THE UNESCO
Courier
January-March 2026

How Indigenous knowledge drives scientific discovery

- Lessons from the water people in **Brazil**
- **Namibia**: the secret skies of Kalahari
- In **China**, the radiant health of traditional Dai medicine

OUR GUEST

Interview with **Chimamanda Ngozi Adichie**, Nigerian writer

ISSN 2220-2285
9 772220 228014 12026

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2026 • n° 1 • Published since 1948

The UNESCO Courier is published quarterly by the United Nations Educational, Scientific and Cultural Organization. It promotes the ideals of UNESCO by sharing ideas on issues of international concern relevant to its mandate.

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Printing: UNESCO

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The UNESCO Courier is published thanks to the support of the People's Republic of China.

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7, place de Fontenoy, 75352 Paris 07 SP, France

ISSN 2220-2285
e-ISSN 2220-2293

THE UNESCO Courier

Contents

Editorial

Indigenous knowledge has long been ignored, and sometimes even opposed, by science. Now, however, it is receiving renewed interest — and it's about time: the consequences of global mechanization, along with crises linked to climate change and health issues, are encouraging us to assign new importance to knowledge, practices and expertise that have long been marginalized.

Rooted in the careful observation of ecosystems and passed down orally from generation to generation, this knowledge offers valuable keys to building a sustainable future. It has been gaining increased recognition for several years. The United Nations Declaration on the Rights of Indigenous Peoples, adopted in 2007, affirms the right of these peoples to preserve, control and develop their traditional knowledge.

UNESCO has long been a pioneer in this field. Through its Local and Indigenous Knowledge Systems (LINKS) programme, the Organization promotes exchanges between Indigenous knowledge-holders and scientists, particularly in the fields of ecology, water management and natural risk prevention. Biosphere reserves are a concrete example of this approach — they bring together researchers and local communities to develop solutions adapted to specific territories. This is a major shift, as science is no longer seen as a single, top-down form of knowledge, but as a dialogue between knowledge systems. Furthermore, the Convention for the Safeguarding of the Intangible Cultural Heritage protects practices, techniques and skills passed down from generation to generation, recognizing their universal dimension.

Beyond providing empirical data, Indigenous knowledge challenges the very foundations of the scientific approach, whether in terms of the place of ethics, the relationship between humans and nature, or the long timeframe of observations. In agriculture, traditional medicine and climatology, this knowledge has already inspired major innovations, which are often more sustainable than purely technological solutions.

But this recognition must be accompanied by guarantees — the free and informed consent of communities, equitable sharing of benefits, and protection against abusive appropriation. The objective is not simply to absorb Indigenous knowledge into mainstream science, but to promote cooperation for the benefit of all.

By promoting this knowledge, UNESCO is reminding us of the obvious — to understand and preserve the world, we have everything to gain by integrating the knowledge and traditions of all peoples. True science, and the ethics appropriate to our diverse world, are those that make room for all human expressions, in all their diversity.

Agnès Bardon
Editor-in-Chief

How Indigenous knowledge drives

Lagipoiva Cherelle Jackson

Indigenous climate journalist from Samoa reporting for The Guardian *on Pacific Island issues, she currently serves as Professor of Pacific Island Studies at Portland State University (United States).*

From the Aboriginal practice of controlled burning to prevent wildfires to Inuit weather forecasting, and the *zaï* techniques used in some African countries to capture water, the world is rich with diverse, proven Indigenous wisdom. This knowledge is particularly valuable in the context of climate change and declining biodiversity.

Work by Ecuadorian photographer Carolina Zambrano, embroidered with chambira fibres, a palm tree emblematic of Indigenous Amazonian craftsmanship.

scientific discovery

© Carolina Zambrano

Long before satellites orbited Earth, Polynesian navigators crossed thousands of miles of open ocean by reading stars, swells, bioluminescence, and seabird flight patterns. In the Sahara, Tuareg guides historically travelled by celestial patterns, the sun, wind, and terrain, although their modern navigation now relies more on landmarks and daytime travel. Cognitive science research has revealed that these navigation systems demonstrate sophisticated spatial reasoning through diverse environmental cues, far more integrated than the single-input methods used in laboratory studies.

There are many more examples of how traditional knowledge has proven its worth, in areas as diverse as water management, agroforestry, health and fishing. Far more than a collection of techniques, these practices are also an expression of a worldview. Textile creation, for instance, has served as another form of navigation, this time in a spiritual sense. The woven skirts of Micronesia's Outer Islands and the strip-weaving traditions of Ghana and Nigeria map community knowledge and cultural identity into symbolic pattern language.

These practices represent entire knowledge systems. They encode, preserve, and transmit understanding across generations. Today, Indigenous communities worldwide are defending their rights to protect such cultural heritage while actively making the case of traditional knowledge systems as parallel scientific frameworks. As Fijian researcher Salanieta Kitolelei noted at the 2025 Second Pacific Island Ocean Conference in Honiara, Solomon Islands: "It is the same thing — we just use a different language to talk about the same thing."

Traditional Indigenous knowledge has gained recognition in recent years, thanks notably to international instruments like the United Nations Declaration on the Rights of Indigenous Peoples — but it is nonetheless threatened by cultural and commercial appropriation.

Guardians of biodiversity

As the climate crisis intensifies and biodiversity collapses, the world turns to the very knowledge systems it once dismissed. According to the United Nations, Indigenous Peoples comprise less than 5 per cent of the global population yet steward lands containing about 80 per cent of Earth's remaining biodiversity. From their close relationship with the surrounding natural world, they have derived valuable knowledge that merits greater attention.

> **"Indigenous skills and wisdom are codified to form complex systems of knowledge**

"We observe nature, our animals and plants. We are the guardians of nature and we possess an enormous amount of knowledge about our environment," noted Hindou Oumarou Ibrahim, an Indigenous Mbororo leader from Chad and Chair of the 23rd Session of the United Nations Permanent Forum on Indigenous Issues, in April 2024. "This knowledge is not theoretical; it has been tried and tested for centuries."

The accumulated skills and wisdom are not solely passed down mechanically from one generation to the next, but also codified to form complex systems of knowledge, as illustrated by the mastery of textile art in the Pacific and Africa. Pacific weavers understand plant ecology, sail dynamics, and cultural protocol. West African weavers master loom technologies, natural dyes, and symbolic pattern languages. In both regions, knowledge is transmitted through apprenticeship and cultural practice. The textiles themselves become living archives where knowledge resides in the hands, the patterns, and the process.

LINKS programme: promoting Indigenous knowledge

Established in 2002, UNESCO's Local and Indigenous Knowledge Systems (LINKS) programme mobilizes the knowledge, know-how and practices of local communities and Indigenous Peoples to support their inclusion in environmental decision-making, particularly with regard to biodiversity and climate change.

LINKS aims to build dialogue among Indigenous and local knowledge holders, natural and social scientists, resource managers and decision-makers to secure an active and equitable role for local communities in governance. The programme aims to strengthen knowledge transmission of elders' knowledge, and to find a balance between community-based knowledge and global knowledge in formal science.

Among other roles, the LINKS programme currently hosts the Indigenous and Local Knowledge Technical Support Unit of IPBES (the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems Services). In this role, it provides support and expert advice to help IPBES better include Indigenous and local knowledge in its assessments.

◥ *Traditional fire management in Kakadu National Park, northern Australia. Photograph from the series* Fighting Fire with Fire *by Australian photojournalist Matthew Abbott.*

In Taumako, Solomon Islands, women are custodians of land and sea, harvesting and processing pandanus — a small tree abundant throughout regions like Polynesia and Micronesia — and weaving sails that powered voyaging for more than 3,000 years. As islander Delsie Betty Bosi explains, "The men build most of the canoes; the women feed the workers and children, keeping morale strong, and build the sails." This gendered division of labor, with women as knowledge keepers, mirrors patterns found across the Pacific.

In West Africa, master weavers created kente cloth whose geometric patterns encode philosophy, historical memory, and social identity. Kente, developed by the Asante in Ghana's Bonwire weaving village, was inscribed in 2024 on UNESCO's Representative List of Intangible Cultural Heritage. Kente patterns encode meanings tied to wealth, spiritual values, historical events, and moral principles.

The sacred fire

Indigenous ecological knowledge continues to demonstrate sophisticated understanding of environmental relationships. In Australia's Northern Kimberley, Aboriginal communities have revived traditional fire management after decades of colonial disruption. A large-scale study published in 2024 compared fire metrics across eleven years without Indigenous fire management (2001–2011) and eleven subsequent years under Indigenous fire management (2012–2022). It found that fire frequency decreased across more than 42 per cent of the study area during the Indigenous management years.

Using controlled, small burning practice, or "cool burns" to clear the underbrush during the dry season, the Balanggarra, Dambimangari, Wilinggin, and Wunambal Gaambera peoples reduced wildfire intensity, protected biodiversity, and lowered greenhouse gas emissions. As Catherine Goonack, Chair of Wunambal Gaambera Aboriginal Corporation, explained: "Our Wanjina Wunggurr ancestors have been using fire to manage →

and protect our country for a long, long time. Fire is our most important thing to look after and keep our country healthy." Similar practices are being revived in California (United States) by tribes like the Karuk.

Across the Arctic, Inuit knowledge keepers document rapid climate shifts that confound Western meteorological models. Hunters combine generational observations with modern tools to navigate unpredictable ice conditions. Inuit traditional weather forecasting remains essential, even as elders note that some inherited knowledge no longer functions reliably due to rapid environmental change.

In Africa, farmers across Burkina Faso, Niger, Mali, Kenya, and Senegal use techniques like *zaï*, which capture and redistribute water in degraded soils. These methods, combined with intercropping and reliance on Indigenous plant varieties, support soil fertility without synthetic inputs. A 2025 Scientific Reports study in South Africa found that 92 per cent of farmers used Indigenous plant-based measures to manage pests and diseases.

Two-eyed seeing

The question of what counts as knowledge sits at the core of Indigenous intellectual sovereignty. Western science prioritizes replicability, quantification, and separation of the observer from the observed. Indigenous knowledge systems operate relationally, holistically, and through long-term intergenerational observation.

UNESCO's Local and Indigenous Knowledge Systems (LINKS) programme defines Indigenous knowledge as practices, understandings, skills, and cosmovisions developed by societies with deep relationships to their environments. These systems are dynamic and validated within their own epistemic frameworks. The Inuit Circumpolar Council describes Indigenous knowledge as systematic ways of thinking that integrate biological, physical, cultural, and spiritual realms.

The concept of two-eyed seeing, developed by Mi'kmaw Elder Albert Marshall (Canada), encourages viewing the world through the strengths of both Indigenous knowledge and Western science. Inuit researchers have expanded this by calling for a shift from seeing to sensing, recognizing that intuitive and relational ways of knowing can lose meaning when stripped from their cultural and spiritual context.

Globally, institutions are beginning to recognize these frameworks. The World Health Organization (WHO) established its Global Traditional Medicine Centre in 2022, and the 2024 WIPO Treaty on Intellectual Property, Genetic Resources and Associated Traditional Knowledge now requires patent applicants to disclose and credit Indigenous knowledge used in scientific and commercial applications.

Irreplaceable loss

Indigenous knowledge is inseparable from Indigenous identity, governance, and self-determination. As Elin Magga, a Sámi reindeer herder, told a 2024 Arctic gathering, climate change threatens not only livelihoods but entire ways of life. Where Indigenous land rights are secure, conservation succeeds. When rights are undermined, ecosystems collapse.

Research collaborations frequently reproduce extractive patterns. True partnership requires Indigenous leadership from research design through data control and full respect for data sovereignty. Every lost language erases ecological knowledge embedded in vocabulary, stories, and place-based understanding. Every elder who passes without sharing their knowledge represents an irreplaceable loss.

> **"Every lost language erases ecological knowledge embedded in vocabulary and place-based understanding**

Indigenous knowledge offers tested solutions to global crises, but integration requires structural change. Indigenous leadership must guide the process. Knowledge must be respected within its own frameworks, and intellectual property and data sovereignty must be protected. Long-term support for intergenerational transmission is essential.

