-woven items, shaped like pots with dimensions of approximately 15 cm in diameter and 23 cm in length. They are made by the traditional technique of interweaving the leaves of the Palmyra species, *Borassus flabellifer*, which is commonly found in the coastal areas of Tamil Nadu and is used to create a range of household items including mats, baskets, and bags. These bags have traditionally been used for a variety of functions, from storing and transporting groceries or fish to packaging food.

Specific goals of the projects were:

- **Enhancing livelihoods:** Create economic opportunities for local communities by promoting their traditional craft of Palmyra bag making.
- **Involving women:** With new skills and earning opportunities, women can be more self-sufficient and independent in their daily lives.
- **Reducing plastic pollution:** Replace plastic nursery bags by using eco-friendly Palmyra bags to reduce plastic waste in the mangroves and surrounding areas.
- **Encouraging nature-based solutions for mangrove restoration:** Using Palmyra bags in mangrove nurseries, which have more water seepage compared to plastic bags, enabling good growth of spiral roots.
- **Encouraging palm plantation:** Encouraging palm (*Borassus flabellifer*) plantations as palm leaves are used as the raw material.

Methods

- **Skill Training:** Local women who knew the skill of Palmyra bag-making shared this knowledge with other community members in trainings organized by OMCAR Foundation.
- **Palmyra Bag Production:** Locals made 6,000 palmyra bags, which were collected by OMCAR Foundation and utilized for setting up mangrove nurseries.
- **Mangrove Restoration:** Local communities were involved in planting mangrove saplings using the fishbone technique for hydrologic restoration.
- **Protected Area Establishment:** Collaborated with local governments to designate the status of protected areas to safeguard restored mangrove areas.
- **Education and Outreach:** Awareness programs were conducted in local schools and communities about the ecological importance of mangroves and benefits of eco-friendly mangrove restoration approaches.

Groups involved and roles

- **Local community:** They are the core beneficiaries, actively participating in skill training and the planting process.
- **Government Agencies:** Partnering with government bodies (Tamil Nadu Forest Department) enabled access to resources, establishment of protected areas, and support for sustainable practices.
- **Schools and Educational Institutions:** Involving educational institutions aided in awareness campaigns and engaging the youth in preserving mangroves.

CASE STUDY 9 | INDIA

Local knowledge

In the context of successful mangrove restoration and conservation, local knowledge plays a pivotal role, with traditional Palmyra bag-making emerging as a crucial practice that supplants plastic nursery bags for planting mangroves. Due to the prevalence of plastic products, **only a handful of villagers, primarily fisherwomen, knew and continued to practice the art of weaving Palmyra leaf into various products.** However, due to the time-intensive nature of weaving and their daily commitments, these women could only produce 8-10 bags per day. To weave the thousands of bags required for nursery planting, **these fisherwomen trained other local women.** Mrs. K. Sathya orchestrated these training endeavors and fostered greater participation of fisherwomen in Palmyra bag production as an alternative livelihood.

Presently, **local communities hold an abundance of valuable information concerning mangrove locations, distribution, species diversity, as well as changes that have occurred over time** and the overall intricacies of mangrove ecosystems. Moreover, **their insights extend to identifying threats such as erosion, pollution, illegal logging, the impact of climate change, and overexploitation on mangrove ecosystems. They also possess inherited knowledge of the medicinal uses, food sources, building materials, and cultural significance associated with mangroves.** By integrating this wealth of local knowledge, conservation efforts and mangrove restoration activities were substantially strengthened, while fostering a profound and symbiotic bond between the community and the mangrove ecosystems.

Meeting with local villagers at the restoration site in presence of Forest Department officials and local community leaders. © OMCAR

Palmyra nursery bags being filled with soil by local women community members. © OMCAR

Local women involved in palmyra bag making. © OMCAR

Outcomes

- **Cultural heritage and social impact:** The project helped revitalize the Palmyra bag craft, ensuring its continuation for future generations.
- **Economic Empowerment:** The project improved the livelihoods of a marginalized local fishermen community and increased their financial stability.
- **Environmental Sustainability:** The project will contribute to the conservation of palm trees, reducing plastic nursery bags, and restoring mangroves in an eco-friendly manner.

The weaving of Palmyra bags has been ongoing and is being scaled up. In response to the increasing demand for bags from the Forest Department and other government agencies to replace plastic bags in both mangrove and terrestrial nurseries, the training program has been expanded to include 12 marginalized fisherwomen. It is actively working to extend this training to additional coastal villages. Interest extends beyond the region; an order of 4000 Palmyra bags from West Bengal was recently fulfilled. Also, given benefits of Palmyra palms (e.g., bio-shield, alternative livelihood opportunities) and the threats they face (e.g. urbanization, agricultural expansion), OMCAR has collaborated with the Tamil Nadu government and Forest Department on a Palmyra seedling planting initiative. The goal is to plant 100,000 Palmyra seedlings over the next few years in the degraded coastal areas of Thanjavur and Pudukkottai Districts.

To learn more about this case study visit:

https://www.youtube.com/watch?v=TS_HhJONkyk

CASE STUDY 10 | INDONESIA

Building with Nature (BwN) Indonesia – Securing eroding delta coastlines

Contributing authors

Abu Dawud* (member of Sido Makmur community group of Betahwalang Village): informant. **Mat Sairi***(member of Barokah community group of Timbulsloko Village): informant. **Kuswantoro, Woro Yuniati, Apri Susanto Astra** (Wetlands International Indonesia): interviewing the informants and writing the article according to the informants.

Location

Coastal area of Demak Regency, Central Java, Indonesia. 6°48'6.70"S 110°33'31.82"E

Project Size

20 hectares of mangrove area in Betahwalang Village out of the total 119 ha in Demak intervened by the BwN Indonesia project.

Mangrove species

Acanthus ilicifolius, *Avicennia alba*, *Avicennia marina*, *Excoecaria agallocha*, *Aegiceras corniculatum*, *Rhizophora mucronata*, *Rhizophora apiculata*, *Bruguera sexangular*, *Sonneratia alba*.

Mangrove associates:

Hibiscus tiliaceus/Talipariti tiliaceum/ Ziziphus mauritiana

Project Duration

2015 - 2021

BIODIVERSITY | PHYSICAL PROCESSES | RESTORATION APPROACHES

Community members conduct monitoring of sedimentation and natural mangrove regeneration. © Kuswantoro

Project outcomes and goals

Coastal areas of Demak in Northern Java are suffering from coastal erosion mainly caused by near total conversion of mangroves for the expansion of brackish water aquaculture. A thin outer barrier of mangroves, which had previously protected community settlements and aquaculture ponds, has been lost along 20 km of this coastline. Erosion, in turn, has displaced villagers from their settlements and subsequently has led to a reduction in income for the local communities.

The Building with Nature (BwN) project aims to develop a coastal infrastructure design approach that combines local ecological knowledge, ecological regeneration, and smart engineering, while introducing sustainable land management practices through transdisciplinary cooperation and the involvement of multiple stakeholders. To achieve the long-term vision of a 'healthy mangrove greenbelt that provides coastal safety and enables local communities to prosper', the project had three objectives: rehabilitation of mangrove coastal protection system, revitalization of aquaculture ponds, and helping increase local capacity.

Methods and approaches

The reestablishment of a mangrove coastal protection system was undertaken by following the ecological mangrove restoration (EMR) method that promotes natural mangrove recolonization. The use of 'permeable structures'-- fence-like constructions consisting of two rows of poles with brushwood fill in between-- creates sheltered zones with reduced flow velocities and wave impact, which enables sufficient accretion of suspended sediments.

Local communities were involved for the entire process, including guidance, preparation, planning, procurement, construction, monitoring, and maintenance. Participatory field surveys were undertaken throughout the project implementation cycle (i.e., construction, monitoring, and maintenance phases). The exact location for building the permeable structures was initially determined by remote sensing, and then verified through participatory field surveys in which the community and their knowledge of local conditions was involved.

Over the course of the project, established community groups were involved in monitoring to assess the durability of the permeable structures, sediment increment behind the structures, and natural mangrove colonization. Monitoring also allowed for both acquired information to be implemented and further planning to increase the construction's efficiency.

The project facilitators trained and accompanied the community initially and then the community groups conducted field monitoring and the project team analyzed the data. Results were discussed with community group members in a facilitated discussion to elicit correction measures to optimize the accretion process. Participatory monitoring enabled the local communities to address possible problems by employing their local knowledge, as well as gain additional knowledge on the effectiveness of the built structures. Besides providing the skills and labor needed, participatory monitoring increased community engagement allowing for a sense of ownership over the structures.

CASE STUDY 10 | INDONESIA

Local knowledge

Locals contributed their knowledge during the planning process and the implementation phase to inform the spatial and structural design of the structures. **Spatial design relied on the community's knowledge about local conditions including the locations of muddy coasts with erosion, solid soil layers less than 1.5 m from the high-water level mark, and minor land subsidence; sediment flow from the river; boat channels; and local sources of mangrove seeds.** The community suggested the structure be placed near the mouth of the river to more quickly trap sediment.

The local community also applied their knowledge in construction and maintenance of the permeable structures. Initially, a wood expert recommended using the locally available and durable construction material, 'kayu gelam' (*melaleuca sp.*), to improve the efficacy of the permeable structures. However, after one year of being inundated, the construction materials were deteriorating from shipworm and mollusk infestation, reducing their effectiveness. The community then suggested the use of petung bamboo (*Dendrocalamus asper*) for vertical pole material combined with protection wrapping (using plastic, carpet, or *terpaulin*) and *apus* bamboo (*Gigantochloa apus*) for the longitudinal beams, which has been more durable. Whenever they found broken joints, collapsing brushwood or washed poles, they repaired them, funded by a conditional loan scheme (Biorights). Although knowledge about maintaining the structure was obtained from the training provided by the program, the technical implementation was adapted to local knowledge and customs, such as the importance of human labor.

Community group installs a simple sediment trapping structure. © Kuswantoro

Community group installs warning boards at the rehabilitation site. © Kuswantoro

Outcomes

At the locations where permeable structures were built, coastal erosion was halted. In addition, measurements in the first year showed 0.45 m of sedimentation. Mangroves settled once elevation was above mean sea level, which happened behind several structures within a year. However, in 2017, elevation lowered again in the western part of Demak adjacent to the City of Semarang and mangroves disappeared due to land subsidence. Mangrove rehabilitation activities have been more successful in the eastern part of Demak (including Betahwalang Village).

Despite the uncontrollable subsidence in some areas, the local communities developed the technical knowledge and skill in rehabilitating eroded mangrove ecosystems using low-tech but cost-effective methods. In addition, local communities learned about land subsidence in their region, so they have a better understanding of how they can deal with and adapt to the situation. An inspiring example of empowerment among the community groups is Sido Makmur of Betahwalang Village. The group members have been actively practicing mangrove rehabilitation using EMR (Ecological mangrove rehabilitation) method to rehabilitate up to 20 ha of degraded mangrove area (from the initial 3.7 ha restored area during the project) and plan to restore another 10 ha in the near future.

To learn more about the BwN Indonesia program, please visit:

https://www.wetlands.org/case-study/building-with-nature-indonesia/

https://www.ecoshape.org/en/pilots/building-with-nature-indonesia/

https://buildingwithnatureindonesia.exposure.co/building-with-nature-indonesia-1

https://www.decadeonrestoration.org/building-nature-indonesia

CASE STUDY 11 | INDONESIA

Kerakera: restoring traditional management practices to safeguard mangroves

Contributing authors

Dahlan Iha* – Head of Pattimburak Village, Fakfak. **Hanggar Prasetio** – Konservasi Indonesia, Ridge to Reef and GIS Coordinator. **Sefrianto Saleda** – Konservasi Indonesia, Acting Fakfak Program Senior Coordinator. **Susan Lusiana** – Konservasi Indonesia, IKI PME Senior Programme Manager.

Location

Kinam, Kiminakra, Batufiafas, Patimburak, and Mandoni Villages, Berau Bay, Fakfak, West Papua. Fakfak is a district in West Papua, which is in the 6th position as a district that has the widest mangrove ecosystem of 4,007 ha (KLHK, 2020).

Project Size

The total intervention area is 762.16 ha[33], with 389.5 ha managed under Kerakera/local wisdom intervention by a local indigenous community.

