

## Anticipatory co-governance for human rights to sciences across knowledge systems

Rosemary Hill

**To cite this article:** Rosemary Hill (31 Oct 2023): Anticipatory co-governance for human rights to sciences across knowledge systems, The International Journal of Human Rights, DOI: [10.1080/13642987.2023.2273290](https://doi.org/10.1080/13642987.2023.2273290)

**To link to this article:** <https://doi.org/10.1080/13642987.2023.2273290>



© 2023 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



Published online: 31 Oct 2023.



Submit your article to this journal [↗](#)



View related articles [↗](#)



View Crossmark data [↗](#)

# Anticipatory co-governance for human rights to sciences across knowledge systems

Rosemary Hill<sup>a,b</sup>

<sup>a</sup>Division of Tropical Environments and Societies, James Cook University, Cairns, Australia; <sup>b</sup>Ro Hill Environmental Consulting, Cairns, Australia

## ABSTRACT

The interface between Indigenous and Western knowledge systems highlights the existence of diverse sciences, each with their own history, contexts and processes for validation, with relevance to the human rights to sciences (HRS). The lens of intersectional universality shows how Indigenous peoples differ in ways that affect the HRS, through: (1) holding unique connections to territories, distinct cultures, worldviews and knowledge systems; (2) experiencing dispossession of their lands, territories and resources leading to great disadvantage in socio-economic status; (3) bearing a disproportionately high impact from colonial scientific practices that breach human rights; and (4) utilising Indigenous governance systems based on customary institutions for decision-making. Human rights law requires that these institutions are consistent with principles of non-discrimination – the universal aspect. From this recognition of difference and sameness, we argue that diligent anticipation of risk needs to be based on recognition and support from states for the institutions that govern Indigenous sciences, redress by relevant scientific organisations for the negative impacts of colonial scientific practices, and capacity-building to overcome inequitable distribution of resources and power. Anticipatory co-governance with Indigenous peoples can empower Indigenous agency, Indigenous perspectives on human rights and provide a fertile ground for future thinking to diligently anticipate risks and benefits of science and scientific progress.

## ARTICLE HISTORY

Received 22 January 2023  
Accepted 13 October 2023

## KEYWORDS

Sciences; Indigenous; rights; culture; trust; co-governance; protocols

## Introduction to the anticipation of risk and benefit in the human rights to sciences

The United Nations' (UN) Universal Declaration of Human Rights (UDHR) and International Covenant on Economic, Social and Cultural Rights (ICESC) recognise the human rights to science (HRS). Article 15(1b) of the ICESC sets out everyone's right to enjoy the benefits of scientific progress and its applications. Current global circumstances highlight the potential benefits of science, including Western and Indigenous

**CONTACT** Rosemary Hill  rohill2421@gmail.com

© 2023 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group  
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

sciences, in understanding and responding to numerous global challenges that affect human health and wellbeing including climate change, pandemics and biodiversity loss.<sup>1</sup> On the other hand, the interface between Western scientific and Indigenous knowledge systems has often been characterised by grave human rights abuses, include living Indigenous people being collected and displayed in zoos, theft of human remains and cultural objects, and removal and exploitation of Indigenous knowledge of medicinal plants.<sup>2</sup> As a result of this context, Indigenous people encounter unique challenges in anticipating the benefits and risks associated with the HRS.