Indigenous knowledge systems offer alternative paradigms rooted in reciprocity, stewardship, and long-term ecological responsibility. The weavers still work the dried pandanus. The fire keepers still sense the land. The navigators still teach children to read stars and waves. Despite colonization and disruption, Indigenous Peoples continue to protect biodiversity and hold solutions the world now urgently seeks.

Ihirangi Heke, a Maori researcher, cultural leader and environmental knowledge keeper, described Indigenous knowledge as the longest-running environmental study on Earth. He warns that knowledge sharing must be cautious because of past misuse and that climate spaces like The Conference of the Parties (COP) often tokenize Indigenous voices.

For Ihirangi Heke, the question is not whether Indigenous knowledge can solve the climate crisis. The question is whether Indigenous Peoples will be in the room with the power to shape the decisions that define our future. The next frontier of Indigenous sovereignty may also be the frontier of our collective survival.

Marcelo Silva
de Sousa

Journalist in Brasilia (Brazil)

Brazil: lessons from the water people

Faced with a dramatic decline in pirarucu, a fish that is essential to their survival, the Paumari people of Amazonas state took part in a programme to restore the species, combining scientific and traditional knowledge. After a few years, the fish are once again populating the Purus River.

On the Purus River, as the light fades and the heat lingers over the water, a pirarucu fish comes to the surface to gulp some air. This sound — deep, damp, ancestral — revives a pulse that this land had almost lost. "Nature was begging for our help," recalls Chico Paumari, a young fisherman. "We would arrive at the lake to find there was nothing left. It was heartbreaking to see our food supply exhausted. We didn't know how to feed our children."

Dawn gives off an odour of ferrous humidity mingled with brazier smoke. The Paumari, an Indigenous people of about two thousand souls living in the vast region of Amazonas state in the north-west of the country, have a way of defining themselves that can't be found in any scientific textbook: "We are the people of the water, the only ones who truly live within it." When the population of pirarucus, the world's largest freshwater fish, fell to just 266 adult specimens in 2009, the Paumari faced an existential threat.

For years, academic research and traditional knowledge evolved in parallel without ever meeting. Technicians arrived

During the fishing season, the Paumari work in continuous shifts to quickly transport pirarucu from the lakes to the cold chain.

with their forms. Indigenous communities offered their intuition. The turning point came when they both decided to "share the same canoe", an alliance fostered by OPAN (Operação Amazônia Nativa), one of Brazil's oldest Indigenous organizations, which, on this occasion, acted as a bridge between these two worlds.

A bridge between two worlds

The recovery of the pirarucu, whose population now numbers more than 10,000 adult individuals, was made possible by a community management method that combines territorial surveillance, annual censuses and controlled harvesting that never exceeds 30 per cent of adult fish. This is neither purely science nor purely tradition, but a form of social technology that draws its core components from both worlds: from biology, protocols and monitoring; from ancestral knowledge, the ability to read the water, life cycles and respect for the limits imposed by nature.

"They know how the river flows, where the fish take refuge, how they react to the moon or the mud," explains Felipe Rossoni, a biologist at OPAN who has been working with the community since 2009. "Our role has been to help organize this knowledge without altering its essence so that we can engage with State regulations."

According to Rossoni, this joint management has made it possible to achieve much more than simply restoring a fishery resource — it has united the community around a common agenda, strengthened local governance, enabled the building of infrastructure and the creation of a community fund, while restoring a sense of pride in those who had felt rejected for generations.

© Adriano Gambarini / OPAN

Pirarucu, a fish that can reach three metres in length and weigh 200 kilograms.

> **"It is a matter of translating the traditional worldview into procedures that can influence climate policies**

"Today, when we see that the lake is full of fish again, we know that it has come back because we have protected it," says Chico Paumari. "We never want to be a forgotten people again."

Influencing decisions

This local success is part of a broader process in Brazil — the gradual incorporation of Indigenous knowledge into national decision making. At the heart of this movement is Eloy Terena, an Indigenous lawyer and executive secretary of the Ministry of Indigenous Peoples, created in 2023, who recognizes that this approach presupposes education. "The challenge is both technical and legal — we have to succeed in integrating village knowledge and the rhythms of nature into the functioning of the administration," he explains.

LVMH and UNESCO partner to defend biodiversity

Since 2019, LVMH has been a partner of UNESCO's Man and the Biosphere Programme (MAB). During the first five years, this initiative focused on eight biosphere reserves in the Amazon region situated in Bolivia, Brazil, Ecuador and Peru, covering nearly 30 million hectares and home to 1.3 million people, including many Indigenous communities.

Working closely with these communities, more than 80 initiatives benefiting over 1,000 families and young people have restored ecosystems and created sustainable sources of income. These initiatives include the establishment of participatory governance in the eight biosphere reserves as well as training in forest firefighting. The partnership has also promoted the development of income-generating activities, such as jewellery-making in Bolivia and cocoa production using agroforestry practices in Ecuador and Peru.

In addition, nearly 28,000 people in Peru have indirectly benefited from training in fire prevention and management. Nearly 18,000 people have also indirectly benefited from support for ecotourism and agroforestry, as well as cocoa, coffee, craft and honey production in Peruvian reserves.

© Adriano Gambarini / OPAN

Members of the Paumari people wash pirarucu nets on the banks of the Tapauá River in northwestern Brazil at the end of the fishing season.

Put simply, it is a matter of translating the traditional worldview into procedures that can influence environmental permits, boundaries and climate policies. This approach still meets with some resistance. Some economic sectors continue to perceive land demarcation as an obstacle to development.

However, studies show the relevance of Indigenous practices in the management of their lands. According to IPAM, the Amazon Environmental Research Institute, these Indigenous lands are "far better" equipped to contain deforestation.

"The figures speak for themselves," says Paula Guarido, a researcher at IPAM. "Over the last 30 years, Indigenous lands in Brazil have lost only 1.2 per cent of their original vegetation. Private lands, over the same period, have lost nearly 20 per cent."

The climate data are even more revealing. In the Xingu Indigenous territory, located in the Brazilian states of Mato Grosso and Pará, the average temperature is two degrees lower than in the surrounding agricultural areas, and evapotranspiration — the driving force behind the "flying rivers" that irrigate the south-central part of the continent — is significantly higher. "Where there is Indigenous land, there is standing forest," sums up Paula Guarido. "They represent the last green frontier."

During the climate conference (COP30) held in November 2025 in Belém, Brazil, the voice of Indigenous Peoples became established as a necessary pillar of any serious climate strategy.

Flying rivers

There is a direct link between the restored lakes of the Purus, satellite images of the Xingu and global climate commitments. A link that, according to experts, indicates that the defence of Indigenous territories is inseparable from global climate stability.

At dusk, when the sounds of the rainforest change frequency, the Amazon continues to send moisture, in the form of flying rivers, towards the south of the continent, irrigating crops whose beneficiaries often ignore — or underestimate — the role of those who perpetuate this cycle.

The lesson from the water peoples is simple and urgent: protecting Indigenous territories is not an act of anthropological charity; it is a strategy for planetary survival.

> **"Protecting Indigenous territories is not an act of anthropological charity; it is a strategy for planetary survival**

Dinamam Tuxá, coordinator of APIB (Articulation of Indigenous Peoples of Brazil), delivers a message that sums up the spirit of this story: "We have the technology to prevent the end of the world. The question is whether humanity is ready to learn, or whether it will continue to believe that it knows better than the Earth," he concludes. ■

When biopiracy takes root

Daniel Robinson

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David Jefferson

Associate Professor at the University of Canterbury (New Zealand), his research focuses on the intersection of biodiversity, intellectual property, and Indigenous knowledge systems.

For the past thirty years, international regulations have sought to limit the exploitation of Indigenous knowledge by industry so that it does not occur at the expense of local populations. But despite these measures, cases of misappropriation remain widespread.

There is a huge diversity of Indigenous Peoples, cultures, languages, and knowledge systems around the world. These systems, developed over hundreds or thousands of years, have greatly contributed to the development of the foods we eat, traditional and modern medicines, and fibres and materials used in our homes and our clothes. Although often described as "traditional", Indigenous knowledge systems originate from empirical observation and repeated practice, and like other knowledge systems they continuously evolve over time to incorporate new information and as local conditions change.

Indigenous insights on the properties of plants, animals, and other non-human inhabitants of ecosystems have often been sought by researchers and companies for the development of new technologies and innovations. This process, sometimes referred to as "biodiscovery", frequently occurs in the sectors of agriculture and food, biotechnology, pharmaceuticals, cosmetics, forestry, and others to create products that are marketed globally.

Resorting to biodiscovery can offer numerous advantages for those developing new products. For example, in the pharmaceutical industry, where research and approval timelines are long, product development processes are expensive, and intellectual property and regulatory protection strategies are risky, Indigenous knowledge can help bring products to market more quickly.

However, there is criticism against biodiscovery as "free riding" on knowledge developed by Indigenous and other local peoples. When the role of their knowledge is not sufficiently recognized in scientific investigation, product development, or commercialization, and where the users of this knowledge do not appropriately share benefits with ancestral knowledge holders, it can be called "biopiracy".

The struggle for benefit-sharing

The case of the kava (*Piper methysticum*), a plant in the pepper family that is native to the Pacific, appears to be a prime example of misappropriation of knowledge developed by Indigenous and local communities. Kava has attracted hundreds of patent applications, many of which relate to its anti-anxiety and sedative effects, long known to Pacific peoples. Despite this massive interest, there are no known agreements today for securing permission or implementing benefit-sharing for research and patent claims.

Oil produced from the nuts of the Moroccan argan tree (*Argania spinosa L.*) provides another example. Argan oil is now used in hair and skin care products around the world for essentially the same purposes for which Amazigh (or Berber) women used it for over 1,000 years. While some major international companies with relevant patents selling argan-based products have set up benefit-sharing agreements with Amazigh women's cooperatives, others appear never to have shared benefits with Amazigh communities.

Not all commercial use of Indigenous knowledge linked to genetic resources constitutes biopiracy; some projects are mutually beneficial. For instance, the Indjalandji-Dhidhanu people in Australia have worked with researchers at the University of Queensland to build upon their Indigenous knowledge of spinifex, a hardy perennial tussock grass traditionally used for a variety of purposes. The collaborative research agreement includes provisions for benefit sharing. A spinoff company is now developing medical gels from cellulose nanofibers extracted from spinifex, and a composite material from

> **"Today, many countries require prospective users of Indigenous knowledge to first secure consent from the knowledge holders**

Argan oil production workshop at a women's cooperative in Tafraout, southwestern Morocco.

> **For over a thousand years, Amazigh women have used argan oil, a product that is now commercialized globally**

the grass has been patented. Benefits that have already been shared under the agreement include employment opportunities for First Nations youth and funding for training and educational opportunities for Indigenous Australians.

Common heritage of private goods?

The root of the biopiracy question lies in a historical transformation: the moment the global community began treating biological resources not as a shared heritage, but as proprietary assets.

The circulation of plants, animals, and other components of biodiversity around the world and the sharing of associated knowledge between different human groups is nothing new. Well before the era of European colonization, there were broad global movements of different species and knowledge about how to cultivate and utilize them. People have long traded domesticated animals, spices, herbal medicines, foods and beverages, and fibre products across vast distances, frequently drawing upon knowledge developed by other groups to understand how to use the items obtained.

For most of human history, international law treated such biological resources as the "common heritage of humankind", meaning that anyone could obtain and use them without needing to obtain permission or to share benefits with resource providers. However, with new developments in the science of genetics starting in the mid-twentieth century, products based on or derived from biodiversity came to be understood as "genetic resources". This corresponded with new ways of assigning value to the components of biodiversity based on potential, rather than only actual uses.