Mangrove species

The total number of identified mangroves is 22 species, of which 14 are true mangroves: *Acanthus illicifolius Aegiceras corniculatum, Avicennia marina, Ceriops tagal, Bruguiera gymnorrhiza, B. sexangula, Excoecaria agallocha, Lumnitzera littorea, Nypa fruticans, Pemphis acidula, Rhizophora apiculata, R. mucronata, Scyphiphora hydrophillacea, Sonneratia alba, Xylocarpus granatum dan X. mollucensis.*

Project Duration

Phase 1: 2022-2023,
Phase 2: 2024-2027

BIODIVERSITY | CULTURAL PRACTICES | HABITAT CONNECTIVITY

Environmental Education: Conservation Snakes and Ladders Game in Patimburak Village by Gen-K (Generation Conservation, a local community group based in Fakfak Regency). © Orlin Ozora Yowei/Konservasi Indonesia

33 Based on Rencana Pengelolaan Dan Zonasi Kawasan Konservasi Taman Pesisir Teluk Berau Dan Taman Pesisir Teluk Nusalasi-Van Den Bosch Di Kabupaten Fakfak, Provinsi Papua Barat (RPZ Taman Pesisir Fakfak). Enacted in 2018

Project goals and objectives

The project goal is to enhance protection and management of mangroves areas. The targeted villages are located inside the Teluk Berau Marine Protected area (MPA), with part of mangroves in this area included as a mangrove zone in the MPA. Therefore, better management of mangroves will contribute to improved management of the conservation area while also supporting international targets for conservation such as the "30x30" target under the Global Biodiversity Framework. According to the Mangrove Health Index (MHI) analysis, an internal report by the Indonesian government agency Badan Riset dan Inovasi Nasional (BRIN), even though this area has many mangroves, only those in six of the villages are considered in good condition while the rest are in moderate condition. The MHI consists of three parameters, density, canopy cover, and diameter.

This situation is caused by both natural and human activities, including:

1. Lack of awareness and unsustainable practices among younger generations, including mangrove logging, use of natural poison for catching fish, overfishing/overuse, and plastic pollution. With the naturally low canopy height of mangrove ecosystem in this region, mangrove logging will worsen the location's MHI.
2. Lack of knowledge in mangrove rehabilitation methods.
3. Lack of livelihood options lead people to cut and sell mangroves for charcoal and limited opportunities to enable mangrove conservation to enhance livelihoods (capacity, marketing, funds, and policy support).
4. Infrastructure development. This includes roads, a small port for Crude Palm Oil (CPO) distribution, and a chemical/fertilizer factory.

Methods/approaches

To improve the protection and management of the mangrove area, the project delivers several interventions through awareness raising, capacity building, and policy dialogue with local authorities including local government and tribe/traditional leaders. Several activities are being carried out including:

1. Drawing from Kerakera (i.e., local wisdom that once agreed upon becomes an obligation) and building capacity for mangrove monitoring.
2. Environmental education and awareness raising among younger generations.
3. Developing alternative livelihoods through ridge to reef ecotourism development.

Groups involved and roles

The project involves several stakeholders in the field activities:

1. **BLUD UPTD Pengelolaan KKPD Kaimana** - Fakfak (MPA Managers)
2. **Fakfak Mengajar (FM)** - Local groups concerning on environmental education.
3. **POKMASWAS Nusa Matan** - Community based MPA patrols group
4. **Petuanan Pegpeg Sekar** - Indigenous community group (tribal authority holder)
5. **Petuanan Wertuar** - Indigenous community group (tribal authority holder)
6. **Petuanan Arguni** - Indigenous community group (tribal authority holder)

CASE STUDY 11 | INDONESIA

The community presents a seasonal calendar for utilizing the mangrove ecosystem during training © Orlin Ozora Yowei/Konservasi Indonesia

Focus Group Discussion: Sustainable Tourism Management in Andamata Village © Orlin Ozora Yowei/Konservasi Indonesia

Local knowledge

Pegpeg Sekar, Wetuar, and Arguni are three native/ Indigenous Papuan Kingdoms (Petuanan) located in Fakfak regency, West Papua. Most people are clustered in several villages including Kinam, Kiminakra, Pattimburak, Batufiafas, Mandoni, and Andamata. Like other Papuan people, nature is their main source of life, with two main products supporting communities' needs being fisheries and nutmeg harvest from adjacent forests. People recognize mangroves as a source of food, specifically a place to collect fishes, shells, shrimp, and crabs. People also collect "Tambelo" (wood-boring shipworm) from dead mangrove (mostly *Rhizophora*) wood, which is used for local culinary/ traditional dishes. Locals can identify the crab's egg laying season through the seasonal changes in mangroves (*Xylocarpus moluccensis*). Some people use mangroves as traditional medicine, such as using *Xylocarpus* for toothaches. They also use the wood for fires, both for their daily lives and the nutmeg drying process. In addition, people use the leaves of *Nypa frutican* for the local cigarette paper and for roofing material.

Responding to the threats facing the mangroves, the "adat" authority, a traditional authority similar to a kingdom usually inherited from one generation to the next, established a Kerakera implementation to protect the existing mangrove. **Kerakera is a kind of local wisdom or traditional mechanism inherited by the adat ancestor and belongs to the adat community, but is a practice rarely implemented today. As an adat mechanism, rules/regulations limit people access to certain areas during a certain time with the purpose of protecting the area from overuse/ exploitation. In this case, it was implemented to legally protect and sustainably manage mangroves.** Prohibition of mangrove logging and overexploitation of mangrove biodiversity was accomplished by setting a closed and open season to access the location. Under the initial agreement, mangrove areas will be closed for three months and only can be open for one month for each period. These time periods are based on local knowledge of the ecosystem and its species (e.g., breeding periods). Kerakera assigned a community representative to do regular patrol and monitoring.

Focus Group Discussion: Kerakera (customary closure) of Mangroves by the people of Mandoni and Kiminakra villages © Orlin Ozora Yowei/Konservasi Indonesia

Outcomes

A key outcome of this project was the establishment of Kerakera mainly aimed for protecting the "adat" mangrove territory from outsider access. This is also aligned with the spirit to bring back the traditional practices and reintroduce this tradition of the "adat" and Kerakera to younger generations. Implementation of Kerakera to protect mangroves is expected to secure economic benefits and enhance disaster risk reduction. A total of 389.5 ha of mangrove area is now protected and managed under the Kerakera mechanism in three villages. For the project management, Kerakera has enriched the implementation of mangrove conservation that was previously limited to only patrol activities; now, it connects with the local culture and tradition. Through the Kerakera implementation, it is expected that communities can get more sustained benefits from the mangrove ecosystem, while also preserving their local values and knowledge.

Focus Group Discussion: Kerakera (customary closure) of Mangroves © Orlin Ozora Yowei/Konservasi Indonesia

To learn more about this case study visit:

https://www.mangrovealliance.org/wp-content/uploads/2023/12/GMA-Policy-Brief_V6.pdf

https://www.mangrovealliance.org/news/improving-livelihoods-mangroves-in-indonesia-with-the-food-planet-prize/

CASE STUDY 12 | KENYA

Protection of the 450 ha mangrove forest that surrounds the village of Matondoni

Contributing authors

Lionel Dishon Murage – Field Representative, East Africa, Seacology. **Abdu Mahamudu*** – Chairman, Matondoni Beach Management Unit (BMU) and a local prawn fisher within the mangrove forest of Matondoni. **Somo Somo*** – Chairman, Indian Ocean Water Body BMU Network and Lamu County BMU Network.

BIODIVERSITY | HABITAT CONNECTIVITY | THREATS AND IMPACTS | RESTORATION APPROACHES

Location

Matondoni Village (-2.269152°, 40.839298°), Lamu West, Lamu County, Kenya

Project Size

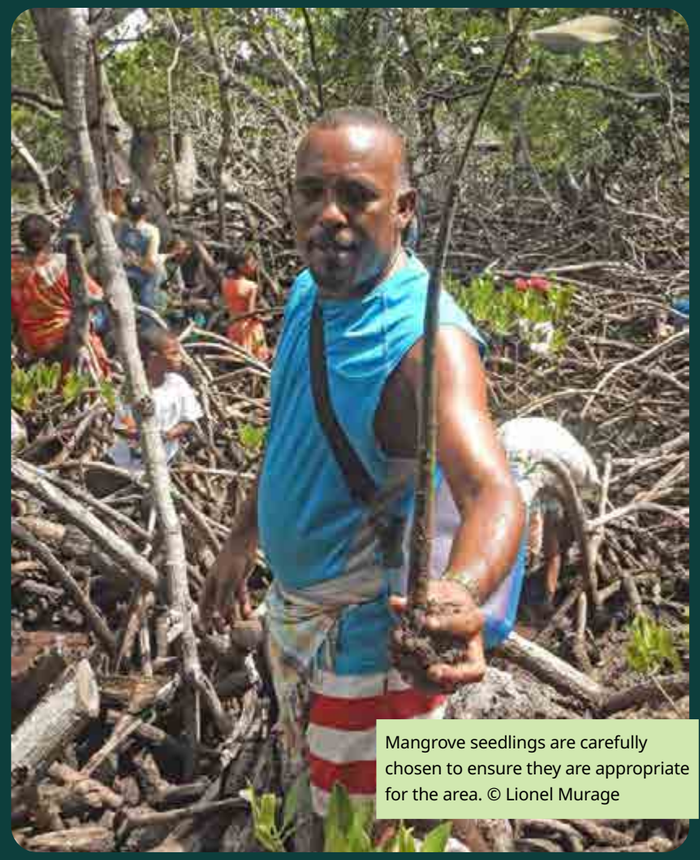
450ha

Mangrove species

A total of seven different mangrove species are found within the area and include *Avicennia marina* (***Mchu***), *Ceriops tagal* (***Mkandaa***), *Rhizophora mucronata* (***Mkoko* or *Mrungu or Msisi***), *Bruguiera gymnorrhiza* (***Muia* or *Mkifi***), *Sonneratia alba* (***Mpia* or *Mlilana***) and *Xylocarpus granatum* (***Mkomafi* or *Mronga***) and *Lumnitzera racemosa* (***Kikandaa***)

Project Duration

2014 – 2021



Mangrove seedlings are carefully chosen to ensure they are appropriate for the area. © Lionel Murage

Project goals and objectives

The mangrove forest in and around Matondoni village provides rich fishing grounds, particularly for prawn, as well as forest products. High demand for these products has degraded these mangroves. The highest demand for such products is from Lamu town where most of the houses utilize mangrove poles for construction and the nearby Mokowe jetty serves as a gateway to transport mangrove products to other parts of the Kenyan coast. Ideally, harvesting forest products is regulated by the Kenya Forest Service working in partnership with the recently established Lamu Community Forest Association. However, due to limited capacity, illegal activities (e.g., clear cutting of mangroves, illegal harvesting of poles), especially by outsiders from Lamu and the mainland, is evident in some areas. In addition, there is still limited awareness among local community members of applicable national laws and policies such as the Forest and Environmental Acts, especially in relation to their participation and contribution in sustainable natural resource management.

Given these pressures, this project aims to restore mangroves in a site where a local community had observed illegal harvesting of mangrove poles. Specifically, the project aims to:

- Replant degraded areas of the mangrove forest with appropriate species based on an initial baseline assessment.
- Identify and support alternative livelihood options, such as beekeeping, to reduce pressure on the mangrove forest.
- Conduct targeted awareness raising and production of information and communication materials to sensitize local community and school children on the need to protect and conserve the mangrove forest.

Methods/approaches

An initial assessment was conducted to establish the location and status of degraded areas within the Matondoni mangrove forest. The assessment was conducted by a team drawn from several local groups, including Beach Management Units (BMU), specifically Matondoni BMU and Lamu County BMU network, and the Lamu Community Forest Association (CFA), as well as the Lamu station of the Kenya Forest Service. After the baseline assessment, two sites were selected for restoration with suitable species for replanting based on the recentness of degradation, importance of site to local use (e.g., fishing), and type of species present.

Targeted awareness raising was conducted through community meetings and events held in the village, where members of the recently established CFA and BMU were invited to participate. One example was regular village clean-up exercises held twice a month, with such events used to raise awareness of environmental issues affecting the villages. Other approaches included a launch event held by Seacology at the beginning of the project to sensitize community members on the expected outcomes of the project and production of awareness materials (e.g., t-shirts, signboards).