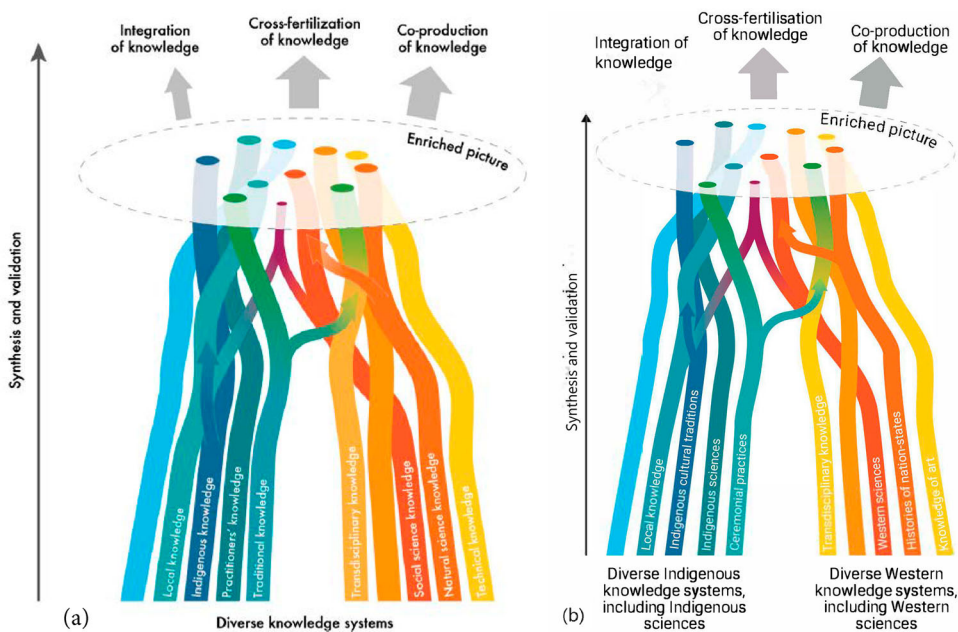
The aim of this article is to examine the content, scope and bearers of the various duties and responsibilities to diligently anticipate the potential risks and benefits of the HRS, taking account of the interface between Indigenous and Western knowledge systems. The term ‘Indigenous knowledge systems’ refers here to cumulative bodies of knowledge, practices and beliefs, evolving by adaptive processes and handed down and across generations by cultural transmission within diverse Indigenous societies.<sup>3</sup> ‘Western knowledge systems’ similarly refers to knowledge, practices and beliefs, arising in western European countries and consolidated in post-Renaissance Europe on the basis of wider and more ancient roots, and which have now spread across the globe.<sup>4</sup> I investigate this interface from the standpoint of a non-Indigenous environmental scientist who has worked at that interface for some decades [see Mclean et al.<sup>5</sup> for a useful discussion of positionality in this context]. My perspective aligns with Sen’s<sup>6</sup> position that human rights are pronouncements in social ethics, sustainable by open public reasoning, whether or not they are reflected in legislation or other normative formats. Public reasoning necessarily occurs across cultures, with diverse worldviews and perspectives about what constitutes human rights, and thereby across diverse knowledge systems – hence consideration of the interface between Indigenous and scientific knowledge systems is important.

States have duties under the UN frameworks to anticipate both the risks and the benefits of science and scientific progress. Here I argue that Indigenous peoples, now frequently recognised as First Nations although not nation-states, also hold duties to diligently anticipate the risks and benefits of science, internationally under the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). Care is required to understand how these duties and responsibilities arising from collective human rights under the UNDRIP can be structured and implemented in ways that are consistent with, rather than in conflict with, the HRS.<sup>7</sup> The article begins with a description of the interface between Indigenous and Western knowledge systems and sciences, followed by a discussion of how intersectional universality provides a means to identify difference/similarity and navigate potential conflicts between UNDRIP and the HRS. I then provide a brief overview of the impacts of human rights breaches by Western scientific practices on Indigenous peoples, and the beginning of initiatives by scientific organisations to provide redress, with some examples. I consider examples of benefits arising from Western science and technology (i.e. derivatives of scientific progress) for and with Indigenous peoples, and identify mechanisms and conditions that made this possible, including capacity building. The final section sets out how anticipatory co-governance at both national (domestic) and international levels can underpin pathways to diligent anticipation of the risks and benefits of science relevant to the HRS consistent with the UNDRIP, and is followed by concluding comments.