The situation changed dramatically in the 1990s with a few developments. First, intellectual property rights were harmonized under the World Trade Organization (WTO) agreements, changing how states allowed intellectual property protection relating to genetic resources. In 1992, when the Convention on Biological Diversity (CBD) placed genetic resources under state sovereignty, it also laid the foundation for systems designed to prevent the misappropriation of traditional knowledge. More recently, the 2010 Nagoya Protocol on Access and Benefit Sharing created an international template for users and providers of genetic resources and traditional knowledge to negotiate agreements governing how these assets may be utilized.

Clear consent

The reinforced international framework of rules and agreements, built over the past 30 years, has brought about some positive change. Today, many countries require prospective users of Indigenous knowledge to first secure clear consent from the knowledge holders and sign agreements detailing how benefits will be shared.

Additionally, an increasing number of laws require that applicants for intellectual property rights — particularly patents — disclose the origin of any genetic resources or traditional knowledge used to create the invention. Such "disclosure of origin" requirements may be adopted by a growing number of countries following the finalization of the 2024 World Intellectual Property Organization Treaty on Intellectual Property, Genetic Resources and Associated Traditional Knowledge.

But despite these measures, biopiracy continues to occur due to exploitable gaps in the system. For instance, the rules may be bypassed by collecting genetic resources or traditional knowledge from a country where no restrictive legislation has been adopted or by obtaining genetic resources from historical collections made prior to the entry into force of the convention. Furthermore, while much attention is paid to patent abuse, other forms of intellectual property, such as plant breeders' rights and trademarks, also facilitate the misappropriation of Indigenous knowledge. Without major change, the persistence of these gaps means biopiracy will remain an unfortunate reality.

Yang Sha
and Du Junzhi

Journalists in Beijing (China)

China: the radiant health of traditional Dai medicine

The traditional medicine of the Dai people, an ethnic minority in southwestern China, is rapidly gaining recognition. People from across the country are travelling to seek relief through proven remedies up to 2,500 years old.

Before 2022, Cao Liming, a man from northeastern China, was facing a painful reality: both of his parents, now in their 70s, had suffered strokes. Their speech was slurred, their limbs weak, and wheelchairs had become part of family life.

He left a well-paid but travel-heavy job and drove his parents south in a camper van. "I wanted to experience a warmer climate and explore some traditional remedies," he explains. After months on the road, the family reached Xishuangbanna in Yunnan, southwestern China — a region famous for its tropical monsoon climate and the distinct culture of the Dai ethnic minority. There, they visited a Dai hospital to explore the local traditional medicine.

The results surpassed expectations. "After just two treatments, their speech was clearly improving," he says. Over the next month, with a regimen of herbal remedies, acupuncture, topical therapies and the sleeping-medicine therapy known in Dai as Nuanya, his parents regained significant independence in their daily activities.

Word of their improved health spread quickly. Friends and relatives back in Jilin Province asked about the experience, then traveled to Yunnan themselves to spend the winter and try Dai therapies. As interest and demand grew, Cao opened a wellness guesthouse in Menghan Township, welcoming long-stay visitors interested in Dai medical care.

Wind, fire, water, and earth

As one of China's four major ethnic medical traditions, Dai medicine boasts of more than 2,500 years of history. Early Dai scholars documented their medical knowledge on palm-leaf manuscripts, drawing on the region's rich tropical biodiversity. Over centuries, they developed a theoretical system built around the "four elements and five aggregates".

According to renowned Dai-medicine inheritor Lin Yanfang, the four elements — wind, fire, water and earth — represent the body's material foundation, while the five aggregates define perception, consciousness, sensation, thought and action. Dai medicine combines this

Courtesy of Li Zhen

> **"Dai medicine is one of China's four major ethnic medical traditions**

Sleeping-medicine therapy in a traditional Dai medicine hospital in Xishuangbanna Dai Autonomous Prefecture, southwestern China.

Courtesy of Li Zhen

Lin Yanfang, a practitioner of Dai medicine, and her students observe the leaves of Malabar nut (Justicia adhatoda L.).

theory with detoxification principles, paired with diagnostic practices such as observation, inquiry and pulse reading. "Health depends on balance between the elements," she says. "Excess or deficiency leads to illness. Dai medicine seeks to restore that balance by following the rhythms of nature."

68-year-old Lin is one of Yunnan's most respected Dai-medicine experts. Now officially retired, she remains as busy as ever. "I've worked in Dai medicine in clinical practice, research and teaching for nearly 50 years," she says. "Now, I want to devote more time to training the next generation."

Born into a family of traditional Chinese medicine (TCM) practitioners, Lin learned to identify herbs early on. In 1974, she became a village doctor in Xishuangbanna, where most treatments relied on Dai remedies gathered from the wild. One day, she watched a Dai healer cure a dying horse foaming at the mouth with leaves picked straight from the roadside. She was deeply impressed.

Lin, who didn't speak the Dai language, pushed herself to learn it by treating local villagers during the day and studying Dai script at night school. "Whenever a treatment worked, I felt so encouraged. The more I saw, the more determined I became to understand Dai medicine deeply."

> "Sustaining this ancient knowledge requires a modern education system

She later pursued formal medical studies and, in 1990, became one of the first students selected for China's national apprenticeship program for senior TCM physicians. Over the years, Lin has trained many national, provincial and prefectural inheritors of Dai medicine in China. "Some of my students are part of joint programmes between China and Thailand," she says. "What connects them is the same intention: to heal. That is the essence of this tradition."

New generation

Among Lin's students is 28-year-old Yang Jianmei, a member of the Dai ethnic group and part of the first class majoring in Dai medicine at West Yunnan University of Applied Sciences. In 2019 she joined Lin's apprenticeship program. "During holidays and weekends, we shadowed Dr. Lin at her clinic," Yang recalls. "We learned pulse reading, tongue observation and how she reasons through a patient's condition. It was the kind of learning you can never learn from a textbook."

Today, Yang works at the Lin Yanfang Ethnic Medicine Hospital in Xishuangbanna. "Among Dai people, food and medicine share the same origin," she adds. "If you feel unwell, you go to the garden or the forest and choose something that clears heat and detoxifies. Many such foods are also medicinal herbs."

China's medical system has provided new pathways for ethnic medical traditions. →

Dai medicine was officially recognized in the 1980s as one of the country's four major ethnic medical traditions. Since then, policies in Yunnan and at the national level have supported talent development and clinical standardization.

One of the most distinctive therapies is the sleeping-medicine therapy. It is widely used for stroke recovery, rheumatic pain and insomnia. Herbs are soaked, steamed, combined with medicated wine and spread on a warm bed. Patients lie on it as another layer of herbs is placed over the body, which is then wrapped to maintain heat for about 30 minutes.

Shi Da, deputy director of medical services at the Institute and Hospital of Traditional Dai Medicine of Xishuangbanna Dai Autonomous Prefecture, notes that in 2025, the highest number of patients receiving sleeping-medicine therapy in a single day reached 119. The growing demand reflects how deeply ethnic medicine has integrated into modern clinical practice.

Living Indigenous heritage

The UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage, adopted in 2003, was a culminating point in recognizing cultural expressions as part of our common heritage. Its Preamble recognizes the important role of Indigenous communities and groups in the production, safeguarding, maintenance, and recreation of this living heritage. Since its adoption, it has helped raise international awareness of Indigenous knowledge systems while helping to preserve them.

To safeguard intangible cultural heritage at the international level, three lists are foreseen under the UNESCO 2003 Convention: the Representative List of the Intangible Cultural Heritage of Humanity, the List of Intangible Cultural Heritage in Need of Urgent Safeguarding, and the Register of Good Safeguarding Practices. Many manifestations of Indigenous living heritage — including oral traditions and expressions, performing arts, rituals and ceremonies, traditional craftsmanship, knowledge and practices — have been inscribed on these lists.

Tradition and clinical safety

Historically, Dai medicine was passed down through apprenticeships in villages and temples. In 1990, China launched a national programme to preserve the clinical knowledge of senior TCM physicians. In 2007, policies allowed folk practitioners to obtain official medical licenses through standardized examinations, creating a system that protects tradition while ensuring clinical safety.

Sustaining this ancient knowledge requires a modern education system. Zhang Chao, founding dean of the School of Ethnic Medicine at Yunnan University of Chinese Medicine, has spent years building exactly that. The university began enrolling students in Dai-medicine tracks as early as 2006, with a dedicated undergraduate program launched in 2014. The university has built key labs and a Dai medicine hospital, forming a complete talent pipeline from undergraduate to doctoral studies. Zhang estimates the province has cultivated nearly 1,000 Dai-medicine professionals in the past decade.

According to Zhou Hongmei, deputy director of the Yunnan Provincial Health Commission, a scientific and systematic standard for Dai medicine is urgently needed. "We're strengthening funding, streamlining approvals, expanding training, supporting research and promoting the use of standardized practices."

The rapidly increasing demand for Dai medicine could challenge the sustainability of the locally harvested herbal resources. To prevent this from happening, a nursery has been established in the Naban River Watershed National Nature Reserve in Xishuangbanna, hosting over 200 species of Dai medicinal plants. This offers a way to secure a future for this thousand-year-old medicine.

Courtesy of Yang Sha and Du Junzhi

A teacher preparing Dai medicine pouches at West Yunnan University of Applied Sciences, Xishuangbanna Dai Autonomous Prefecture.

Sisco Auala

Senior Lecturer at the Namibia University of Science and Technology, she holds a Ph.D. in community-based tourism development from Nelson Mandela University (South Africa).

The secret skies of Kalahari

In northeastern Namibia, the Jul'hoansi hunter-gatherers have developed a unique astronomical knowledge, but their precious connection to the lunar cycle is threatened by light pollution.

The Jul'hoansi, an ancient hunter-gatherer people based primarily in northeastern Namibia, live at the intersection of ancestral customs and the digital age.

The Jul'hoansi people are a hunter-gatherer group residing primarily in northeastern Namibia and parts of Botswana and Angola. This ancient tribe is known for their trance dance, a spiritual practice that connects them to the spiritual powers of the stars for healing. As one elder explains it: "My father would dance the traditional dances at night — and if one was very ill and sleeping, he would dance until they woke up."

Considered to be the first inhabitants of southern Africa, the Jul'hoansi of Namibia lead a semi-traditional lifestyle as they navigate the old world and the new digital age. They still use the lunar cycle to develop complex hunting strategies to sustain their nomadic lifestyle. They see the night sky as a living entity that has guided them through many civilizations, providing them with precise knowledge for understanding time and the seasons in their pursuit of wild food and medicine.

Today they see their ancestors as the first astronomers who observed and theorized about the night sky, developing complex knowledge systems that helped them better understand the interconnectedness of life on Earth with the cosmos. Their knowledge remains primarily oral and is transmitted through

> **"The Jul'hoansi use the lunar cycle to develop complex hunting strategies**

→

storytelling, myths, legends, dances and rituals.

The cosmic tale

The Jul'hoansi possess a cosmic narrative that explains the universe's creation. Central to the myth is the ostrich, a flying bird created by the God for Good and the God for Bad — who existed in isolation and balance before the universe was born. The bird flew around the unlit world, dropping a feather every day. According to the legend, the gods tied these feathers to a kite that showed if the bird was feeling hopeful or sad. Eventually, the ostrich dropped its last feather, which glowed so brightly that it transformed into the Moon and stars. That's how the sky was lit up and the ostrich became one of the many constellations in the Southern sky.

This cosmic narrative of a bird present at the birth of creation is echoed in several Indigenous cultures worldwide. The Jul'hoansi believe in the spiritual connection and interdependence of humans with both the celestial and terrestrial environments, asserting that the well-being of both is paramount to human existence and the health of the broader ecosystem. This traditional wisdom holds valuable potential to complement modern scientific methods in the areas of environmental adaptability and sustainability.

Artificial lighting

Yet, Indigenous knowledge of astronomy is disappearing at a rapid rate, especially in Africa. Little remains of the storytelling around the fire once so commonplace in many African cultures, when Indigenous knowledge of astronomy was transmitted verbally. In parallel, night skies are disappearing just as quickly, as even rural areas are increasingly polluted with artificial lighting.