CASE STUDY 12 | KENYA

Groups involved and roles

1. **Lamu Community Forest Association (CFA)** - Local
2. **Kenya Forest Service (KFS)** - National Government Agency
3. **Lamu County Directorate of Fisheries** – County Government
4. **Matondoni Beach Management Unit** – Local/ Village Resource Users
5. **Lamu County Beach Management Unit Network** – Local/County Resource Users
6. **Matondoni Primary School** – Local Education

Local knowledge

All project activities were implemented by the local community based in Matondoni village represented through the BMU and CFA and local knowledge about mangrove use, species selection, assessment, and preferred planting methods (e.g., raising seedlings in a community-run nurseries) informed the project. Members of the two organizations guided the team in conducting the initial site assessments, **and local knowledge about how recently an area had been degraded and appropriate mangrove species for the location were vital for the replanting efforts.** For example, Mr. Abdu, a fisher, indicated that the recently degraded mangrove forest around the

Women group members participating in the replantation. © Lionel Murage

Mangrove replantation. © Lionel Murage

Matondoni village is a key fishing ground for prawn fishing, as the species both breeds and feeds there. Not all areas of the mangrove forest are ideal for prawn, because **prawns prefer areas populated by *Sonneratia alba* (mlilana) and *Rhizophora mucronata* (Mkoko). The degraded site identified by Mr. Abdu was selected as a replanting site because it was one of the key fishing grounds previously populated by these two mangrove species.** These observations were later confirmed by a site visit from the team led by the Kenya Forest Service personnel. Since the area was recently degraded and Mr. Abdu knew the mangrove species previously at the site, he was confident replanting efforts using *Sonneratia alba* and *Rhizophora mucronata* would be successful. This is just one example where local knowledge of the mangrove forests guided community member decisions as to which species would be most suitable for replanting. The purchase of 4,500 mangrove seedlings that were used for replantation efforts came from mangrove tree nurseries that the project had previously supported and were run by the community.

Outcomes

A key outcome from the project is the increased mangrove cover from the restoration efforts. Additionally, community groups have expanded the number of nurseries. They are also including species of commercial value for replanting on nearby farmlands, as well as species that could be used for fuelwood, thereby reducing dependence on the mangrove forest for firewood. Community groups continue to earn an income from the sale of seedlings. They have also established beekeeping as an alternative income generating project to enhance and diversify their income sources.

CASE STUDY 13 | KENYA

Mwache mangrove forest regeneration: An integrated approach to restore mangrove habitat with a local community

Contributing authors

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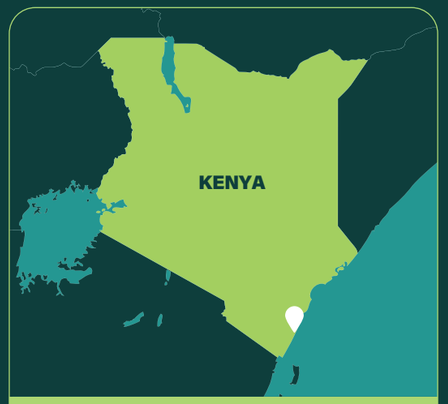
Said Chirunga Juma* – Bonje Community Forest Association in Mwache, Chairman of the group.



BIODIVERSITY | THREATS & IMPACTS

Mwache local community taking care of mangrove nursery. © Gilbert Atuga

Location

Mwache community in the upper part of Port Reitz (4°3'S, 39°38'E), 20 km Northwest of Mombasa City

Project Size

Mwache mangrove forest covers 12 km², roughly 70% of the total area of the creek.

Mangrove species

Rhizophora mucronata, Avicennia marina, Ceriops tagal

Project Duration

2017 - Present

Project goals and objectives

The Mwache mangrove forest is under threat of extinction. From 1997-1998, El Niño caused heavy sediment deposition in the creek, smothering mangrove roots and leading to the destruction of 200 ha of mangrove forest in the upper region of the creek. Further losses have been driven by human encroachment and overharvesting. Efforts to restore this forest through conventional planting have born little fruit, which is unsurprising because the reasons for mangrove degeneration were not addressed prior to planting, few stakeholders had been involved, and there was little community engagement in the restoration process. Therefore, to restore the Mwache mangrove forest, a community-led strategy was used to remove anthropogenic and environmental stressors and create an enabling environment for replanting and natural regeneration.

Objectives

- Application of nature-based approach with local community involvement for Mwache mangrove forest restoration (i.e. building with nature).
- Create mutual trust and sense of environmental ownership and knowledge sharing among the Mwache community members.
- Devise strategies that include ideas from marginalized community members (including women and people living with a disability).
- Have a compliance strategy that prevents harvesting of Mwache mangrove forest by local community members.

Methods/approaches

The first important step was to harness community involvement and understand their knowledge of the Mwache mangroves and how it could inform the project. **A prosocial approach was used** to engage stakeholders and work together. This approach is based on a core design principle that enables community members to transparently develop and stay focused on their goals. **The Mwache community members identified benefits of mangrove conservation, shared clear goals for Mwache mangrove restoration, and agreed on new behavior to achieve results (e.g. stopping destruction of mangroves trees).** Based on identified stressors, monitoring was conducted with community members playing a leading role to identify suitable sites for Mwache mangrove restoration and solutions to identified challenges. Prior to planting, a field survey in which the community was involved identified mangrove distribution and tidal requirements.

Groups involved and roles

- **Fisher communities**: Provide insights on how degraded mangroves can be restored to thereby restore mangrove fisheries
- **Local communities**: Provide knowledge on suitable areas for mangrove restoration
- **Mwache mangroves community-based organization**: Provides different strategies to restore mangroves, considering challenges encountered, and plausible solutions
- **Kenya Forestry Service**: Provides guidance for nursery development, and enforcement to avoid further Mwache mangrove destruction
- **Fisheries Department**: Brings together different fisher groups, and creates awareness of Mwache mangrove restoration
- **Kenya Marine and Fisheries Research Institute**: Plays coordinating role for local community and different stakeholders in knowledge sharing and implementation

CASE STUDY 13 | KENYA

Local knowledge

During informal brainstorming sessions and forums, the community mapped a suitable location for mangrove growth based on their knowledge of where Mwache mangroves thrived historically. After identification of those sites, a Kenya Marine and Fisheries expert guided the community with a survey to assess suitability of the suggested sites for restoration using the targeted planting of mangrove species.

Additionally, **the local community identified different stressors** and solutions to these stressors. Identified factors included: i) climate change impact of heavy rains in 1998 and 2007 El Niño; ii) sedimentation; iii) human pressures, such as cutting of mangrove trees for firewood and construction, iv) encroachment of mangrove areas for informal settlement; v) lack of skills in nursery development; vi) grazing of mangroves by goats; and vii) a lack of clear coordination in planting, with mangrove die-off after replanting from nurseries.

Outcomes

Approximately 50 to 100 hectares are under restoration. To address goats grazing on both old and newly planted mangroves, the community suggested mapping goats' entry points to mangroves and fencing these with locally available materials, which resulted in a 5 km perimeter fence. To reduce plastic debris that smothered mangrove roots and killed mangroves, a community-led clean up initiative removes debris from the restoration site monthly and the community has increased awareness about litter in mangrove zones. Another major stressor, which the community identified with the help of experts during the survey, was influence of waves during high tide. Therefore, the community constructed a 1.2m high brushwood groyne to attenuate waves and enable natural regeneration of mangroves.

To read more about this case study visit:

https://www.rufford.org/projects/gilbert-nyabochwa-atuga/mwache-mangrove-forest-regeneration-integrated-approach-to-restore-mangrove-habitat-MTU1MTQ/

Community providing a solution to goat grazing stressor on mangroves by constructing a fence using local materials without obstructing the water hydrology to the mangrove. © Gilbert Atuga

CASE STUDY 14 | KENYA

Greening the blue initiative

Contributing authors
Levis Sirikwa – Ceriops organization, Co-Founder: Project leader. **Mwinga Ngozi*** – Amani Jipange (Community Group), Chairperson, Community lead. **Nelly Ndule*** – Amani Jipange (Community Group), Woman representative.

Location

Tudor Creek mangrove scape, Mwakirunge, Kenya.

Center coordinates of the planted site: -3.98298, 39.62403

Project Size

0.492 ha

Mangrove species

Red mangroves (*Rhizophora mucronate, Mkoko)*

Project Duration

2023 - 2024

BIODIVERSITY | THREATS & IMPACTS

Community-led mangrove restoration. © Ceriops

Project goals and objectives

The project seeks to restore the degraded patches of mangrove and conserve restored areas to protect the marine fisheries on which the adjacent communities depend for their livelihoods.

Methods/approaches

One of the major objectives of *Greening the Blue model* is to enhance long-term protection of the restored mangroves through planting, monitoring, and incentives for sustainable alternative livelihoods (e.g., beekeeping). To work towards these goals, **a knowledge co-production approach was used, where local knowledge and technical scientific knowledge were intergrated** to plan and implement the project. The first phase, mangrove planting, was done through collaboration among community groups, Ceriops organization, and Kenya Forest Service. The community groups and Ceriops Organization established nurseries, planted mangroves, and are monitoring the planted sites. The **major roles of the community groups include traditional knowledge sharing, labor, community mobilization, sensitization, and monitoring.** Ceriops organization handles data management, reporting, mapping, capacity building (skills and knowledge based on technical scientific insights), monitoring, and resource mobilization. Kenya Forest Service provides policy support on legal frameworks around the project area.

Groups involved and roles

The project has been supported by the following organizations:

- **Ceriops Environmental Organization:** Project lead organization.
- **Amani Jipange Community group:** Host community (mangrove restoration).
- **Kenya Forest Service:** Policy support role (mangrove space allocation to the community, approval of Ceriops to support the community in active mangrove restoration).
- **Global Landscapes Forum (Restoration Stewards Award):** Funding support to the project.

Local knowledge

Local knowledge is the backbone of active mangrove restoration in Mwakirunge in the following ways:

1. **Navigation:** The Indigenous groups first understood the nooks and crannies of the ecosystem due to their long history of fishing and firewood fetching activities in the mangroves. Therefore, ground truthing in GIS studies consults the locals for specific locations in the ecosystem and the Kenya Forest Services relies on the local knowledge to navigate through this ecosystem.
2. **Threats:** Indigenous knowledge informed the government on the drivers of mangrove change, including illegal logging, commercial logging for export in the late 20th century, oil spillage from Mombasa port (Kilindini Harbor), and the impact of El Niño in 1998. Local elders had first-hand experience with these situations. Knowing that one of the largest causes of degradation was logging, rather that biochemical or hydrological degradation, indicates that restoration at this site is possible through planting methods.

CASE STUDY 14 | KENYA

3. **Species dynamics:** Local knowledge provided the local names of the nine mangrove species found in Kenya. This particular project restores *Rhizophora mucronate*, which in English is red mangrove or loop root mangroves and in Swahili, *Mkoko*. Local knowledge on the reproductive dynamics of mangrove species informed restoration activities; locals shared when propagules are found in the ecosystem, hence when to collect them and pot them in the nurseries for future planting. Locals have also shared which marine species found in mangrove ecosystems are important to adjacent communities and can enhance food security, such as mangrove eels, mud crabs, shrimps, and prawns. By providing information on tidal inundation (flooding dynamics), the community has helped plan for efficient mangrove planting activities during spring and neap tides. Through a collaborative effort connecting science and Indigenous knowledge, site selection and species-site matching before any planting activities led to higher survival rates (>90%).

The sharing of this knowledge is both a work in progress and a moving target because not only are elders being lost, but the world is transitioning rapidly to a modern lifestyle that fails to recognize and appreciate that **old is gold in the face of digitalization.** Furthermore, **avenues or platforms for the elders to share the knowledge are lacking. However, the co-production approach of this project allows the community to offer the wisdom and knowledge gained from experience**, while Ceriops Organization offers technology and scientific knowledge. Working as a team allows for collaborative roundtable sessions, planning, troubleshooting, and embracing adaptive management when it comes to project development and implementation.

Traditional knowledge informing hole digging using poles. © Ceriops

Stakeholder collaboration is key to mangrove restoration success. © Ceriops

Outcomes

The project has completed its first phase (planting), with a survival rate of approximately 95%. To date, the project has restored 0.492 hectares of previously degraded mangrove landscapes by planting 2000 mature red mangrove seedlings from the community nursery. The women from the community established the mangrove nurseries as a means to raise alternative income. Whenever a mangrove planting project is planned, the women sell their seedlings to the project. The project has financially supported the labor of 20 men and women from the community who engaged in mangrove planting. The project's main stakeholders are set to actively monitor the planted mangroves for the first 12 months to assess their growth performance and survival rate.