## The interface between Indigenous and Western knowledge systems and sciences

In 2020, guidance was published on working across Indigenous, local and scientific knowledge systems for assessments in the context of the global intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES).<sup>8</sup> This guidance built on conceptualisations of the value of a multiple evidence base (MEB), drawing together an enriched picture from knowledge systems based on distinctive world views.<sup>9</sup> Each knowledge system has its own history, context and methods for validation of knowledge claims<sup>10</sup> (Figure 1a). The MEB framework provides effective practices for crossing the boundaries between knowledge systems in ways that take account of historical injustices and power imbalances, without privileging Western over Indigenous science.<sup>11</sup> Practices of expecting rights, supporting care and mutuality, strengthening Indigenous peoples and local communities (IPLC) and their knowledge systems and supporting effective knowledge exchange dialogues, have proved an effective interface of knowledge systems in biodiversity assessments.<sup>12</sup>

Nevertheless, Indigenous and Western scientific knowledge systems share many commonalities as well as distinct differences. ‘Western scientific knowledge systems’ is a short-hand term for a body of work which is mostly characterised by cross-fertilisation and exchange, and during the colonial era – which continues today – by theft, oppression and what appears as extreme cruelty.<sup>13</sup> A recent history of sciences has demonstrated that the first recorded botanical garden in the world was established by the Aztec rulers in the ancient city of Tenochtitlan (now Mexico City). Encounters between Indigenous peoples and Western scientists were foundational in the establishment of botanical gardens



**Figure 1.** Encounters across diverse knowledge systems with sciences embedded in them. Adapted from Tengo et al. 2014.<sup>82</sup>

across Europe.<sup>14</sup> Copernicus, often hailed as the founder of the scientific revolution, drew on Islamic texts taken to Italy after the Ottoman conquest of Istanbul, and their astronomical measurements, to formulate his model of the planetary movements.<sup>15</sup>

The UNDRIP identifies that Indigenous people consider their own knowledge to include ‘sciences’ (see Article 31). The definition of science provided by the CESCR<sup>16</sup> for interpretation of the HRS (Box 1) is certainly broad and inclusive of cultural diversity in the sciences. Indigenous peoples in diverse states are asserting a history of scientific endeavours. For example, in Australia, recent publications promote Australia’s Indigenous peoples as the ‘first scientists’.<sup>17</sup> School curricula link Western science with this Indigenous scientific knowledge.<sup>18</sup> In the USA, a group of First Nations scientists released a statement prior to the 2017 March for Science setting out their perspective that there is more than one ‘science’ and their Indigenous cultures include sciences, while giving different emphases to aspects of the scientific process than those of Western sciences.<sup>19</sup> Figure 1b highlights recognition in this article of an encounter across Indigenous, Western and other knowledge systems (*sensu* Tengo et al. 2014<sup>20</sup>) each with sciences embedded in them.

**Box 1.** Definition of science provided by CESCR<sup>21</sup> for interpretation of the HRS.

‘Science’ signifies the enterprise whereby humankind, acting individually or in small or large groups, makes an organized attempt, by means of the objective study of observed phenomena and its validation through sharing of findings and data and through peer review, to discover and master the chain of causalities, relations or interactions; brings together in a coordinated form subsystems of knowledge by means of systematic reflection and conceptualization; and thereby furnishes itself with the opportunity of using, to its own advantage, understanding of the processes and phenomena occurring in nature and society ... ‘the sciences’ signifies a complex of knowledge, fact and hypothesis, in which the theoretical element is capable of being validated in the short or long term, and to that extent includes the sciences concerned with social facts and phenomena.

Figure 1a and b continues to highlight that each knowledge system, and the sciences embedded in them, have their own processes for validation, for determining what is true.<sup>22</sup> The sharing of knowledge is determined by rules innate to each knowledge system – for example, among many Australian First Peoples, according to their customary knowledge protocols, some Indigenous information can only be shared in certain places, and only with certain people.<sup>23</sup> Article 31 of the UNDRIP sets out the rights of Indigenous peoples to ‘maintain, control, protect and develop their cultural heritage, traditional knowledge, and traditional cultural expressions, as well as the manifestations of their sciences’. Among many Indigenous societies, sharing of knowledge is not a right nor a responsibility.<sup>24</sup> Protection of Indigenous cultural and intellectual property is a key priority.<sup>25</sup> This collective right to control manifestations of their sciences under the UNDRIP is potentially in conflict with the HRS, which recognises the rights of everyone to participate in science, access and enjoy the benefits of science, and be protected against the adverse effects of science.