Global initiatives, like those of the Dark-Sky International organization that promotes the use of eco-friendly lighting at night, have been instrumental in creating awareness of the importance of protecting the night sky. Astrotourism can be a powerful tool to promote dark and quiet skies.

Namibia, known for its exceptionally low global population density, is the perfect location for community-led astrotourism development as it provides unpolluted night skies in most areas for the best part of the year. In the remote Kalahari Desert settlement of Tsumkwe, a pioneering initiative is turning the

© Wilderness

Keeping track of Indigenous knowledge

Through its transdisciplinary Local and Indigenous Knowledge Systems (LINKS) programme, UNESCO is bringing together two of Africa's remaining hunter-gatherer communities to combine Indigenous knowledge with the latest information technology.

In May 2025, UNESCO launched, in northern Tanzania, a series of workshops with members of Tanzania's Hadzabe community and Namibia's Jul'hoansi community. The training allows them to share their knowledge and test the CyberTracker application — a technology initially developed by South African scientist Louis Liebenberg to record animal tracks, signs, and ecological data.

The Jul'hoansi and Hadzabe have extensive knowledge of wildlife, tracks, and signs, which they have used to gather food and navigate predators for millennia. The icon-based application is designed for people with little or no formal education, but who are rich in oral knowledge, to gather georeferenced data about nature. Data collected by expert trackers will be valuable in protecting endangered species, monitoring environmental changes, analyzing trends, and preventing poaching and wildlife trafficking.

The CyberTracker training also encourages elders to share their language and traditions with young people while documenting their interactions digitally. Completion of the training cycle is planned for 2026, after which trackers will be tested on their skills and awarded international certificates of competence.

Little Kulala, a stargazing spot at the heart of the Namib Desert in western Namibia, sheltered from urban light pollution.

night sky into a catalyst for community development.

Astrotourism

The Nyae Nyae Conservancy, established by the Jul'hoansi community in 1998, has launched in 2021 an Astro-Tourism Project that offers visitors an experience that combines stargazing with Jul'hoansi storytelling. Tourists can even visualize the legendary ostrich and its feather-to-star transformation via a virtual reality experience, which was co-designed with the community to preserve and share Indigenous star lore. Linked to the UNESCO Chair in Digital Technology Design with Indigenous People at Namibia University of Science and Technology, the project aims to empower Indigenous groups to control their cultural heritage narrative.

> **"According to the Jul'hoansi, the celestial and terrestrial environments' well-being is paramount to human existence**

Such initiatives also serve to promote, globally, the importance of protecting our remaining night skies.

Anna Ruohonen

Journalist in Rovaniemi (Finland)

The Sámi people, indispensable guardians of climate change

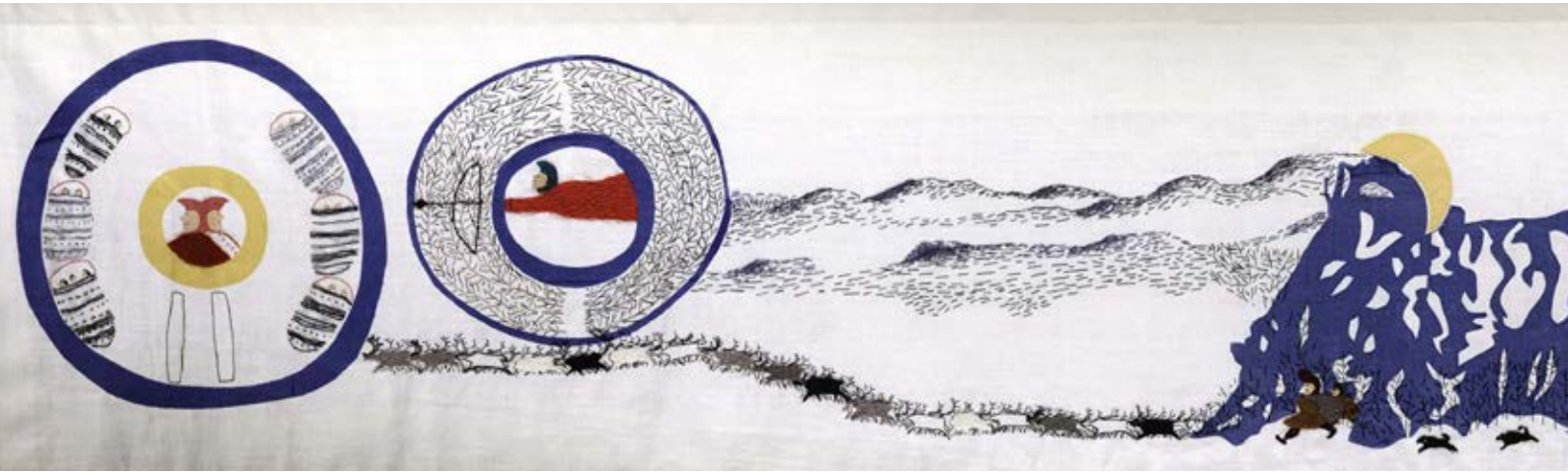
In the northernmost corner of Europe, the nomadic Sámi reindeer herders have developed a millennia-old understanding of the Arctic zone — precious knowledge that helps protect ecosystems and inform climate change adaptation.

Surrounded by Europe's last remaining true wilderness, in Enontekiö, Finnish Lapland, stands a small village, or *siita* in North Sámi. Kalkujärvi is so small that the word "village" might be an exaggeration — just some buildings around a lake that are inhabited only for part of the year. The border of Norway is close, and back in the days when the village was born, there was no border at all. The Sámi, Europe's only recognized Indigenous People, were here long before the creation of the state. For thousands of years, they have used the land in the northern parts of Norway, Sweden and Finland, and much of the Kola Peninsula of the Russian Federation, for traditional reindeer herding.

> **"The temperatures in the Arctic continue to rise at three times the global annual average**

In this northernmost corner of Europe, there are no forests — only dwarf birches and dwarf shrubs on gently rolling hills. In winter, everything is covered with snow and ice. In summer, the reindeer escape the mosquitoes by going to the Kalkujärvi area, as do the reindeer herders. There are approximately 60 herders around Kalkujärvi. The overall Sámi population across the borders is estimated to number between 50,000-100,000, some 10 per cent of whom work in reindeer husbandry.

In these open, mountainous fell areas, the traditional way of following the annual cycle of the reindeer is still practised: the animals follow their biological needs and migrate to optimal grazing land; and in turn, the herders follow the animals. Today, herders balance tradition with modernity, utilizing tools like GPS tags to



Detail from Historjà *(2003–2007), a 24-metre embroidery by Swedish Sámi artist Britta Marakatt-Labba, depicting Sámi myths, history, and daily life.*

Historjà, Britta Marakatt-Labba, 2007. © Britta Marakatt-Labba / KORO / BONO. Photo: © Annar Bjørgli / Nasjonalmuseet

◥ *Detail from the* Historjà *embroidery.*

follow the reindeer, and snowmobiles for herding.

The vanishing palsa

But as the temperatures in the Arctic continue to rise at three times the global annual average, pasture conditions are changing fast.

"Permafrost keeps the soil wet so that lichen, reindeer's main food in summer, grows also during hot summer months. Now these kinds of places are dry. In addition to lichen, also the number of cloudberries, that some call the national berry of the Sámi, has decreased", says Klemetti Näkkäläjärvi, who lives in a small village of Vuontisjärvi, 30 kilometres as the crow flies from Kalkujärvi, which is his family's traditional herding land. He is both a member of the Sámi reindeer herding family and a researcher whose interests include climate change and the protection of the traditional knowledge of the Sámi.

Born in the 1960s, he recalls that when he was a child, there was a palsa bog in Kalkujärvi — a peatland with a permanently frozen soil core that creates steep slopes that rise above the surface. Today the permafrost has melted and the palsa bog is gone, leaving behind flat ground. Such transformation also disrupts the customary routes; traditionally, those higher points on the landscape are used for navigating, but here they have disappeared.

More than 400 words for snow

Members of the Sámi community know how the nature-based system between reindeer, humans, and the environment works. Although this traditional knowledge is not easily quantifiable by the standards of Western science, it's evoking a growing interest within the scientific community.

For instance, researchers have used the Sámi knowledge to study what is maybe the most famous indicator of the Arctic: snow. The Sámi language is probably the language with the richest terminology to describe it. During his long career, Näkkäläjärvi has interviewed →

Historjà, Britta Marakatt-Labba, 2007. © Britta Marakatt-Labba / KORO / BONO. Photo: © Annar Bjørgli / Nasjonalmuseet

approximately 150 Sámi people in Finland, Sweden, Norway and Russia. He has listed around 400 Sámi words for snow, and if you include the words that are related to water and ice, the number grows to 560. The amount is remarkably more than what science uses.

Deep snow, for instance, has 21 meanings in Sámi languages. However, due to climate change, some of the words describing snow conditions in the spring or autumn have become obsolete. "The words are vanishing simultaneously with the forms of deep snow," Näkkäläjärvi says.

Deep knowledge

Simply adapting the vocabulary is not enough. "The words are always made for something. The Sámi created them for a purpose," Näkkäläjärvi says, arguing that traditional snow concepts also contain information on practical matters such as grazing conditions and weather. "Natural scientific knowledge cannot access the deep knowledge of cultural lifestyle," he adds.

He believes that traditional Sámi snow knowledge is a key factor in understanding future changes in the Arctic. Scientists can combine this knowledge with the experiments and models they have employed to predict future changes. For example, in early winter, when snow or rain falls on warm soil and temperatures rapidly change, the soil gets an impervious ice layer. This freeze-thaw cycle prevents the reindeer from digging lichen. The multiple nuances of Sámi vocabulary can be useful in monitoring and understanding such developments.

> "Sámi knowledge is key to understanding future changes in the Arctic

Long-time observations

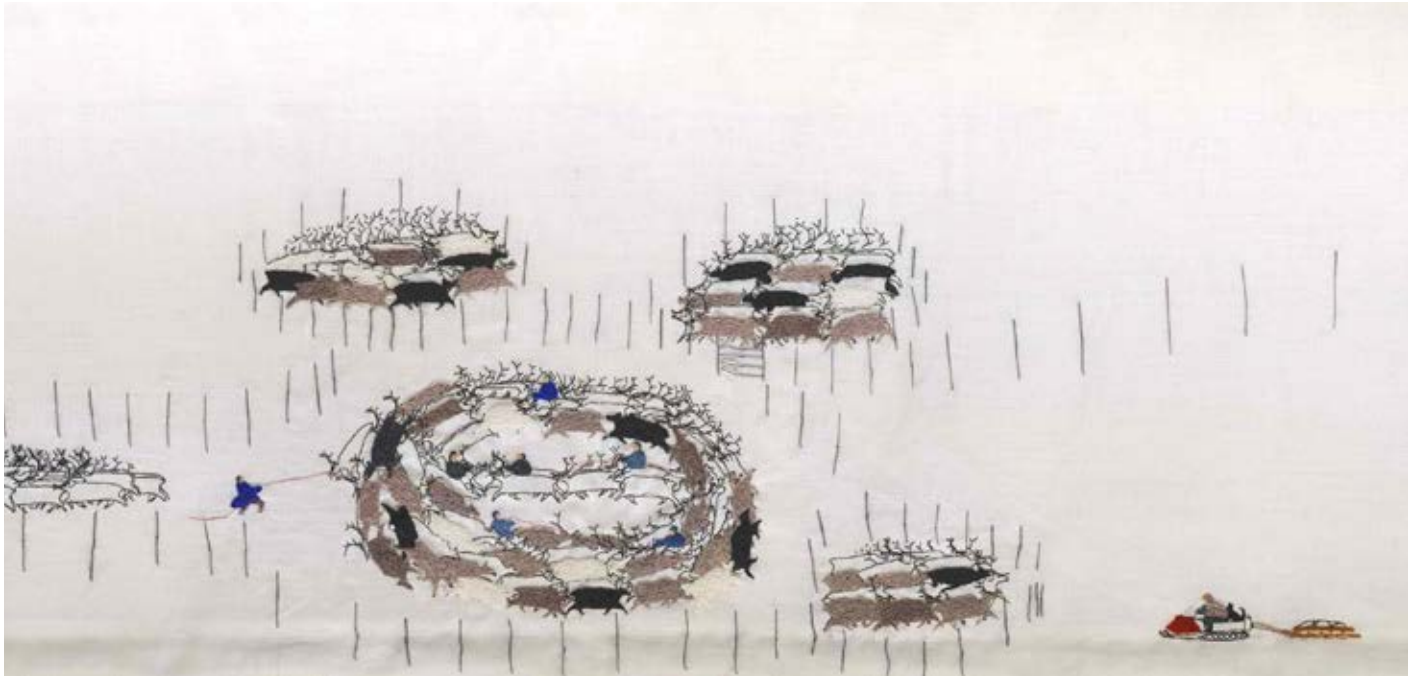
Adaptation to climate change is not just a question of transforming Indigenous knowledge into scientific language. To make the science relevant, it needs to be acted upon. This extends the knowledge question to where the decisions are made.