A sense of belonging in mangrove conservation. © Ceriops

CASE STUDY 15 | LIBERIA

Improving sustainable use of mangroves through protection, planning, and livelihood creation

Contributing authors

Mike Olendo – Peace Amoah-Quiminee*, Sabawu Yennego* Conservation International (CI) Liberia.

BIODIVERSITY | RESTORATION APPROACHES | CULTURAL PRACTICES | HABITAT CONNECTIVITY

Location

Grand Cape Mount County (*Bendu town, Bamboja, Falie, &* Mando)

Grand Bassa county (*Blewein, Edina, Nyanba & Sanwein*)

Margibi (*Ben's town, Snafu, & Dorzon*)

Project Size

Establish a marine protected area of at least 35% of Liberia's mangroves.

Mangrove species

Acrostichum aureum, Avicennia germinans, Conocarpus erectus, Rhizophora x harrisonii, Rhizophora mangle, Rhizophora racemose

Project Duration

2016-2019

Monitoring patrols in Liberia are designed to reduce violations in mangrove use, and allow for early intervention where loss is identified. © Solomon Carlon / CI Liberia

Project goals and objectives

Liberia may have lost up to 65% of its mangroves since 1980 (FAO 2007). The most significant causes of loss are urbanization, infrastructure development, mining, and oil exploitation. Further loss and degradation have been caused by hunting, firewood collection, charcoal production, timber extraction, and pollution from agriculture, oil exploration, mining. Climate change may also be having an impact.

In 2016, CI's GEF Project Agency funded a mangrove project to "*strengthen the conservation and sustainable use of Liberia's globally important mangrove forests through effective participatory land-use planning and establishment of marine protected areas in at least 35% of Liberia's mangroves*".

To achieve this objective, two project components were developed:

1. Enabling conditions for establishing coastal and marine protected areas in 20% of priority mangrove forests.
2. Reducing pressures on an additional 15% of priority mangrove forest areas through integrated land-use planning, improving local community livelihoods, and increasing stakeholders' capacity and awareness.

Methods and approaches

The project conducted a site selection survey, mapping mangroves along the entire Liberian coast using GIS and Landsat imagery. The project used conservation agreements (CA), a tool for poverty reduction that also achieve ecosystem benefits. CA are an explicit agreement between a group of resource users (*communities around the mangroves*) and an organization representing conservation investors, specifying conservation commitments on the part of the resource users and a benefits package provided to resource users in return for these commitments. Benefits were determined with the resource users to respond to local needs and priorities and includes their local knowledge and experience. The delivery of benefits depends on verified compliance with conservation commitments. The project worked with the local community to provide contextually relevant mangrove management and conservation practices by integrating and documenting existing traditional/Indigenous practices into formal management approaches.

Local knowledge

Communities' traditional norms and practices were used in developing the rules and conditions in the conservation agreements. Participatory mapping with the community helped to identify areas used for traditional practices that were to be protected. For example, **mangroves are the location for many cultural practices, traditional ceremonies, and rites at particular times of year, and some of these areas are traditionally protected and inaccessible to outsiders or for wood extraction.** Wood is traditionally collected by the community; there is no clear cutting, and sites for fuelwood cutting and extraction are alternated to avoid depleting a particular site. Such approaches aim to reduce canopy and crowding to allow for better growth/regrowth. Fish spawning areas were also earmarked as important and not to be fished during certain times, based on cultural practices that relate to the moon (tides) and seasons.

CASE STUDY 15 | LIBERIA

Outcomes

1. At least 20% of priority mangrove forests in Liberia have been identified and delineated, and management plans to safeguard them have been completed.
2. Enhanced integration of local Indigenous knowledge in mangrove management, as well as engaging the community and providing awareness and education opportunities.
3. The project produced an ecological, socio-economic, and threats survey report, Mangrove Map for Liberia, and base maps/map books for Lake Piso and Marshall Proposed Protected Area.
4. A validated Management Plan for Lake Piso Multiple Use Reserve.
5. Two Co-Management Committees (CMCs) for Lake Piso Multiple Reserve and Marshall Proposed Protected Area, including Liberia Forest Development Authority (FDA)-endorsed financial plans for both Lake Piso Multiple Use Reserve and a template for Marshall Proposed Protected Area.
6. The project included 80 community meetings, nine workshops, and the development of a Participatory Land-Use Planning tool kit.
7. Some 514 target beneficiaries, government officials (168 women and 346 men), 4,058 community members (997 women and 3,061 men), and 101 county and community leaders participated in the project. For the community members, it was through participatory engagement and knowledge sharing.
8. The Liberia Environmental Protection Agency (EPA) developed and approved a mangrove monitoring plan using Survey123 for ArcGIS. The system set up at the EPA GIS Lab tracked and the community reported a total of 4,455 monitoring patrols.
9. Ten community land use plans were also developed as guides for the 18 communities that signed on to the Conservation Agreements.

Safeguarding mangrove forests is vital for vulnerable species, like sea turtles, who return to nest on their shores. © Solomon Carlon / CI Liberia

The creation of protected areas and improved mangrove management plans are helping to reduce mangrove loss from illegal logging and timber extraction. © Solomon Carlon / CI Liberia

Mangroves thrive after Conservation Agreements were developed for three Liberian counties, where the rules and conditions were largely based around the traditional norms and practices of the local communities. © Solomon Carlon / CI Liberia

CASE STUDY 16 | MADAGASCAR

Community-led mangrove conservation and restoration in the Baie des Assassins

Contributing authors

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[†]*Blue Ventures Conservation*

Location

Baie des Assassins, Morombe (District), Atsimo-Andrefana (Region). 22°08'53"S, 43°18'23"E

Project Size

10 villages who are managing 1393 ha of mangroves under Marine Protected Areas from the Ministry of Environment and Sustainable Development.

Mangrove species

Seven mangrove species (*Rhizophora mucronata, Ceriops tagal, Bruguiera gymnorrhiza, Avicennia marina, Sonneratia alba, Xylocarpus granatum, Lumnitzera racemosa)* occur in the project area. Restoration work focuses on replanting *Rhizophora mucronata, Ceriops tagal* and *Bruguiera gymnorrhiza,* as these species are the most commonly harvested across Madagascar.

Project Duration

2014 - 2037

BIODIVERSITY | PHYSICAL PROCESSES | THREATS & IMPACTS | RESTORATION APPROACHES | CULTURAL PRACTICES | LEK IN OUTREACH

Participatory concept modelling exercise with the community of the Bay to identify drivers of mangrove degradation. © Cicelin Rakotomahazo

Project goals and objectives

To protect and restore mangroves for improved fisheries, carbon sequestration, and community livelihoods.

Methods/approaches

Community-based associations carry out mangrove management and restoration with technical and financial support provided by Blue Ventures. Local communities are fully involved in the project and decision-making, which begins with securing community rights. This includes the participatory development and implementation of management plans under legal frameworks that grant communities the rights to manage, conserve, and restore mangroves. The project supports the community to harness their local ecological knowledge (LEK) to understand the drivers of mangrove loss and identify potential solutions. The project uses a participatory zoning system based on LEK that delineates mangroves into three management areas: strict conservation, sustainable use, and restoration. To restore degraded sites, propagules are directly planted by hand.

Groups involved and roles

Grassroots groups, fishers and women associations, school children, aquaculture farmers, microfinance Savings and Internal Lending Communities (SILC), church and youth groups, and football clubs all participated in the mangrove reforestation and conducted awareness raising to get more people involved in this activity.

Local knowledge

Identification of mangrove loss/degradation: Communities assessed the status of their mangrove resources (i.e. increasing, decreasing, stable) based on their daily relationship with these resources and stories from their elders (e.g., comparison of current fisheries' catch with the past five years).

Establishment of the area to be put under strict conservation and sustainable use: Communities zoned their mangroves in three zones based on cover, use patterns (e.g. wood extraction areas), and ecological value (e.g. important habitats and nurseries for different species). Following these, they developed the rules to govern these zones based on their traditional rules. For example, each village has its own resource boundary and outsiders need to ask permission. In addition, taboo areas must be valued.

Identification and mapping of the degraded area to be restored: The process was done through participatory mapping. Zones to be restored were delineated based on the local community's spatial knowledge of the mangrove areas. They were asked to list degraded areas and then delineate them on the printed map. The process was followed by ground-truthing.

CASE STUDY 16 | MADAGASCAR

A Member of local communities trained to lead reforestation monitoring in the village of Lamboara. © Cicelin Rakotomahazo

To ensure the success of the mangrove restoration, LEK was collected about the sites' history, soils, and hydrodynamic factors. Specific knowledge included peaks of propagule availability, which species previously occurred, tides, soils, duration of inundation, and the level of ongoing disturbance.

Communities were also involved in developing the details of reforestation initiatives, including planting techniques and schedules; management rules; stakeholders; equipment; budget; and compensation strategies such as whether people participating in planting sessions would be paid or volunteers.

Mangrove replanting event: Communities usually scheduled replanting during the spring tide to ensure that the replanted area would have tidal inundation to improve restoration outcomes. Before the reforestation event, members of communities perform local rituals using rum to ask for the ancestors' blessings to make replanting successful.

Outcomes

Mangroves in the Baie des Assassins are on their way to recovering ecologically and increasing their provision of goods and services such fisheries, carbon stocks, coastal protection, and improved livelihoods. The majority of the degraded mangroves have now been replanted with an average survival rate of 85%. LEK helped inform the development of the project design, management, and implementation, and positively influenced the effectiveness and efficiency of conservation and restoration initiatives in the area, contributed to securing management rights, and reduced mangrove exploitation and loss.

Including cultural aspects such as rituals has promoted collective buy-in, ownership, and participation in management and restoration (including women and youth), which has supported overall management success.

Members of local communities trained to lead reforestation monitoring in the village of Tampolove. © Cicelin Rakotomahazo

CASE STUDY 17 | MEXICO

Raíces para las comunidades y el clima: Network of mangrove honey producers in the Yucatán

Contributing authors

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BIODIVERSITY | TRADITIONAL SKILLS | HABITAT CONNECTIVITY

Location

Rio Lagartos (21.5965° N, 88.1579° W) and San Felipe, Yucatan, Mexico (21.5665° N, 88.2333° W).

Project Size

1 protected area, two communities and 9 honey producers

Mangrove species

Red mangrove (*Rhizophora mangle*),

White mangrove (*Laguncularia racemosa)*

Black mangrove (*Avicennia germinans*)

Project Duration

2021 - 2025

Mangrove beekeeping is an innovative alternative livelihood with vast benefits for both the communities supported by it, and the mangrove trees pollinated by the bees. © C. Duran

Project goals and objectives

Recognizing that local people are experts in defining key issues and developing solutions, the Raíces (Mangroves for community and climate) project seeks to incorporate their knowledge and work with them to generate solutions to strengthen sustainable livelihoods that are susceptible to climate change, by:

1. Restoring and conserving mangroves through the creation of alliances, design of public policies, and strengthening of mangrove monitoring systems.
2. Fostering learning communities and community-based restoration strategies.
3. Increasing community resilience to climate change through disaster risk reduction and capacity building to support livelihoods.
4. Identifying and supporting innovative financial solutions that support mangrove ecosystem services.

This write-up details one such solution, mangrove beekeeping in San Felipe and Rio Lagartos. The Yucatan peninsula in Mexico generates about 40% of the national honey yield, most of which is exported. Increasing opportunities for mangrove honey production could benefit both local livelihoods and the ecosystem, for example, through enhancing pollination surrounding the apiaries.

In San Felipe and Rio Lagartos, beekeepers are small producers with less than 50 boxes per person. They have traditionally produced forest honey but are exploring production of **mangrove honey, which has a distinct flavor and potentially high value.** Despite little external technical support, they have great knowledge about their activity, which can be strengthened with the incorporation of organic production, increased access to markets, and improved climate change resilience.

Methods/approaches

The project works with local beekeepers and incorporates their traditional knowledge to promote the conservation of mangroves and their ecosystems services and generate ideas of sustainable livelihoods. First, community members helped map enterprises that were: 1) community or family owned, and 2) result in positive mangrove conservation. Then, led by a local community member and supported by the project, a community group of mangrove beekeepers from Rio Lagartos and San Felipe Yucatán was created. The group and project team generated ideas for increasing access to markets. The project also includes trainings that focus on best practices, governance, and resilience to climate change.