This is something that interests another Enontekiö-based researcher and a member of a Sámi reindeer herder family, Anne-Maria Magga. Recently, her focus has been on the *siida* laws. *Siida* is a traditional organization of several herders whose reindeer graze together. The *siida* laws provide a concrete framework for community life, covering everything from the ethical treatment of reindeer to proprietary rights. They are transmitted orally and maintained through the daily practice of herding work.

According to Magga, *siida* rules are still in use in Sámi areas of Finland, Sweden and Norway. In the Kalkujärvi area they are in use in parallel with reindeer herding laws set by the national government. She believes that Sámi laws and governance are effective for governing local ecosystems. "Traditional knowledge results from long-term observations. It's developed so that it could be used for governing the land."

Due to various land-use projects, commercial forestry, wind power mills, the mining industry and expanding tourism, the Sámi area is under growing land-use pressure. The effects have already degraded the pasture areas. Splitting the area further may prevent the reindeer from following their traditional, annual cycle.

These changes can have far-reaching consequences. For Anne-Maria Magga and Klemetti Näkkäläjärvi, both academics from traditional Sámi families, the deterioration of traditional knowledge risks undermining the very foundation of a sustainable future of the Sámi area.



Historjà, Britta Marakatt-Labba, 2007. © Britta Marakatt-Labba / KORO / BONO. Photo: © Annar Bjørgli / Nasjonalmuseet

Detail from the Historjà *embroidery.*

Ora Marek-Martinez

Archaeologist and co-lead of the Southwest Hub (Northern Arizona University) of the Center for Braiding Indigenous Knowledges and Science (CBIKS), United States

Interview by
Katerina Markelova

UNESCO

Ora Marek-Martinez: "Our knowledge has long been regarded as folklore"

As an archaeologist from the Navajo Native American community, Ora Marek-Martinez argues that research requires a fundamental paradigm shift — one that centres on close collaboration with Indigenous Peoples.

As an archaeologist of Navajo descent, how do you reconcile Indigenous knowledge with the scientific approach?

In many ways, it is exactly like a braid: three strands woven together. The first strand is the recognition of thousands of years of observational data and relational knowledge tied to our homelands. The second involves bringing this localized knowledge into dialogue with scientific knowledge. And the third strand is the space where scientists and Indigenous knowledge holders work together.

The most important aspect of this "braiding" is establishing relationality. As Navajo, we understand ourselves as the five finger Earth surface people, meaning we are all connected. Our homelands give us our language, identity, and cultural practices. In return, we have a responsibility to care for them.

As Indigenous scientists trained within Western academic institutions, our role is to help the next generation learn how to braid these two knowledge systems in ways that honor and protect the integrity of both.

The third strand of the braid is a co-created space. This is where researchers and knowledge holders come together to establish research protocols, ethics, and shared values. Relationality is essential here. It may require researchers to step outside their institutions and spend time with community members. Doing so allows for a deeper appreciation of what is happening on the ground, while also giving scientists space to explain their disciplines. The idea is that research benefits both the community and the scholarly world.

How do you define the "indigenization of science"?

For many of us it begins with reclaiming knowledge that has long been regarded as myth or folklore. Today, Indigenous scholars are bringing our knowledge systems and research methods into academic spaces, and that is opening up powerful opportunities to rethink long-held theories about who we are.

In archaeology, for example, the discovery of ancient footprints in White Sands National Park (New Mexico, United States) in 2021 pushed the human presence in North America back to around 23,000 years ago — significantly earlier than one of the most widely cited earlier reference points: the Ancient One or Kennewick Man, discovered in 1996 and dated to between 8,400 and 8,690 years ago.

Here in the Southwest, many archaeological sites were first identified with the help of Navajo guides. Some of the deepest insights come from people without formal academic credentials. For me, that is the future of archaeology, and of many disciplines: a form of convergence that moves beyond the ivory tower and becomes a collaborative, community-engaged science.

The key principle of indigenization is simple: "nothing about us without us". In the United States today, research mandates require that tribal nations approve any work conducted within the boundaries of their reservations.

Over a long period, thousands of anthropologists and archaeologists descended on tribal lands, excavating artefacts and ancestors. This practice was considered acceptable until 1990, when the Native American Graves Protection and Repatriation Act (NAGPRA) made it illegal. Yet even today, when ancestral remains are discovered, they are often sent directly to Western research institutions. Tribal nations must then request repatriation.

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> **"Today, Indigenous scholars are bringing our knowledge systems and research methods into academic spaces**

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The decade of Indigenous languages

UNESCO is the lead agency for the implementation of the International Decade of Indigenous Languages (2022-2032), a global initiative aimed at drawing attention to the disappearance of many Indigenous languages and mobilizing support for their preservation, revitalization and promotion.

It is globally estimated that Indigenous Peoples speak more than 4,000 of the world's approximately 7,000 languages. Yet, around the world, languages are disappearing at an alarming rate, and a significant number of them are Indigenous. This also threatens the deeply rooted knowledge systems inextricably linked to language.

At the policy level, the decade convenes a wide range of stakeholders to align their efforts, accelerate development plans, make strategic investments, set research and legislative agendas, and launch concrete initiatives. Since its launch, a multitude of events and initiatives have focused on areas such as digital empowerment, language preservation and transmission, and raising public awareness.

Part of this long-standing mindset was an effort to determine "who was here before Native Americans," based on the assumption that Native peoples were not advanced enough to have created sites such as Cahokia Mounds in Missouri, Mesa Verde in Colorado, or Chaco Canyon in New Mexico.

A crucial step, then, is acknowledging these historical biases. It means exposing the deep-seated colonial tendencies that still exist in Western academic institutions.

What can be done to build trust among indigenous communities?

Researchers first need to acknowledge that they don't know what Indigenous nations need. Starting with an open conversation about what the researcher hopes to achieve and how they can contribute to the community is absolutely essential. This is precisely what we aim to teach our students

It's a paradigm shift in research. Co-creating research agendas ensures that Indigenous communities' priorities and needs are at the center. That, in turn, is one of the first steps in building genuine trust. For me, the research process is deeply ceremonial. You enter the community as a stranger, and you leave as a relative. In this way, research becomes a transformational space, one that fosters deeper understanding of the phenomena being studied.

Has your identity as an Indigenous woman shaped the way you practice archaeology?

I am a citizen of the Navajo Nation, primarily in Arizona, and a member of the Mountain Cove Clan. My father was a citizen of the Nez Percé tribe of Idaho, where I was born and raised. I grew up on the reservation, a place shaped by the displacement of Native Americans from their homelands.

Becoming an archaeologist required a difficult reconciliation for many of my Navajo relatives. Because the work that you do as an archaeologist is similar to the work that Hataałii, our sacred people, do.

I was raised by my father, who helped people pass. He sang songs and prayed, and he taught me these practices. Entering Navajo culture, where women carry distinct responsibilities connected to childbearing, sometimes left me navigating a conflicted space.

Over time, as I demonstrated who I was and the skills I carried, I received support from the Navajo community. I was welcomed into ceremonies and gifted stories, songs, and rituals for caring for our ancestors. From that point on, I viewed archaeology as ceremonial-sacred work.

What was Indigenous archaeology like when you first started in the late 1990s?

When I started, there were very few Indigenous people in the field. Even today, fewer than one per cent of all Ph.D.s in the United States are held by Indigenous scholars. As a student trying to find my own path, I felt the weight of a colonial legacy when I suggested incorporating oral histories and other forms of Indigenous knowledge into research. My ideas were often ridiculed and critiqued. It took a great deal of courage as a young woman to continue.

Navajo guide Markus Buck presents the "Big Kachina Panel," a rock face in Bears Ears National Monument on the Colorado Plateau (Utah) decorated with petroglyphs that are famous for their large, broad-shouldered anthropomorphic figures.

What projects does the Center for Braiding Indigenous Knowledges and Science lead?

We're leading an Indigenous Research Foundations project, working with the 13 tribal nations affiliated with the San Francisco Peaks to develop research paradigms and agendas focused on climate and the protection of sacred and heritage sites and food systems. Our goal is to prepare both researchers and tribal nations to collaborate from the ground up, because this kind of work has never been done before.

We're also creating opportunities for tribal nations to establish intellectual property agreements, ensuring they maintain data sovereignty and can use the information in ways that benefit their communities and homelands.

> **"Our goal is to prepare both researchers and tribal nations to collaborate**

We've shared findings through many channels including theatre, comic books, and podcasts, trying to meet communities where they are.

Through these projects, we hope to inspire other initiatives of this kind. Ultimately, what's at stake is not just one community, but all of us as five finger Earth surface people — as human beings — our shared responsibility to future generations and the lands we inhabit. Our hope is to advance a broad paradigmatic shift that influences Western science, research practices, and the ways we are taught. ■

Exile through a child's eyes

Down a little lane in Mardin, south-east Türkiye, a few kilometres from the Syrian border, are the modest premises of Fotohane DARKROOM, "the house of photography" in Arabic, Kurdish, Persian and Turkish. Plunged in semi-darkness, young people watch as shadowy shapes slowly emerge on photo paper: silhouettes of friends, street corners, odd fragments of a daily life that has become theirs since arriving from Syria or Iraq.

Created in 2024 by Syrian photographer Serbest Salih and Turkish photographer Amar Kılıç, Fotohane DARKROOM is a non-profit project that teaches photography to children and young people aged 8 to 15 who have experienced war and exile. In these six- to eight-week workshops, they learn how to load film, compose a shot and develop prints. Above all, they learn to tell their stories, to use images to express what is sometimes difficult to put into words, and to share their experiences with others.

In one year, 126 children have joined in this adventure, and their images have already travelled from London to Toronto, from Athens to Chennai. Everywhere, we find the same fresh energy, a new look at life, told from a child's point of view. Fotohane's strength lies in its simplicity: a darkroom, a few cameras and the conviction that art can help repair what violence has broken. Serbest Salih says he never ceases to be touched by the children's wonder when they see an image appear in the developing tray, as if by magic. A fragile, but essential magic. ■

Photos: **Fotohane DARKROOM**

Text: **Katerina Markelova**
UNESCO

Emir, 12 years old.

Mahmut, 9 years old.

Yusuf, 10 years old.

Said, 11 years old.

Samet, 13 years old.

Elif, 13 years old.

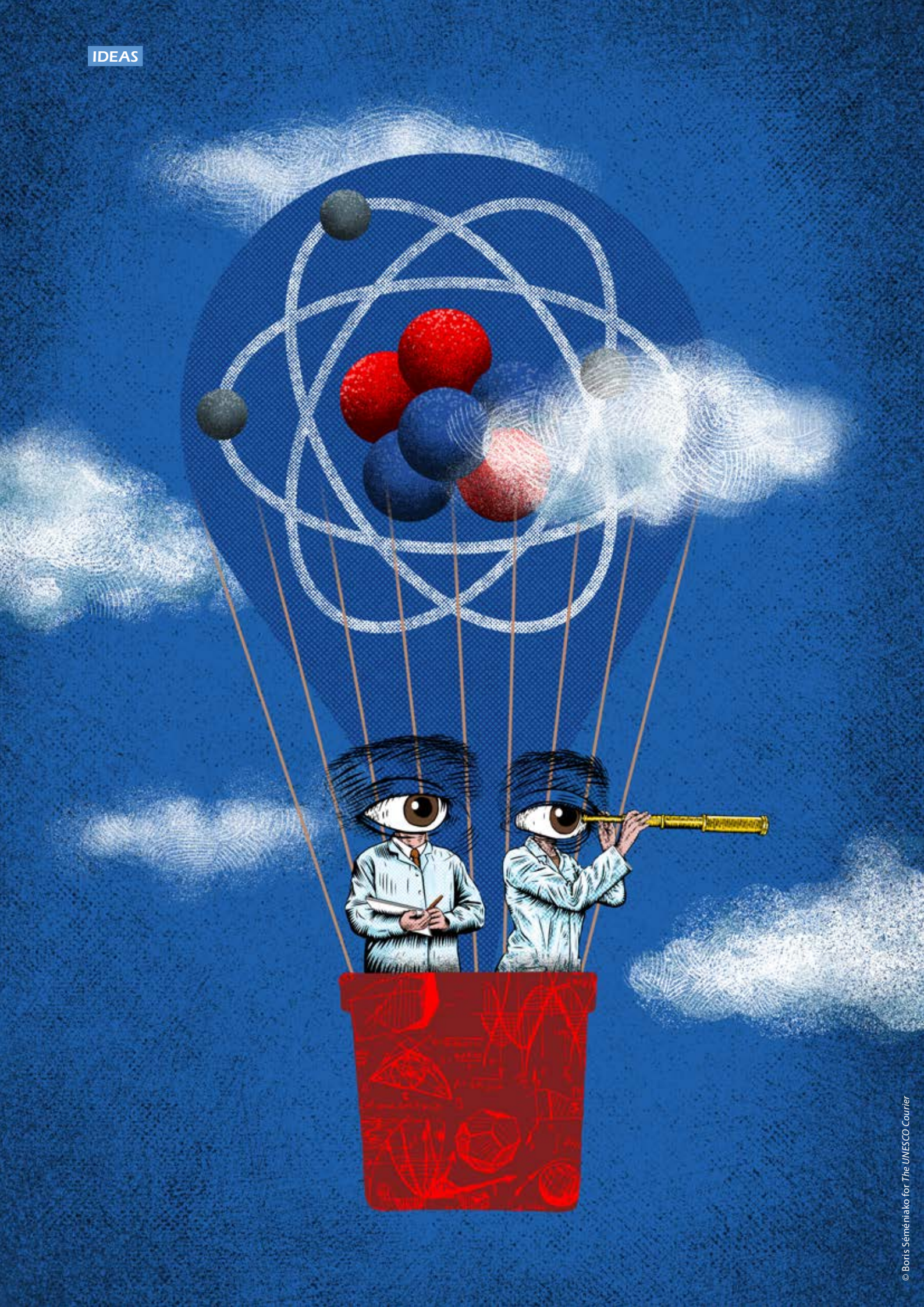
Asenet, 8 years old.

Enes, 12 years old.

Emir, 13 years old.

Berfin, 9 years old.

Ilknur, 7 years old.



Jim Al-Khalili

Iraqi-born British quantum physicist and science popularizer, he is Distinguished Professor Emeritus at the University of Surrey (United Kingdom) and a Fellow of the Royal Society.

Welcome to the second quantum revolution

It was precisely a century ago that quantum mechanics triggered a profound shift in our understanding of reality. Today, the tangible applications of quantum physics surround us, from microprocessors to GPS to lasers. New breakthroughs promise to fundamentally change our lives through exponentially powerful computers, truly unbreakable communication, and revolutionary sensors.

This year we are celebrating the centenary of the birth of quantum mechanics — a theory that, more than any other scientific idea in history, has changed and shaped our world. It was in 1925 that two of its founders, Erwin Schrödinger, an Austrian-Irish physicist, and Werner Heisenberg, a German physicist, separately came up with different mathematical formulations that describe the quantum realm and which therefore underlie much of modern physics, chemistry, and potentially even biology.

The quantum world is fuzzy and ephemeral, utterly different from the solid certainty of the everyday world of our senses. Scientists describe a world that is based on chance and probability, a world where nothing is certain until we measure it and where quantum entities can perform outlandish tricks when our backs are turned. But despite all this weirdness, the rules of quantum mechanics are now firmly established and have enabled us to develop remarkable technologies that we take for granted today. These technologies are part of what is referred to as the first quantum revolution.

From transistors to laser

One of the early quantum inventions was the transistor, an electronic component based on the quantum properties of semiconductors, which controls the flow of tiny electrical currents. The transistor led to the development of modern electronics and the integrated circuit, then the microchip and the microprocessors that drive modern computers and smartphones.

The mid-20th century saw the invention of a whole host of new technologies, from atomic clocks, which are central to GPS, to LEDs, and laser and nuclear magnetic resonance imaging. The laser alone has transformed the world in quite unexpected ways. Today, lasers can be found everywhere, from supermarket checkout scanners to systems used in medicine, industry, entertainment, scientific research, telecommunication, printing, imaging, and data recording. They are also fundamental to the high-capacity optical fibres that power the internet. Laser light travelling through these fibres enables high-speed, long-distance data transfer and global connectivity in many telecommunication systems.

We are now witnessing the birth of a second quantum revolution, one that makes use of some of the even more mysterious features of the subatomic world. Quantum particles can exist in what is called a "quantum superposition" of →

> **"The quantum world is utterly different from the solid certainty of the everyday world of our senses**

The 2025 international year of quantum

To mark the centennial of quantum mechanics, the United Nations declared 2025 the International Year of Quantum Science and Technology. As the lead agency of the initiative, UNESCO inaugurated the year-long initiative in Paris on 4 and 5 February, attracting over 1,200 participants, including several Nobel Prize laureates.

Throughout the year, scientists, educators, and citizens worldwide were invited to explore and celebrate quantum innovations. Global events elevated public awareness and fostered collaboration, highlighting quantum science's potential for sustainable solutions. UNESCO spearheaded efforts for inclusive development and universal access to quantum science's benefits. Focus areas included building capacity in the Global South, advancing gender equality in science, technology, engineering and mathematics (STEM), and tackling the growing quantum divide.

having a range of values simultaneously, such as being spread out in space or spinning in two directions at once. Only when we choose to measure them do we force them to decide on one of the many options in which they were co-existing. When two or more particles join forces they can become quantum "entangled".

> **"In the quantum realm, everything is constantly getting entangled and unentangled with everything else, all the time**

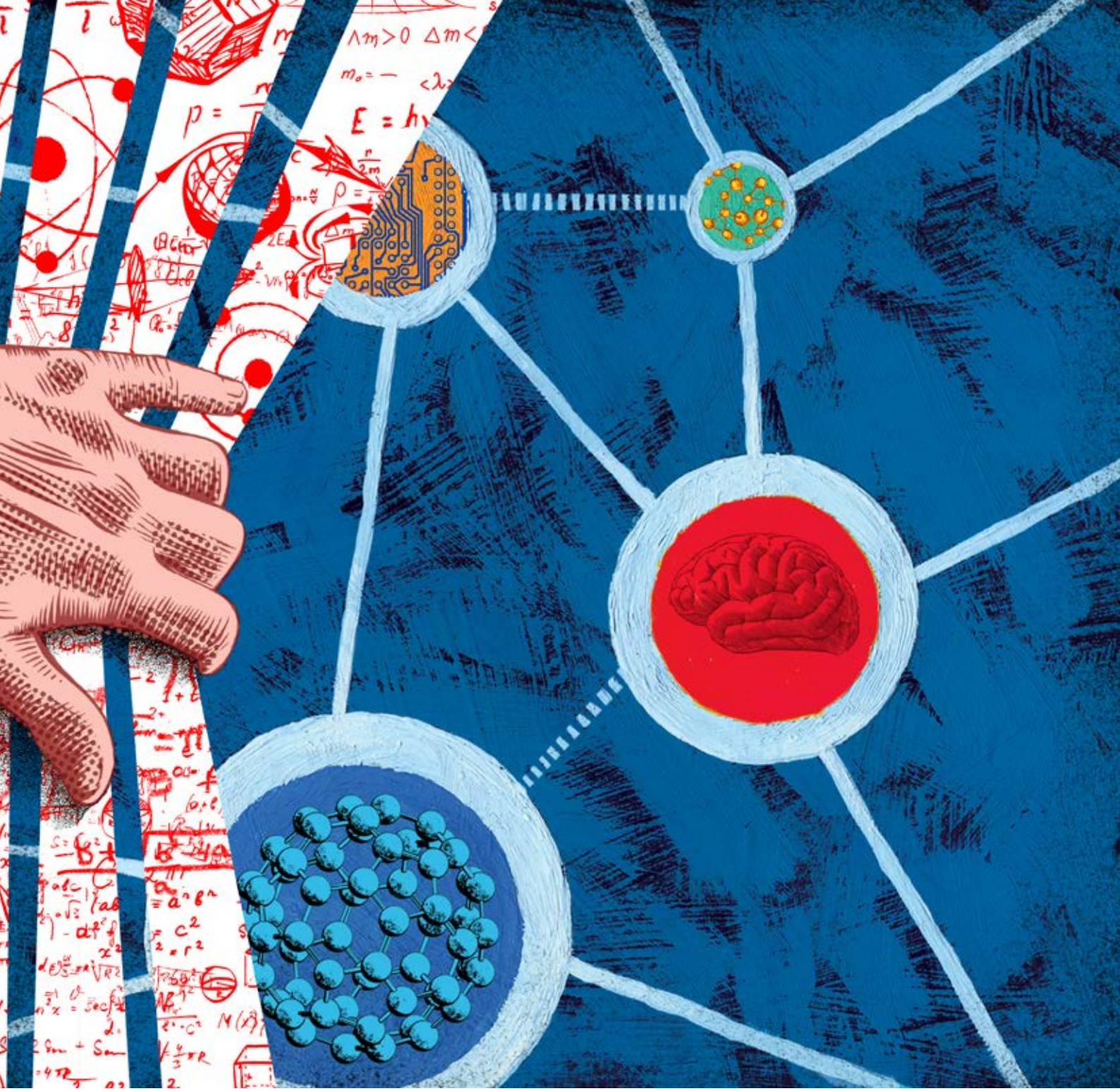
This quantum entanglement is far from being a novel phenomenon that only happens rarely in nature, nor is it restricted to a "spooky" telepathic connection between two separated particles. Rather, it is one of the most, if not *the* most, prevalent process in the entire Universe. Everything everywhere down in the quantum realm is constantly getting entangled and unentangled with everything else, all the time. The new quantum revolution, which involves technologies that make direct use of quantum superposition and entanglement, is already well underway and will without doubt transform our world.

Sensors reading our thoughts

One such technology is quantum sensing. We now have quantum devices that can sense changes in Earth's gravity to one part in a billion and which can help in studying the Earth's climate as well as having many practical uses in the construction industry. Quantum sensors are even being developed to hunt for dark matter, the illusive invisible substance that holds galaxies together.

There are even quantum sensors that can read your thoughts. A special brain scanner that can be worn like a cycle helmet is so sensitive it can detect the electrical firing of individual neurons inside a patient's brain, enabling researchers to "see" brain processes in real time. This device is already proving useful in analyzing a range of neurological disorders such as autism, epilepsy, dementia, and schizophrenia and is far less intrusive than other established imaging techniques like functional MRI where the patient has to lie very still for a lengthy period inside a noisy, claustrophobic machine.