Groups involved and roles

- World Wildlife Fund (WWF) - Mexico: Channeling of funds, creation of alliances and accompaniment of the group of beekeepers.
- Small-scale community beekeepers from Rio Lagartos and San Felipe.
- National Commission of Natural Protected Areas (CONANP): Institutional support.
- ECOSUR: Research and postgraduate center, technical support and training for groups of beekeepers.

Local knowledge

Beekeeping has been part of the Mayan culture since pre-Hispanic times. With the arrival of the Spanish, breeding Apis bees replaced native bees. However, traditional beekeeping practices have survived thanks to the experience and tradition of the region's producers.

CASE STUDY 17 | MEXICO

Traditional knowledge has been passed on from generation to generation about climate, phenology, and ecology. Their knowledge of climate, specifically rainfall, results in part from the strong connection to fishing in this region, which requires the ability to observe and understand clouds, winds, storms, and their effects on nature. Other knowledge includes the flowering of different plant species, understanding which insects can affect bees, and identifying the tracks of animals that roam the apiaries. All this traditional knowledge is key to management of hives and honey production.

Local knowledge also informs adaptation and restoration. Beekeeping is threatened by climate change, as flowering is closely dependent on sufficient rainfall, while flooding and drought affect apiaries, However, **beekeepers use their knowledge to monitor the climate, adapt their hive management, and rescue hives from floods. The monitoring of plant cycles carried out by beekeepers also allows detection of the mangrove tree fruiting season, which can inform restoration activities such as when to relocate seedlings.**

Mangrove beekeepers are experts not only of their bees, but of the patterns and trends emerging in the mangroves that help to inform restoration activities. © C. Duran

Local beekeeper checking on his hives. Mangrove beekeepers often face challenges like flooding, and are exploring creation of a knowledge exchange network to learn from each other the best ways to adapt to these challenges. © C. Duran

Outcomes

The Raíces project, along with community members, identified an opportunity to strengthen sustainable livelihoods through the production of mangrove honey. An alliance was created with 15 independent beekeepers interested in forming a network of mangrove beekeepers. As a result of the work with the group, a roadmap has been created for the coming years to strengthen their activity with support from WWF.

The beekeepers have proposed creating a joint apiary to exchange knowledge, create agreements, and designate tasks. The network will reinforce their capacities and support development of mangrove honey production and commercialization, which had not yet been explored. Technical capabilities gained through this network will help them face the various challenges of beekeeping, such as pest attacks, fluctuating market prices, and extreme weather events.

The group expressed:

> *"The legacy we seek to build as mangrove beekeepers is to be a living testimony of what we can achieve when we work collectively. Our work will not only seek to care for the precious resource which is honey, but also benefit and preserve the mangroves and the environment that surrounds us. We will work with dedication and passion to become a reference of change for our community."*

CASE STUDY 18 | NEW CALEDONIA

Educational trail in the mangrove forest of the Koé tribe

Contributing authors

Didier Amouine* – deputy treasurer of the Hô-üt association. **Amaury Dubano*** – coordinator of the Hô-üt association. **Virginie Tsilibaris** – coordinator of the French mangrove monitoring network, IUCN-FNC.

BIODIVERSITY | RESTORATION APPROACHES | TRADITIONAL SKILLS | LEK IN OUTREACH

Location

Koé tribe, Touho (Tuo cèmuhî), North Province of New Caledonia

Approximate coordinates:

East portion of the trail: -20.795190, 165.261016 to -20.793900, 165.260885

West portion of the trail: -20.795190, 165.261016 to -20.794273, 165.259839

Project Size

The trail is approximately 500 meters long.

Mangrove species

Rhizophora stylosa; Rhizophora samoensis; Rhizophora apiculata; Rhizophora lamarckii; Rhizophora selala; Sonneratia alba; Avicennia marina; Lumnitzera littorea; Bruguiera gymnorhiza; Xylocarpus granatum

Project Duration

2019 - ongoing

Mangrove trail tour 2020. © Association Hô-üt

Project goals and objectives

The Hô-üt association, a local environmental organization, began this project with the aim of raising public awareness on the importance of mangrove ecosystem conservation and restoration through the creation of an educational trail in the mangrove forest of the Koé tribe. The educational trail offers visitors (students, locals, tourists) a wide range of information: mangrove tree species description (names in Cèmuhî, the local Kanak language; characteristics; phenology; and local uses), explanation of the mangroves' role in coastal ecology, history of the mangrove in the Koé tribe, and demonstration of current planting techniques. The trail also offers a visit to the tribe's mangrove plantations.

Methods/approaches

The project is a public awareness and education project.

Groups involved and roles

The educational trail project was created in collaboration with several partners:

- The clan council of the Koé tribe, which is the customary authority in the area.
- The Hô-üt association, an environmental organization working on the conservation projects in the municipality of Touho, listed as a UNESCO World Heritage Site, and in charge of the trail visits.
- The Touho city council and the New Caledonia's North Province, who provided financial support.
- The inhabitants of the Koé tribe who took part in the creation of the trail and, with the help of the Hô-üt association, maintain the trail and accompany visitors.

Local knowledge

Local ecological knowledge on mangrove forests has been passed down through the generations in the families of the Koé tribe. Many inhabitants of the tribe are members of the Hô-üt association, which facilitated the sharing of this local knowledge and its inclusion in the project. In addition, some members of the Hô-üt association visited several families of the tribe to gather additional information, in particular, the translation of plant species into Cèmuhî, the local Kanak language.

The local knowledge involved in this project includes:

- Names of the mangrove and seaside trees in Cèmuhî. This translation work was carried out with elders from the Koé tribe.
- Uses of mangrove trees. Examples include:
  - *Bruguiera gymnorhiza:* The trail offers a presentation of the tree's characteristics, phenology, and adaptations, as well as an explanation of the use of propagules in cooking accompanied by the recipe.
  - *Lumnitzera littorea:* The tree's characteristics and breeding system are presented, and explanations are provided on the use of branches as poles for growing yams.
  - *Rhizophora selala:* The trail guide explains how roots can be used as bows for fishing in the mangrove and presents some fishing techniques.

CASE STUDY 18 | NEW CALEDONIA

Mangrove trail sign. © Association Hô-üt

- History of the mangrove in the Koé tribe, including information on the use of trees for firewood and the construction of lime houses, which led to excessive cutting of trees in the 1960s; observation of a progressive shoreline retreat over the years; and the beginning of mangrove planting in the 1990s by tribal families.
- Presentation of different mangrove fishing techniques (e.g., bow, line, seine, underwater gun).

All this information is shared with visitors orally and through 22 information panels that are placed and removed at each visit to the trail.

This knowledge adds a cultural vision to the project as it enables visitors to better appreciate the cultural importance of mangroves and the link between the tribe's inhabitants and this ecosystem. Testimonies from local residents underscore the importance of this link, such as the following collected by the Hô-üt association during a mangrove inventory project in the Touho tribe (BEST 2.0 project):

> *"When I was a child, we often went to the sea with my dad, brothers and sisters to swim and fish. If one of us got into a fight, the punishment was to pick propagules from the mangroves along the beach and plant them. As a child, I didn't realize the importance of this gesture.* ***Now that my father is gone, I realize that our elders were already well aware of the benefits of mangroves, and that we must continue to preserve them."***

Outcomes

The educational trail project in the mangrove of the Koé tribe was initiated in 2019-2020. Since then, hundreds of visitors have visited the Koé tribe mangrove forest (e.g., school students, tourists, associations, international delegations). They learned how to identify different mangrove species, were informed about mangrove tree planting techniques, and were sensitized to the link between this ecosystem and local Kanak communities.

Mangrove trail tour 2023. © Association Hô-üt

CASE STUDY 19 | PANAMA

Restoring the wetland of Laguna de las Lajas

Contributing authors

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BIODIVERSITY | THREATS & IMPACTS

Location

Las Lajas lagoon, San Félix district, province of Chiriquí.

Boca del estero: 8.165193N, 81.841826W

Boca la Peña: 8.171507N, 81.86701W

Project Size

The lagoon is approximately 155 ha, of which an estimated 74.53 ha has reforestation/restoration potential

Mangrove species

Rhizophora mangle, Laguncularia racemosa, Conocarpus erectus

Project Duration

2016 - ongoing

Restoration in Aug 2023 with Las Lajas College. © Andres Fraiz

Project goals and objectives

Las Laja Lagoon has long been used by local residents for fishing, especially for shrimp (*Penaeus sp.*), drinking water for cattle, and recreation. Although the lagoon is still used, the mangroves that once existed have been degraded and lost. This project aims to reestablish the mangrove ecosystem as a nature-based coastal climate change adaptation solution. Community engagement made the project possible and continues to restore the community's sense of care and belonging to the local ecosystem, now on a path to recovery.

Methods/approaches

The project began in 2016 with the information gathering stage to better understand the lagoon's history and where a restoration project should be sited. The project was identified and defined with the critical input of the local community, notably the Carrera family who highlighted a degraded mangrove ecosystem, which had lost almost all of its forest cover and had also suffered considerable hydrological manipulation. Their historical knowledge enabled the development of a vision and a plan that uses two approaches:

Planting: Although mangrove forests exist nearby, they are no longer directly connected. The lack of mature trees within the main lagoon area is one of the reasons why recruitment is not observed in the site. Mangrove planting is intended to create patches of trees through different parts of the lagoon so that they can act as mother trees (sources of recruitment) and disperse their propagules through currents, thus colonizing and spreading throughout the lagoon over time.

Hydrological restoration: Flow analysis revealed obstructions limiting water passage. As a corrective measure, bridges were designed to replace the two obstructing structures. Meetings have been held with neighboring farmers to confirm the plan's viability.

Groups involved and roles

Project Management: Wetlands International

Collaboration in restoration, technical studies, meetings with key actors:

- Ministry of the Environment.
- Las Lajas City Hall.
- Carrera Family (help maintain the area and perimeter fence).

Participation in mangrove restoration campaigns:

- El María Elementary School in Remedios & Las Lajas High School (teachers support calls for students for the restoration days, obtain student permits, encourage participation).
- Community Board of Santa Lucía in Remedios.
- Las Lajas Community.
- La Miel y El Cuero de Horconcitos Agroartisanal Producers Association in San Lorenzo [Asociación de Productores Agroartesanales de la Miel y el Cuero de Horconcito en San Lorenzo (APAMICUH)].
- Chiriqui Autonomous University [Universidad Autónoma de Chiriquí].
- El María Community Board (assists getting people involved in restoration activities).

CASE STUDY 19 | PANAMA

Local knowledge

Local knowledge was invaluable to project initiation, and the identification and selection of the site. Andrés Emiliano Fraiz-Toma grew up nearby and on family trips to the beach wondered why the lagoon's trees had fallen. Recently, as a Technical Officer for Wetland International, he studied the causes of its degradation and began work to restore the lost mangrove forest. **Several area residents** (Santa Cruz community, San Félix district), including people of some influence, such as landowners and a former mayor, **provided key information, specifically that the lagoon was previously a continuous, uninterrupted mangrove forest**, which over the years was destroyed. Professor Ermila Arjona Carrera, a resident of San Félix, former politician, and UNACHI professor, explained that the mangrove forest was fumigated in the 1970s:

> *"Although we do not know what they fumigated with, the purpose was to enable agricultural use."*

In the following decade, the trees began to die and the mangrove forest was forgotten. The trunks of the trees that grew in the lagoon still appear at low tides during the dry seasons-- a vestige of what once dominated the entire lagoon.

Planting at the Lagoon with students, community members, and Ministry of the Environment April 2022. © Andres Fraiz

Planting at the Lagoon with students, community members, and Ministry of the Environment April 2022. © Andres Fraiz

Outcomes

A key early achievement was to document that Las Lajas lagoon had indeed been a mangrove forest that had been degraded, thereby highlighting it as a promising candidate for restoration. After its selection for the project, a restoration campaign was initiated. There are currently three patches of mangrove covering 5.16 hectares, which are already providing propagules and improving the ecological condition of the ecosystem. **Students, teachers, community members, and local authorities have actively participated for five years in restoration campaigns and continue to do so.**

This amounts to approximately one hundred people each year and older students now talk about the mangroves they planted. The community also helps maintain the perimeter fence that excludes cattle.

Tidal currents destroyed one of the dams that hindered the passage of water from the estuary to the lagoon, leaving another that still needs to be removed. This project laid the foundation for restoration, environmental education, and research projects that have increased knowledge of wetlands in the region.