Another exciting medical application of quantum sensors is the entanglement camera, which is being used to image tissue samples in breast cancer. The science behind it sounds almost like magic. It relies on quantum entanglement of two kinds of light: infrared light, which is very good for bio-imaging and can penetrate inside tissue easily, and visible light, which goes nowhere near the tissue but can produce sharper images in a camera. This technology



gives us information about the tissue sample probed by the infrared light. The entanglement camera can be used to guide oncologists rapidly as to whether a woman should be advised to have chemotherapy after surgery for breast cancer.

The quantum computer is coming

There has been a lot of hype surrounding the various breakthroughs in quantum computer technology, with rival companies eager to announce incremental advances as *the* holy grail. The much heralded quantum computer would be able to perform certain mathematical tasks in mere minutes or seconds that even our most powerful supercomputers today would struggle to complete if left to try for a billion years.

The truth is that a fully working quantum computer is still a decade or two away. But when it arrives it will be able to solve a number of problems beyond the reach of computers today, such as the discovery of new drugs, the design of better batteries and solar panels, improved climate modelling, solving complex optimization problems in logistics, modelling financial data and improving security, advancing physics and chemistry research — the list goes on. In addition, linking quantum computers together on a global scale would create a quantum internet that could mean more secure financial transactions and voting systems safe from tampering.

The first quantum revolution changed our world. The second one promises to be just as spectacular. ■

Interview by
Laetitia Kaci

UNESCO

Chimamanda Ngozi Adichie: "Fiction is humanity's last collective frontier in honest storytelling"

Nigerian writer Chimamanda Ngozi Adichie has become one of the most influential voices of her generation. Throughout her work, from the novels *Purple Hibiscus* and *Americanah* to the feminist manifesto *Dear Ijeawele*, she employs her sharp pen to explore themes of interracial relationships, rootlessness, ambition, and the role of women. Blending intimate experience with a critical view of society, she reflects on her writing journey while reaffirming the power of literature in making sense of the world.

You first studied medicine. When did you come to realize that you were meant to tell stories?

I always knew. I don't remember a time when I did not know that I wanted to tell stories. I started writing when I was five years old. The reason that I thought I should study medicine was because everyone expected it of me. I did well in school and when you do well in school, they tell you that you should be a doctor. But I quickly realized it was the wrong path for me. I always knew that I had a gift for storytelling. I think this is a gift that my ancestors gave me.

You live between the United States and Nigeria. How does this dual anchoring influence your way of writing?

It helps me see clearly and gives me perspective. When I'm in the United States, I sometimes see the contradictions in Nigerian society more clearly, and vice versa. This critical distance gives me a double perspective and helps me understand both worlds better.

In a popular TED Talk from 2009 you warned against the African reality being reduced to a "single story". Do you feel that this perception has shifted?

Yes, a little bit. Some stories are being told differently now. This is partly because people who tell stories of Africa now know their audience isn't only Western; Africans also listen, read, and react. Social media has contributed greatly to this change, which I think is actually one of the good things that it has brought to the world. These young Africans — whether they are Nigerians, South Africans, or Zimbabweans — will challenge the representations if they seem incorrect to them. But Africa remains the least →

understood continent by Westerners. There's still a long way to go.

You have written poetry, plays, novels, and short stories… what determines your choice of form?

I don't have a formula. It's more intuitive than anything else, it's almost spiritual. A story comes to me and somehow, I just know that it's a short story and other times I know that it needs a much larger canvas to be told. I like to say that my creative spirit speaks to me.

In a world dominated by immediacy and overabundance of information, what place is left for fiction?

Fiction plays an even greater role now, a role that has become even more urgent and necessary because of the times we live in. I think of fiction as humanity's last collective frontier in honest storytelling.

Today, there's an increasing distrust of journalism. So much in journalism has become contested — its objectivity and the truthfulness of its facts. This is worrying, but unfortunately, that is the reality. In this context, there is a greater likelihood that people will trust fiction, because it doesn't start out in a political context or pretend to be solely factual.

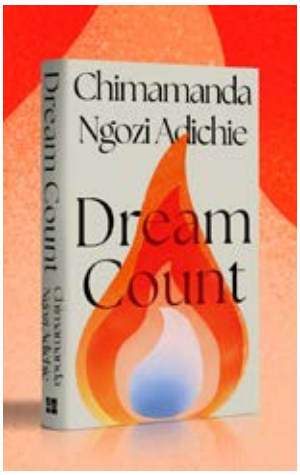
> **"Fiction has a unique power to take us into the lives of other people**

One of fiction's most powerful qualities is its capacity to move us. Where journalism tells us what happened, fiction tells us how it felt. And as human beings, we are most moved when our emotions are engaged with a story.

Fiction also has a unique power to take us into the lives and motivations of other people. It can help us understand those who are different from us. In a world where violence and conflict are becoming the norm, fiction has a role to play in bringing people together.

Dream Count*, your latest novel, follows the lives of three women shaped by love, loss, identity, and resilience. What made you come back to long format fiction with this story?*

Long-form fiction is the most comfortable form of storytelling for me. But I went through a period of creative dry spell and I couldn't write. So, I had *Dream Count* in my head for many years before I could write it.



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To what extent are your characters and storytelling influenced by real events?

A lot of my work is based on reality. I'm always watching. I'm always listening. I'm always taking notes. Some of those notes are about the lives of others, and some are about my own. The characters derive from all kinds of sources.

In *Dream Count,* Kadjatou is the only character directly inspired by a real person. The other three are a mélange of observations, encounters, and shared or personal experiences.

One of the loveliest things that I often hear from my readers is that they recognize themselves in the characters. I think that's because they're grounded in the reality of people's lives.

Dear Ijeawele *is a manifesto-letter addressed to a friend who asked for your advice on how to raise her daughter according to feminist principles. How should we teach feminism to girls — and also to boys — today?*

I wouldn't change much of the content in this book. I still think it's important for girls to be taught very early that they should not apologize for being who they are. They should not apologize for taking up space or having opinions. They don't have to change themselves in order to be likeable; they deserve to be liked as they are.

If I were to write that with boys in mind, I would start by emphasizing how important it is to be able to talk about emotions. Many boys are not encouraged or taught to do so. I believe it is really important to tell them that fear, for example, is a normal human emotion and that masculinity is not about being fearless. Being a man should not mean being unable to express your vulnerabilities. And yet, in so many cultures around the world, this idea is perpetuated, which I think is very damaging.

It's also important to teach boys that girls are their human equals. To teach boys that they do not have entitlement to a girl. They do not have entitlement to the bodies or the emotions of girls. This responsibility to educate them falls to adults. Sometimes I think we could have done better.

Nigeria is known for its remarkably vibrant literature scene thanks to writers like Chinua Achebe, or the Nobel Literature Prize winner Wole Soyinka. What explains this literary fertility?

We are just wonderful; there's magic in the water that we drink [laughs].

But really, I think that there's a wonderful storytelling tradition in so many African cultures. And because Nigeria is Africa's most populated country, it's not surprising that we have many more accomplished writers. So above all, I believe this fertility stems from an ancient African tradition of storytelling, in all its different ways.

All cultures tell stories. It is part of what keeps them together, a way to transmit their culture to the next generation. But I think that there's something particularly

Chimamanda Ngozi Adichie receiving the Everett M. Rogers Award at the University of Southern California (United States), 2019.

powerful about the African storytelling tradition, and all Nigerians benefit from it.

Speaking of which, you recently gave a speech in Enugu, your birth city, during the* Things Fall Apart *festival dedicated to the seminal work of Chinua Achebe.

It felt both creatively and emotionally satisfying to be back in this place that formed me. Everything that I am today, I owe to how and where I grew up, and the values I was raised with.

The festival, organized by the Center for Memories, was wonderful. I loved this idea of not just celebrating the novel, but also of reenacting its world: they had reconstructed the village, the warriors, and even the characters in the novel. I found that really moving and powerful.

Things Fall Apart is a novel that resonated so deeply, not just for Nigerians or Igbo people, but for all Africans. By challenging a global representation of Africans, he did something important and powerful that is still relevant today.

> **Girls should be taught very early that they don't have to change themselves to be likeable**

My keynote speech was about Igbo people. It was a call for renewal: to look to the past to guide us into the future. We are facing many issues today and if there isn't any renewal, then it's going to be dangerous for our future.

There are things going on in the world that I'm worried about, but I also see reasons to be optimistic. It was important to me to give people a sense of hope that we can — and we should — be better.

Do you believe that your literary work reflects this message of hope?

I think so. I generally don't like to be my own critic, but I know there's a connection: although the part of me that writes literature is different from the part that gives keynote speeches and talks about feminism, they share a common foundation.

My sense is that my literature reflects my worldview, one with justice at its centre. It's a worldview in which it's very important to have a fairer, more just world and to speak honestly about things. I believe in the virtues of multiculturalism — that people can be different and still live together in peace. So, this is the foundation of my thinking, and I trust that it comes through in my creative work. ■

Anuliina Savolainen
UNESCO

Africa's book industry:
a new page is turning

A sector brimming with untapped potential. This is the conclusion of *The African Book Industry: Trends, Challenges & Opportunities for Growth* (2025), the first-ever comprehensive mapping of the continent's book industry. The UNESCO publication explores how Africa's rich storytelling history, its vibrant literary culture and thirst for learning can be transformed into a flourishing publishing sector.

BOUNDLESS POTENTIAL

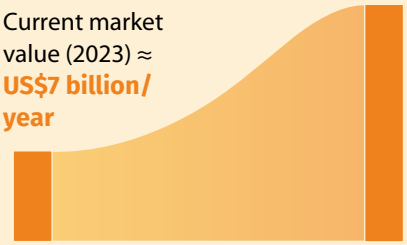
A continent of **1.44 billion people,** Africa accounted for

of the global publishing market in 2023.

MARKET VALUE

Potential value up to **US$18.5 billion/year**

Current market value (2023) ≈ **US$7 billion/year**



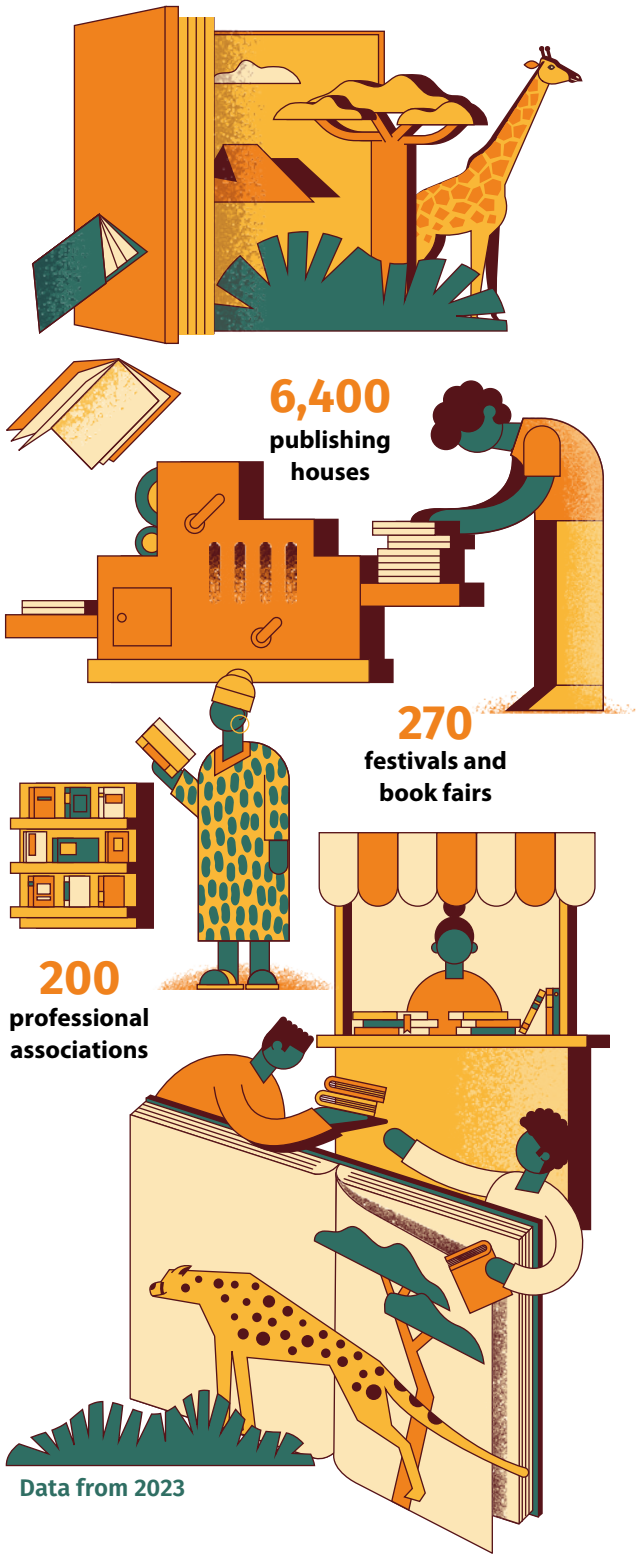
EDUCATIONAL PUBLISHING

of the market

Potential to reach **US$13 billion/year**

A vibrant literary landscape:

86,000
titles published per year



6,400
publishing houses

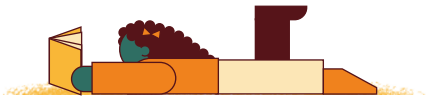
270
festivals and book fairs

200
professional associations

Data from 2023

A market in the making:

Global acclaim.
Example: in 2021, **the Nobel Prize, Prix Goncourt, and Booker Prize all went to African writers.**



Large youth population.
329 million students → expanding demand for textbooks.