To read more about this case study visit:

https://www.youtube.com/watch?v=3PZStm2COF4

https://www.youtube.com/watch?v=9fo-d1Mw4qA

CASE STUDY 20 | PHILIPPINES

Rehabilitating an abandoned fishpond in Nula-tula, Tacloban City

Contributing authors

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Location

Barangay 74, Nula-tula, City of Tacloban, Leyte, Philippines, Coordinates: 11° 15' North, 124° 58' East

Project Size

1.9 hectares

Mangrove species

Aegiceras floridum (tinduk-tindukan), Aegiceras corniculatum (saging-saging), Avicennia marina (api-api), A. officinalis (mi-api), A. rumphiana (bungalon), Ceriops decandra (malatangal; baras-baras), Rhizophora apiculata (bakawan lalaki), R. stylosa (bakawan bato), Sonneratia alba (pagatpat)

Project Duration

2017 - 2018

BIODIVERSITY | THREATS & IMPACTS

Nula-tula fishpond with newly planted mangrove saplings in 2018. © Wetlands International Philippines

Project goals and objectives

This case study describes the reversion (rehabilitation) of an abandoned, underdeveloped, and underutilized (AUU) fishpond back to a mangrove forest, a project led and guided by the local community and urban authorities. In response to the storm surge brought by Super Typhoon Yolanda (Typhoon Haiyan – international name) that devastated coastal communities in the coastal city of Tacloban in 2013, the One Resilient Team – Tacloban Project was implemented with the aim of building a greenbelt of mangroves and beach forest to serve as nature-based protection for coastal communities. This case study is part of this larger project.

Methods/approaches

The reversion of the fishpond included breaking down a dike to restore tidal flow and replanting mangroves. Replanting used an approach where scientific and technical guidance complemented local knowledge. A two-week training program for steps in rehabilitation for the village officials and community members of Barangay 74 Nula-tula was conducted. The collection of wildlings of mangrove species from a nearby natural mangrove forest was informed by local knowledge and supplemented by the saplings of *Rhizophora spp*. from adjacent nursery sites and restored flora diversity. The wildlings were planted one meter apart in a zig-zag pattern, providing sufficient space for tidal water flow and exchange between the coast and fishpond. Community members planted 11,000 saplings on a voluntary basis. The planting was organized by an enthusiastic villager, the late Violeta Cormero, and supervised by the local City of Tacloban Environment and Natural Resources Office (CENRO) staff, Marito Barillo. Another important part of this project was a public awareness campaign about the benefits of mangroves launched by the local CENRO.

Groups involved and roles

This project was included as one of the nature-based solutions in the Integrated Coastal Management Plan: City of Tacloban and Municipality of Palo[34], which had been developed through the collaboration of resource managers, Nula-tula community members and village chief, conservation organizations (One Architecture, Wetlands International Philippines, Zoological Society London (ZSL)-Philippines), and the Philippine government (the CENRO Tacloban, Philippine Reclamation Authority, City Government of Tacloban, and Barangay 74 Nula-tula).

Local knowledge

The Nula-tula community drew attention to the fact that the fishpond in Barangay 74 Nula-tula was a former mangrove site with potential to play an important role in coastal protection. They further provided knowledge on local mangroves species and the location of wildlings and, with strong support of the mayor, they also provided labor in the replanting of seedlings. Community members also shared knowledge on the uses of and threats to mangroves (aside from the conversion to fishponds). All these helped determine the location and approach in the reversion of the fishpond. Wildlings formed the primary source of material for the rehabilitation of the fishpond, which could not have occurred with only one species from nursery sites.

34 Integrated Coastal Zone Management Plan: City of Tacloban and Municipality of Palo was completed in 2019 and turned over to the Department of Environment and Natural Resources.

CASE STUDY 20 | PHILIPPINES

Nula-tula mangroves have grown to 6-8 meters in 2023 and mud has deposited in the channel for birds to feed.
© Wetlands International Philippines

Outcomes

The replanting project was completed in 2018 with an impressive survival rate of 96.5 %. The saplings displayed significant growth over the years. Over time, some species matured and the canopy closed in 2020. By 2023, the trees grew to 6-8 meters.

The rehabilitated fishpond started providing ecosystem services in 2020. The matured trees began to produce seeds and propagules, which were tidally dispersed to adjacent damaged mangrove areas. In the channel built to allow tidal water to flow from the sea to the fishpond, mud has been deposited and provides a feeding ground for shore birds. **Locals have reported recruitment of fish (mudskippers and others) and invertebrates (e.g., shells, shrimps, mud-crabs). These species have become sources of food for sustenance and/or livelihoods.** For example, villagers from Nula-tula and nearby villages have started harvesting horn snails, locally known as *bagongon*.

Community support, expressed through their knowledge sharing, engagement in the initial replanting, and their acceptance of legal protection, continues through their monitoring and surveillance of the project site. The villagers of Nula-tula and the CENRO take pride in the project. This pilot site is now **a model of successful mangrove restoration in Leyte and the Philippines, being a focal point of good mangrove restoration practices to showcase the feasibility and benefits of rehabilitating abandoned, undeveloped, and underutilized (AUU) fishponds in mangrove areas.** Students, the private sector, and a group of Wetlands International-Africa conservation professionals visited in 2019 to learn from the practices demonstrated by the project. Visits by students and offers to replant mangroves in adjacent areas by the private sector were inspired by this pilot and continue today (2023).

To learn more about this case study visit:

https://www.preventionweb.net/news/one-resilient-team-replanting-mangroves-combat-flood-risk-philippines

https://www.royalhaskoningdhv.com/en/projects/sustainable-coastal-protection-for-cities-in-the-philippines

CASE STUDY 21 | VIETNAM

Mangrove reforestation for disaster risk reduction and climate change mitigation

Contributing authors

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BIODIVERSITY | THREATS & IMPACTS | RESTORATION APPROACHES

Location

100 coastal communes (i.e. communities) in Ha Tinh, Hai Phong, Nam Dinh, Nghe An, Ninh Binh, Quang Ninh, Thai Binh, Thanh Hoa provinces, Vietnam.

Project Size

9,000 hectares

Mangrove species

Kandelia Candel, *Rhizophora Candel,* and *Sonneratia* sp.

Project Duration

1994-2017 (although some communities are continuing planting and protection with different sources of funding)

A woman is collecting sea creatures from mangrove forest at low tide. © Vietnam Red Cross

Project goals and objectives

In Vietnam, mangroves were cut for rice planting and aquaculture in the 1980s. Without mangrove protection, typhoon waves destroyed sea dykes, sea water intruded rice farms, and coastal communities were flooded. To combat the loss of natural coastal protection, Vietnam Red Cross (VNRC) launched a mangrove restoration project in 1994 to safeguard sea dykes, reduce flooding risk, and protect livelihoods. The project aimed to restore aquaculture/agriculture areas through planting/natural recovery, as well as to support community-based management and ownership of the mangrove areas. An important part of the project was incorporating local knowledge to provide information about mangrove history and effective planting practices. From five initial pilot communities in Thai Binh province, the initiative was scaled up to over 100 communities in eight coastal provinces. A capacity-building component was added to strengthen community disaster risk reduction. In addition, the project also included educational trainings about mangrove ecology and disaster risk reduction in schools in 222 communities.

Methods/approaches

The project used participatory, community-based approaches at many stages. Local representatives shared their knowledge in meetings, and representatives of VNRC, communities, and local authorities together generated a mangrove planting design and a long-term planting plan that would provide benefits to all stakeholders. They also created several community groups (planters, seed transporters, seed collectors, mangrove protectors, monitors) and the group members received incentives. Mangrove protectors watched mangroves daily the first four years after planting when seedlings are most susceptible to damage. VNRC also organized capacity-building workshops, school education trainings, and planting events. While all community members could be involved in the planting seasons every May and August, fishers who worked in the mangroves planted mangroves every day.

Groups involved and roles

- Local government agencies such as Provincial, District and Commune People Committees played a role in providing land use rights and permission for planting mangroves, as well as providing additional support for mangrove protection after planting.
- VNRC staff at all levels were responsible for planning, implementation, and monitoring the mangrove planting and protection. VNRC negotiated with government agencies, and encouraged mangrove protection and maintenance within 25 years or to recognize mangroves as a protective forest (i.e., forests that protect human beings, settlements, infrastructure, soils against natural hazards and environmental impacts).
- Women's Union, local coastal community members are key labor forces in raising and protecting mangroves.
- Teachers and children at primary and secondary schools share information on the benefits of mangroves.
- Danish Red Cross and Japanese Red Cross mobilized funds for covering the project costs from 1994 to 2017.

CASE STUDY 21 | VIETNAM

Plantation training on the spot. © Vietnam Red Cross

Local knowledge

Knowledge-sharing meetings with coastal community members helped inform this project. This included information on mangrove species that had existed in the area and ways mangroves were used and benefitted locals' daily lives (e.g., collection of marine fauna). Community members also shared their understanding of the reasons mangroves were cut, what happened to the mangrove area after the trees were cut, and additional threats that mangroves faced (e.g., aquaculture farms, road developments, and sea harbors). Planting efforts were also informed by local knowledge, as **community members shared reasons why previous planting efforts failed (e.g., unsuitable mangrove species, poor planting design, lack of protection) and how to successfully plant and protect new mangroves.** Based on this knowledge, local community members and VNRC together decided where to plant mangroves, how to design planting areas, which mangrove species to select, and how to collect and transport mangrove propagules/seeds for best survival rates.

Outcomes

The project was completed in 2017 and provided many socio-economic and ecological benefits to the communities. The mangrove forest has been handed over to local communities and governments who issued a decree in 2017 to protect all coastal forests, including mangroves. 9,000 hectares of mangroves continue to grow well along 100 kilometers of sea dykes. The project has reached 350,000 beneficiaries directly. Reduced dyke damage saves US $80,000 without typhoon direct impact or $295,0000 with landed typhoon direct impact per year.

In each community, about 150-250 people rely on the forest for their daily livelihoods, through aquaculture and non-timber products. The project has increased aquaculture product yields by more than 200%. The project also contributes to climate mitigation, with the value of estimated minimum CO_2 emissions that will be absorbed by the planted mangrove between 1997 and 2025 at US $218 million. In addition, fishers have become long-term partners of the project, as their livelihoods rely on healthy mangrove ecosystems. All community members have played a key role in the project success by protecting the planted mangroves to ensure survival and growth.

Mangroves planted in Bang La and Dai Hop Aug 1998. © Vietnam Red Cross

Current mangroves planted in 1998 in Bang La Dai Hop Hai Phong. © Vietnam Red Cross

4.4

Engaging with and sharing LEK

These case studies highlight that LEK is already being included around the world in practical mangrove conservation and restoration efforts.

They provide examples of the various types of LEK that can inform projects, and the process of how such knowledge is appreciated and included. They also illustrate how local communities and settings can be very different: Indigenous knowledge is highlighted in a number of studies (Colombia, New Caledonia, Fiji) with traditional knowledge also important (India, Mexico), but there are also examples that include recent knowledge, such as replanting methods or causes of degradation (Vietnam, Kenya), and where the "local" population includes local politicians, professionals, and academics (Honduras, Philippines, Panama).

It is noteworthy that, in most of these projects, LEK and other forms of knowledge inform the project, and indeed, the line between LEK and other forms of knowledge at times becomes blurred. The sharing of LEK is typically part of a more complete engagement with local communities. In many projects that process involves knowledge co-production, where a two-way flow of ideas benefits both local and external partners.

Community members use their extensive knowledge of the nearby mangroves to create a hand-drawn map. © Laura Michie, MAP

Before beginning a restoration project, Mangrove Action Project trainers meet with community leaders to learn from their experiences and the local context that only they can provide. © Dominic Wodehouse, MAP

Alongside knowledge, local communities can be key implementors. These case studies show how projects can support employment or other benefits, as well as how local engagement can enable monitoring and adaptive management. The year-round presence and engagement of local people in the mangroves will ensure that successes or failures in replanting efforts, hydrological interventions, or invasive species are quickly spotted and enable adaptive management. In addition, continued engagement with local communities on these projects alleviates the risk of parachute science, as well as ensuring LEK is accurately understood and included.

These stories represent a few examples, probably only a tiny fraction of LEK in mangrove management. In many places LEK and local interventions may indeed be the only form of mangrove management, unseen beyond the local setting. But by drawing attention to such studies, we hope to encourage further recognition and uptake, particularly in those places where local knowledge and expertise may be overlooked.

Perhaps the most important and urgent task for mangrove management is to embed LEK, alongside the collaboration of local communities, into all conservation and restoration projects. LEK can provide a critical contribution, while full and equitable local engagement can create a sense of ownership and ensure long-term continuity of outcomes.

In the final section we consider some processes by which researchers, planners, and practitioners can equitably engage with both LEK and those who hold this knowledge.

5. "How to" tools

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"Teaching to care for the environment is teaching to value life". A sign placed by local people who are leading conservation and ecotourism efforts in Cartagena, Colombia. © Mark Spalding

5.1

Introduction

Local knowledge presents a remarkable opportunity for any individual (including local people) or group to optimize research, planning, and management in mangrove ecosystems.

The approaches to considering and including LEK require thoughtful planning from the onset of project conceptualization through to the end of the project – and beyond!

These steps are meant to provide general guidance throughout the process. Anyone working with LEK and knowledge holders should understand the local context and adjust accordingly. These steps are also recommended for local community members leading such work: communities are diverse and understanding these complexities can help ensure that the work is done in an inclusive and ethical way.

Zulfa Hassan, the founder and chairwoman of the Mtangawanda Women's Association, a group that manages mangrove restoration off the coast of Lamu County, Kenya. © Sarah Waiswa

5.2

Guidance for including LEK in mangrove research or management

Respect, collaborate and share

- At all stages, even in exploratory project planning, respect cultural and traditional norms, including seeking permissions and respecting hierarchy and leadership.
- To engage with LEK and knowledge holders respectfully and appropriately, build in the necessary time needed to engage in the all the steps described below. Do not rush these.

Working in mangrove environments needs to be driven by respect, with the knowledge of local people being shared in a collaborative and inclusive manner, strengthening and empowering their engagement. © Annette Ruzicka

Pre-project planning

Understand "who" is local

- Visit the location, and use direct contacts, maps, and literature to identify all people who may have local knowledge.
- Be aware that there may be multiple communities and these may include different ethnic or societal groupings. Be inclusive of all communities.
- Note that "local" may extend beyond directly adjacent settlements to other areas and even displaced communities.

Know who is "local": it may encompass more than one community, ethnic group, or activity. © Annette Ruzicka

Identify types of LEK that may be critical

- Review lists or classifications of types of LEK that may be relevant to your work. Gain a greater understanding of the many types of LEK that exist. LEK holders can provide knowledge beyond their use of mangroves or threats in the area.
- Seek out specific examples of LEK from the area, the country, or similar projects elsewhere.
- Keep an open mind for opportunities to engage with and include LEK.

Consider fair use and equity

- Plan for free prior and informed consent to any knowledge-sharing. Be aware of national and local regulations, but be prepared to go beyond these.
- Identify ways the project can engage in knowledge co-production activities, and at which stages (consultation, planning/design, implementation, data collection/monitoring, data analysis, dissemination).
- Ensure local sources can be beneficiaries (through funding, acknowledgement, empowerment).
- Respect local participants' time and needs. Ask if and what sort of compensation they need to engage in this work. Not doing so risks undervaluing their time and contributions, which they might provide in addition to or in place of other responsibilities.
- Plan for risks and conflict resolution in the event of disputes or misunderstandings.

Implementation

Engage

- Try to connect fully, possibly through multiple or ongoing engagements.
- Consider appropriate language and technology, engaging translators and approaches that will communicate effectively.
- Listen and revise. Keep an open mind to new knowledge that may fill data gaps or answer novel questions. New ideas and approaches may arise at all stages of engagement.

Collaborate

- Build work in a collaborative manner where local engagement is an integral part of research or management. Where possible allow co-ownership or leadership.
- Provide tools or training if needed to enable deeper local engagement.
- Expect and include feedback and suggestions from local participants.

Engaging and collaborating with local people is critical in research and management, and every effort should be made to build strong partnerships with co-ownership of work and outcomes. © Dominic Wodehouse, MAP

All work needs to be documented, and shared with local people, listening to feedback and adjusting or correcting methods and outputs as required. © Annette Ruzicka

Document and share

- Document all work, interactions, and findings.
- Validate analyses and findings with the people who shared the knowledge to ensure accurate interpretation. Correct any inaccuracies or misinterpretations.
- Continuously share knowledge, understanding, and inferences from the work.

Acknowledge

- Ensure that outputs are shared and local partners appropriately acknowledged as co-authors or co-creators.

Monitor, review and adapt

- Monitor both the work and the process (particularly any safeguards).
- Review and adapt – review should be an ongoing component of any research or management intervention, with an eye to improving processes of work or stakeholder engagement. Take local concerns or suggestions seriously and adjust as is feasible. This should be done multiple times throughout the project.

Follow-through

Leave a legacy

- Report your findings in a collaborative manner with all participants.
- Encourage other projects to learn from your work – both your errors and your successes.
- Seek to ensure that communities are supported and empowered in a manner appropriate to your work (from simple sharing of information to a long-term management framework in which they are leaders or key participants).

Through collaborative work in Madagascar, local communities are now restoring and monitoring their mangroves and reaping the benefits. © Cicelin Rakotomahazo

Through their Community Based Ecological Mangrove Restoration work, local communities inform the Mangrove Action Project of places and issues where mangrove restoration may be most beneficial and are then supported and empowered to undertake restoration and management. (Bengkalis Island, Indonesia). © Dominic Wodehouse, MAP

Swafia Shahibu (right) and Mariam Bwana (left) rest after working in the mangroves. They are members of the Mtangawanda Women's Association, a group that manages mangrove restoration off the coast of Lamu County, Kenya. © Sarah Waiswa

It is important to build local people into the team, and even to engage them directly into research. © Konservasi Indonesia/Hanggar Prasetio

5.2.1 Additional guidance for researchers in combining LEK with AEK

The potential for LEK to inform, guide and support academic research is considerable, and while the guidelines outlined above are equally applicable for researchers and practitioners, the following points may also be valuable for those conducting research:

- Consider the breadth of knowledge that could be helpful. Understanding the scope of LEK can enhance opportunities.
- Be aware of additional institutional requirements, and the requirements of academic publishers for appropriate and equitable engagement, including ethics reviews.
- Avoid "parachute research" by allowing sufficient time for building trust and understanding, and for sharing knowledge in a two-way process.
- Build local people into your team in a way where their knowledge and contributions are respected and valued.
- While academic research can be short-term or transitory, leave a legacy through knowledge-sharing and appropriate acknowledgement.

5.2.2 Additional guidance for engaging with LEK and local communities ethically and inclusively

Given the interest in working ethically with Indigenous and local communities, several organizations have created best practices and guides to assist in such projects. We provide several here that practitioners can use to assist in developing and implementing projects.

Source	Relevance	Link
The Nature Conservancy	Guide that offers tools for how to support and uphold the autonomy, decision-making, and self-determination of people who have stewarded the lands, waters, and resources for generations.	Human Rights Guide for Working with Indigenous Peoples and Local Communities
Conservation International	Provides policies, standards, procedures, and guidance to ensure projects are effective, efficient, and equitable.	Environmental and Social Safeguard System
WWF	Guide that provides information, guidance, and tools for practitioners who seek to address the threats of corruption in community-based work and inclusive conservation efforts.	Communities and Inclusion
Global Mangrove Alliance	Includes best practices for community engagement in mangrove restoration projects.	The Best Practice Guidelines for Mangrove Restoration
Henriika Mustajoki and Arto Mustajoki	Guides best ethical procedures and provides more in-depth understanding.	A new approach to research ethics: Using guided dialogue to strengthen research communities
IPBES	Provides an approach to recognizing and working with Indigenous and local knowledge.	Key Messages from the IPBES Global Assessment
FAO	Toolkit and e-learning product for practitioners working with Indigenous peoples.	Free, Prior, and Informed Consent (FPIC)
UNESCO	To further understand local knowledge and how it supports science and policy.	Local Knowledge, Global Goals
The Nature Conservancy	Practitioner framework to strengthen outcomes for people and nature.	Strong Voices, Active Choices

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A local resident walking through the mangroves in Guangxi Beilun Estuary National Nature Reserve in China, which is home to several endangered species. © Mark Spalding

Appendix 1:
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Appendix 2: Types of LEK in mangrove research

Author	Almasi et al. (2018)	Amin (2020)	Atindana et al. (2020)	Aubé & Caron (2001)	Avtar et al. (2021).	Badola & Hussain (2005)	Badola et al. (2012)	Beitl (2014)	Beitl et al. (2019)	Berkström et al. (2019)	Brown et al. (2018)	Carney (2017)	Carrasquilla-Henao et al. (2019)	Chakraborty et al. (2020)	Choi et al. (2009)	Conchedda et al. (2011)	Cormier-Salemet al. (2017)	Dahdouh-Guebas et al. (2006)	Dahdouh-Guebas et al. (2000)	Damastuti & de Groot (2017)	Damastuti & de Groot (2019)	Darkwa & Smardon (2010)	DasGupta & Shaw (2017)	De Thoisy et al. (2003)	Deb (2015)	Duangjai et al. (2013)	Feka & Manzano (2008)	Fekaet al. (2011)	Firmo et al. (2011)	Francisco et al. (2019)	Furukawa et al. (2015)	Gallup et al. (2020)	Gardner et al. (2017)	Glaser (2003)	Gnansounouet al. (2021)	Griffin et al. (2013)	Hassan et al.(2018)	Hema & Devi (2014)	Hernandez-Cornejo et al. (2005)	Hernández-Félix et al. (2017)	Hoque Mozumder et al. (2018)	
Ecosystem		■	■	■	■			■	■	■	■	■	■			■	■		■	■		■	■			■	■		■	■	■	■				■	■			■	■	55
Ecosystem State or Condition		■	■	■	■						■		■			■		■	■							■		■		■		■				■					■	34
Location											■		■																	■												4
Extent				■							■					■		■												■												11
Condition		■	■								■								■		■					■		■		■		■				■					■	25
State											■																									■						6
Recovery		■																																		■						3
Change		■	■	■	■			■	■		■					■		■	■		■	■			■	■		■	■							■			■	■	37
Spatial				■	■				■		■					■		■	■		■					■		■								■			■	■	23
Temporal				■	■				■		■		■					■			■					■		■		■						■				■	24
Seasonal							■																		■																	4
Climate			■																																						4
Function							■		■		■		■	■		■	■				■	■			■	■		■	■												■	30
Connectivity							■				■		■			■	■				■				■	■		■	■													20
Community Dynamics													■																													8
Nursery Areas											■		■								■	■				■																14
Biodiversity	■	■		■				■		■	■	■	■	■	■	■		■	■	■		■	■	■	■	■			■	■	■	■	■		■	■	■		■	■	57
Mangrove Species		■		■														■	■						■					■	■	■			■				■		26
Presence/Absence				■																					■					■	■				■		■				8
Growth																									■																4
Height				■																																					3
Condition		■		■																																	■				9
Identification																		■	■											■	■	■			■				■		18
Endangered																■	■								■	■						■			■						11
Presence/Absence																■	■								■	■						■			■						11
Identification																	■									■							■			■						4
Population Size																									■																	4
Distribution																■																										4
Other Species		■		■			■			■	■	■	■				■		■		■	■			■			■		■	■			■	■			■	■		32
Changes													■			■		■							■					■												12
Presence/Absence		■					■					■	■						■						■	■					■	■								■	■	20
Identification										■		■														■							■			■						10
Range										■									■																							3
Abundance				■				■			■		■			■		■			■	■						■												■	■	20
Size								■					■									■				■															■	■	6
Human-Mangrove Interactions	■	■	■	■	■	■	■	■			■		■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■		■		■	■	■		■	■	■	■	83
Ecosystem Impacts	■	■	■		■	■		■	■		■			■		■		■	■	■	■	■	■	■	■	■			■			■	■			■	■	■	■	■	■	60
Threats	■	■	■		■	■		■	■		■			■		■		■	■	■	■	■	■	■	■	■			■			■	■			■	■	■	■	■	■	59
Impacts		■	■		■	■		■			■			■		■		■	■	■	■	■	■	■	■	■			■			■	■			■	■	■	■	■	■	51
Drivers of loss			■								■			■						■	■								■				■								■	16
ESS	■			■	■	■	■		■		■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	75
Provisioning	■			■	■	■		■			■	■	■	■		■	■	■	■	■	■	■	■	■	■	■			■			■	■			■	■	■	■	■	■	68
Regulating					■	■	■					■					■	■	■	■		■				■	■		■	■												35
Cultural						■	■				■			■						■	■	■	■	■	■	■		■				■						■		■		35
Supporting													■							■	■		■		■	■			■			■								■	■	28
Applied/Management	■		■			■	■	■	■		■	■		■			■	■	■	■	■	■	■	■	■			■		■		■		■		■	■		■	■	56
Tenure/Laws	■					■	■	■	■		■			■				■	■	■		■				■			■								■				33
Conflicts						■	■	■	■		■			■				■	■	■		■							■												■	25
Conservation Attitudes	■					■	■	■	■					■						■		■	■		■				■				■							■	■	29
Conservation/Restoration strategies	■		■					■	■							■		■	■	■		■	■						■											■	■	30
Community participation									■							■			■	■		■																				9
Traditional/Artisanal fishing or crafts			■					■				■													■				■													7

Appendix 3:

Methodology for mangrove local ecological knowledge systematic review

Primary Question:

- What traditional and local knowledge is there for mangrove ecosystems?