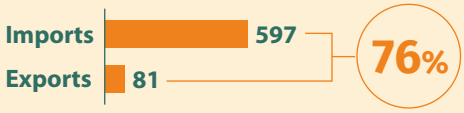
Digital momentum.
Rising demand for **e-books, audiobooks, and book-to-film adaptations.**

Inclusion.
Growing participation of **women.**

OVERCOMING THE OBSTACLES

RELIANCE ON FOREIGN PLAYERS

Book imports vs. exports in 2023.
(US$ million)



trade deficit

LINGUISTIC GAP

Fewer than 1/3 **of the titles** are in local or Indigenous languages.

Africa's 2,000 languages are overshadowed by English, French, and Portuguese.

LIMITED ACCESS TO BOOKS

1 bookstore — **116,000 people**

1 public library — **189,000 people**

INSTITUTIONAL ROADBLOCKS

90% **of the countries** lack book sector-specific **legislation.**

46% have **no national ISBN agency.**

61% do not have **dedicated institutions.**

NEED TO UPSKILL

Only 20% of countries **offer dedicated publishing qualifications.**

RECOMMENDATIONS

- **Strengthen** governance and legislation.
- **Invest** in local and regional markets & export.
- **Develop** professional and academic training.
- **Increase access** to books (libraries, bookstores, online) and promote reading.

Increase in jobs, market productivity, and publishing revenue.

A strong local market safeguarding Africa's cultural and linguistic diversity.

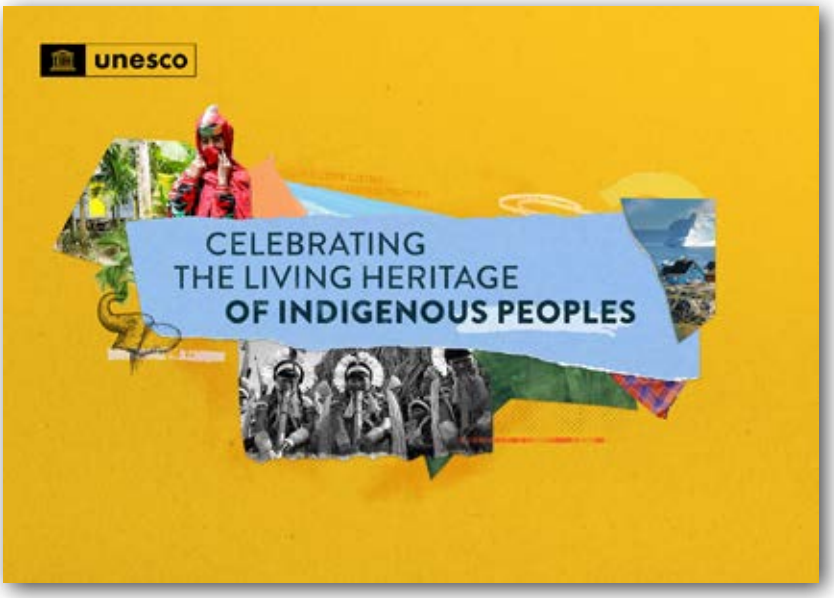
Celebrating the Living Heritage of Indigenous Peoples

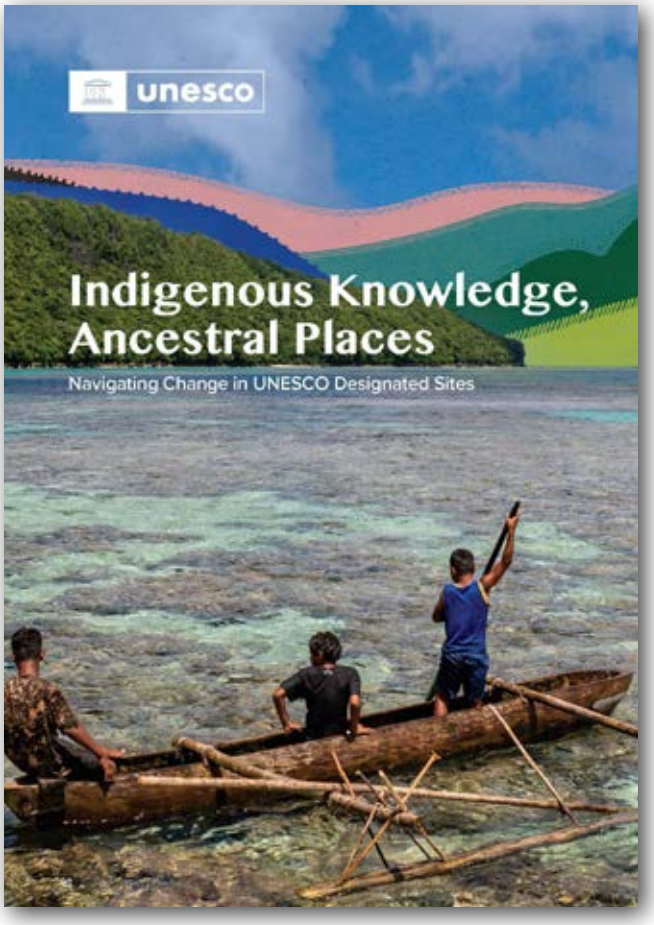
To read the publication

Indigenous Peoples represent a vital part of humanity's diversity, through their knowledge, ways of life, and languages — which make up more than 80 per cent of the world's recognized languages.

From the Caroline Islands to the Amazon and Greenland, the practices of the Aka, Garifuna, Inuit, Kalash, Maasai, Totonac peoples and many others, inscribed on UNESCO's Lists of Intangible Cultural Heritage, reveal an extraordinary cultural richness: sky-watching traditions, songs, dances, spiritual rituals… Let's celebrate this vibrant living heritage and realize a tomorrow where cultural expressions flourish everywhere.

UNESCO Publishing
ISBN 978-92-3-100688-3
142 pages, 300 x 210 mm, PDF





Indigenous Knowledge, Ancestral Places

Through their stories and ancestral knowledge, Indigenous Peoples remind us that protecting the Earth means protecting life. They carry a wisdom shaped by generations of observation. This publication amplifies their voices, from the untouched forests of the Amazon to the glaciers of the Arctic — a vibrant call to preserve the life that unites us all.

UNESCO Publishing
ISBN 978-92-3-100777-4
73 pages, 210 x 297 mm, PDF

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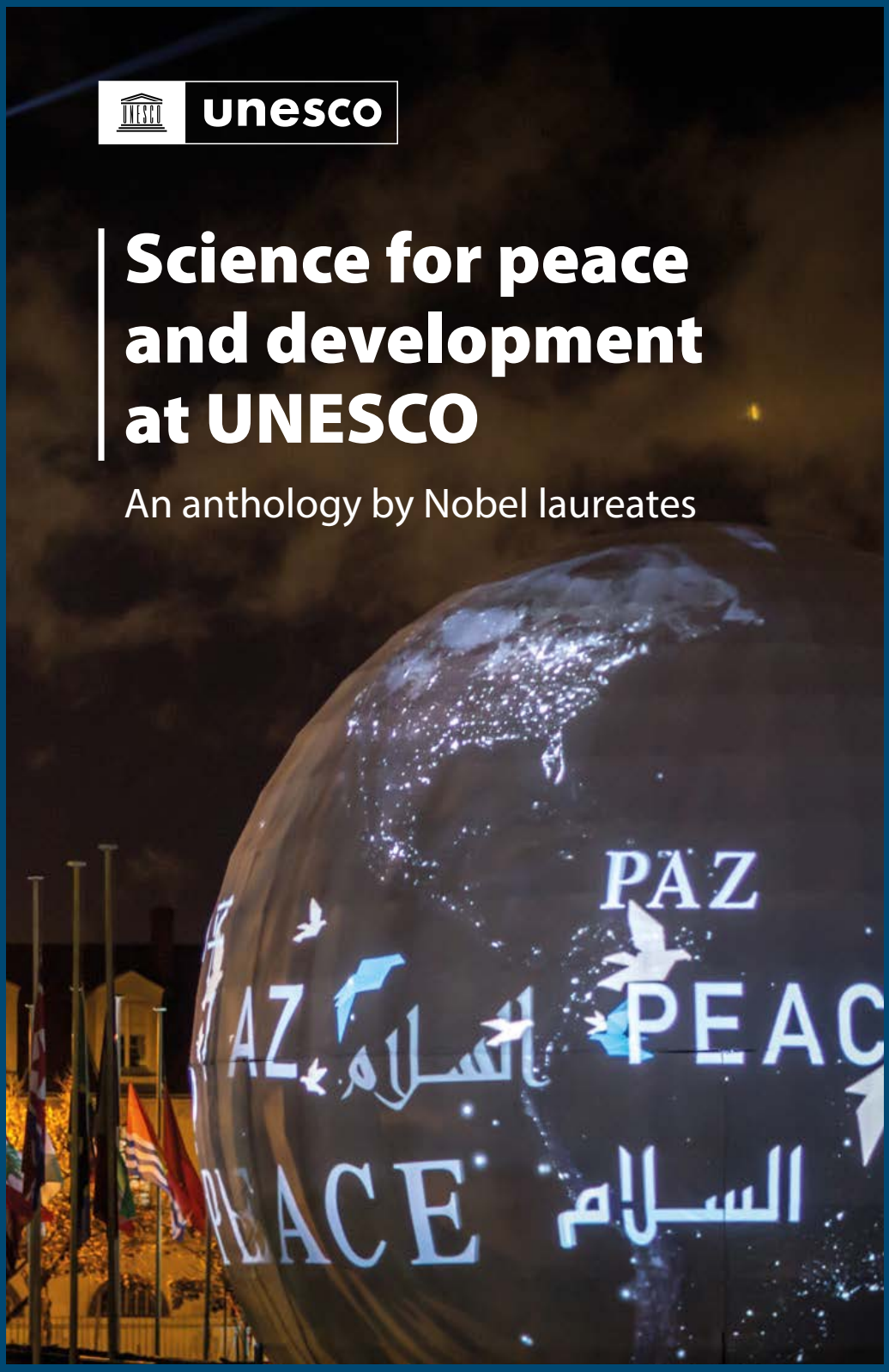
Science for peace and development at UNESCO

An anthology by Nobel laureates



Marking the 80th anniversary of the signing of UNESCO's Constitution, *Science for peace and development at UNESCO* brings together 46 essays by Nobel laureates, drawn from UNESCO's archives. Half of the texts come from *The UNESCO Courier*.

UNESCO Publishing
978-92-3-100805-4
448 pages, paperback, 2025

Read the publication