Secondary questions?

- What are the aims and focus of the studies?
- How is this knowledge being used and integrated?
- What are the different types of knowledge collected?
- Where are these mangrove sites located?
- What were the methods to collect LEK and how was this analysed?
- Who are the people involved?
- Who are the people collecting the information?
- Are authors from the country of focus included?
- What were the main results?
- If LEK and AEK were integrated, how was this done?

Literature search:
Carried out on 29th - 30th July 2021 in Scopus, Web of Science (WOS) and Proquest International Bibliography of the Social Sciences (IBSS).

Search string:
Mangrove AND "biocultural value*" OR "community participation" OR "ecological knowledge" OR "ethnobiology" OR "focus group" OR "group discussion*" OR "Indigenous knowledge" OR "interview" OR "local ecological knowledge" OR "local experience" OR "local knowledge" OR "local livelihood" OR "local people" OR "local residents" OR "non-scientific knowledge" OR "participant observation" OR "participatory mapping" OR "resource management" OR "resource users" OR "semi-structured interviews" OR "socio-cultural value*" OR "structured interviews" OR "traditional ecological" OR "traditional knowledge" OR "gendered knowledge" OR "knowledge exchange" OR "participatory" OR "empowerment" OR "Integrated knowledge" OR "knowledge-based approach*" OR "knowledge transfer".

Inclusion/exclusion criteria:

NO – exclude

- Studies that mention LEK without having primary data.
- Studies that have local knowledge (management, policy, etc.) but it is not specifically ecological knowledge - (e.g., about species; landscape; mapping; conditions; beliefs; cultural values; and relationships between plants, animals, natural phenomena, landscapes, and timing of events (including hunting, fishing and forestry).
- Studies that discuss local participation but not local knowledge.
- Studies that interview only government officials/tourists.
- Non-mangrove ecosystems.
- Modelling data.
- Non-English.
- Not conservation or restoration focus.
- Reviews.

YES- include

- All years.
- Geographical location: global.
- Studies that have LEK in a mangrove ecosystem.*
- English.
- Primary data on specific mangrove location(s).
- Mangrove associated local knowledge.**
- Conservation/restoration focus.***
- LEK from the local population.****

*Ecological knowledge = relationships between the land, water, animals, and plants within a particular area.

**e.g., also including articles about fauna associated with mangroves for all or part of their life cycle and fisheries that occur in and around mangrove ecosystems.

***can have management/governance related LEK as part of it, but the main study focus is conservation/restoration.

****local population = includes anyone living in the local area - local communities.

Title and abstract level screening:
Sysrev - a platform for collaborative extraction of data from documents - was used for management and transparency in this systematic review.

Stage 1: abstract level screening can be seen here: https://sysrev.com/u/4865/p/81676

Stage 2: full text level screening can be seen here: https://sysrev.com/u/4865/p/96265

Accepting/rejecting mangrove LEK studies:
Many studies of local people collected information about household income salary/occupations; these were rejected unless they also included LEK. E.g., If it asked how much of a mangrove product was used, then no. If ask why they use it, how they collect it, where its from, etc. then yes, this is LEK. A Kappa value was run between the two reviewers. A 0.64 = substantial agreement on 250 papers of which 157 were reviewed by both. In Sysrev, both reviewers went through the conflicts and discussed any disagreements in accepting/rejecting articles according to the criteria.

Data extraction:
Began data extraction of the 90 accepted articles in January 2022 using Excel. A codebook was used to extract the same information from each article. Data extracted was a mixture of qualitative and quantitative information, selected from the aims and objectives of the study. A sample size of 10 articles were selected at random and extracted to assess and refine the extraction list and order.

Categorizing and organizing into themes:
To understand the type and scope of LEK in the studies, LEK was categorized into three themes. This was done through a coding approach combining deductive (predetermined categories) and inductive coding (ground-up approach). First, qualitative codes were organized into categories and subcodes, followed by further rounds of qualitative coding. Then, codes and categories were turned into the final category.

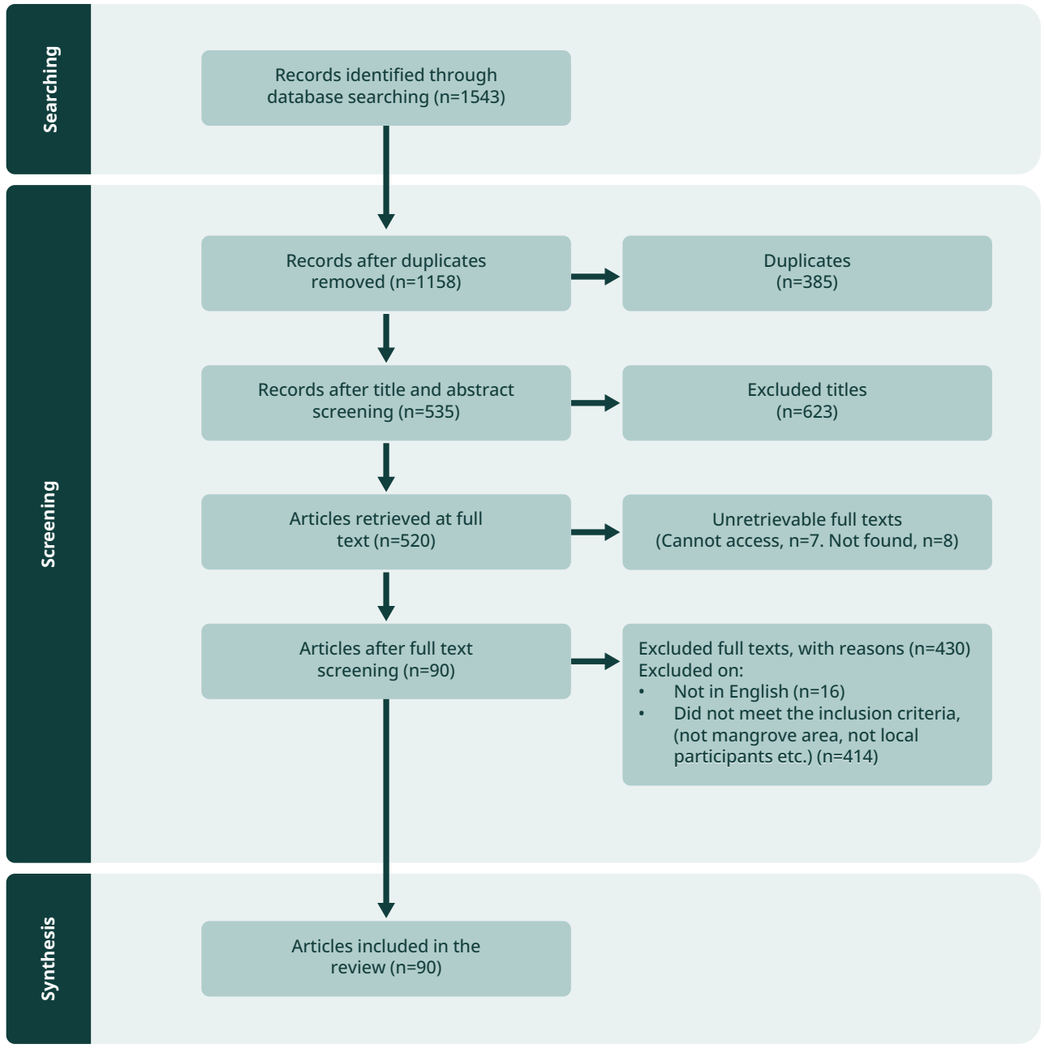

Figure 9: ROSES Flow Diagram for Systematic Reviews (adapted from Haddaway et al. 2017)[35]

35 Haddaway, N. R., Macura, B., Whaley, P., & Pullin, A. S. (2018). ROSES RepOrting standards for Systematic Evidence Syntheses: pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps. *Environmental Evidence*, 7(1), 7.

Appendix 4:
Mangrove LEK case studies guidelines and template

In June and July, 2023 the lead authors of this report reached out via email to mangrove managers and conservation practitioners around the world to solicit the submission of a series of case-studies that would illustrate the practical use and application of LEK. The following text presents that message, and explains the guidelines and template that was provided to all authors.

The integration of local or Indigenous knowledge in mangrove conservation and restoration

The Nature Conservancy and Global Mangrove Alliance, with partners, are compiling a review of the use of local, traditional, or Indigenous knowledge within mangrove conservation and/or restoration projects around the world. In particular, we are keen to identify examples where the local providers of such knowledge are active participants.

Our vision is to develop a series of 10-20 such case studies, which will be included in a wider report and guide on the use of local ecological knowledge (LEK) in mangrove research and conservation. The case studies will be reviewed to develop a summary narrative and all contributors will be invited to be full authors on the final report. **Submissions must include at least one author who is a member of the local community.**

Case Study Guidelines:

We are interested in case studies that:

- Include local community members and their knowledge in some aspect of the project (e.g., project design, implementation, monitoring).
- Are restoration or conservation projects, NOT academic research projects; although cases can include research as part of the larger project (e.g., assessing outcomes of implementation).

Although important, for this review, we are NOT interested in case studies that:

- Use local knowledge WITHOUT any additional engagement with local community members (e.g., we do not want studies where information, such as the location of nursery grounds for fish, is extracted but there is no other local involvement).
- Focus on STUDYING local knowledge of mangroves (e.g., identifying community perceptions of benefits or threats).

If your mangrove conservation or restoration project fits the above guidelines and you are interested in submitting your project as a case study, please see the template below to guide your writing. You do not need to follow it strictly, but please be sure to include all the information.

Template:

Word Count: 400-500 (not including project name, authors, location, project size, and mangrove species)

Contributing authors: Names, affiliations, and roles.

Location: Community (village, estuary/lagoon/river basin/etc., county), region, country.
If possible, provide coordinates or a map location so we can build a map showing all sites.

Project Size: How many hectares is the project and/or area being protected?

Mangrove species: List the species of mangrove involved in this project.

Project goals and objectives: Describe the basics. Include project focus/foci (e.g., restoration, conservation) and reason for the project. For example, is the project:

- restoration of aquaculture/agriculture through planting/natural recovery
- rehabilitation of mangroves diminished by excessive harvest/storm damage/pollution
- enhanced protection and management of mangroves areas threatened by x/y/z
- development of a larger program to do some of the above
- other...

Methods/approaches used: Describe methods/approaches used (e.g., hydrologic restoration, planting, establishing a protected area, economic opportunities, education and outreach).

Groups involved and roles: Mention the key supporting organizations (e.g., government agency, NGO, partnerships, schools) and the key practitioners and/or local collaborators, which must include (but not restricted to) local/traditional/Indigenous individuals, groups, or organizations.

Local knowledge and how it has informed the project: What local/traditional/Indigenous knowledge is involved in this project (e.g., mangrove locations, threats to mangroves, uses of mangroves, traditional management practices)? Who are the holders of this knowledge? How has this knowledge been shared and included? Has this knowledge informed or shaped the project? Has this knowledge changed how project was envisioned, understood, conceptualized? Anything else that you would like to include about local/traditional/Indigenous knowledge?

Outcomes: If the project is completed or has been running for some time, describe the achievements overall in relation to goals/objectives. Also, please include some specific description of the influence or impact the project may have had on the local communities engaged in, or associated with, the project.

Aerial view of a restoration site in Morrosquillo Gulf, Colombia (Case study 4). © Vida Manglar

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