## Intersectional universality at the interface between knowledge systems

Universality is a foundation of all human rights law – as set out specifically in the Universal Declaration of Human Rights: ‘all human beings are born free and equal in dignity and rights and that everyone is entitled to all the rights and freedoms set out therein, without distinction of any kind, in particular as to race, colour or national origin’.

Why then do Indigenous peoples have rights to control access to their sciences under the UNDRIP, when the HRS calls for universal accessibility?

Intersectionality provides insight into this tension, noting that human beings are highly diverse. People differ individually in terms of gender, age, access to material resources and education; and differ as groups, for example in terms of their languages, identities, cultures, histories and religions.<sup>26</sup> Intersectionality's prime concern has been on the interactions of multiple causes of oppression, for example as a result of both ethnicity and gender.<sup>27</sup> More recently, the potential for strategic intersectionality has emerged, whereby oppressed actors gather agency from multiple identities, and increase their power to navigate and challenge multiple structures of discrimination through coalitions and solidarity.<sup>28</sup> Intersectional universality posits that human rights must be understood simultaneously in terms of sameness and difference – both in their fundamental workings and also in how they are realised or violated.<sup>29</sup>

Indigenous peoples' differences are important in considering the HRS. While an official definition of 'Indigenous' has not been adopted by the UN, Indigenous peoples typically self-identify as Indigenous, and are accepted by their community as a member of societies often with historical continuity with pre-colonial and/or pre-settler societies now occupying the same territory.<sup>30</sup> Indigenous peoples have strong links to territories and distinct cultures, beliefs, world views, political and knowledge systems. Indeed, Indigenous peoples have the right to belong to a community or nation in accordance with their traditions and customs (UNDRIP Article 9) and to maintain and develop their collective decision-making institutions (UNDRIP Article 18).<sup>31</sup> Indigenous peoples also share common experiences of dispossession of their lands, territories and resources, which have resulted in great disadvantages in socio-economic status. Even many years since adoption of the UNDRIP by the UN General Assembly in 2007, there is little respite from the violations of human rights experienced in Indigenous peoples' legitimate struggles to protect their lands, resources, livelihoods and cultures.<sup>32</sup> Indigenous peoples have faced multiple and ongoing challenges to maintaining their sciences from external forces wielded by other groups, including states and scientific organisations.<sup>33</sup> These differences provide Indigenous peoples with their own unique perspectives on what constitutes HRS, and particular Indigenous peoples' rights to Indigenous sciences.

The colonial expansion heralded a time of great suffering for the original inhabitants of many lands, some of which was directly at the hands of colonial science. Relationships of domination and subordination characterise colonial science.<sup>34</sup> Many scientific practices breach rights recognised under the UNDRIP. Examples include living Indigenous people being collected and displayed in zoos, theft of human remains, cultural objects, and fossils, removal and exploitation of Indigenous knowledge of medicinal plants, and ongoing 'parachute' science activities – thereby breaching at least Articles 7, 11, 24 and 31 of the UNDRIP (Table 1). Indigenous peoples bear a disproportionate share of negative impacts of colonial scientific practices that breach human rights.

Some ways forward to redress this legacy, prevent its ongoing occurrence and build collaboration between Indigenous peoples and scientific organisations are beginning to emerge. For example, the Africa Museum in Belgium curated an exhibition in 2021 to highlight the truth of their (and others') 'human zoo' exhibitions that led to tragic deaths,<sup>35</sup> although issues of reparation have not been addressed. A global movement

**Table 1.** Negative impacts of scientific practices on the human rights of Indigenous peoples, with current ways forward to redress this legacy.

UNDRIP clauses and negative impacts of scientific practices (UNDRIP clauses)	Specific example	Ways forward
Rights to life free of violence (Article 7). Living Indigenous peoples captured and exhibited in zoos	Head of the New York Zoological Society arranged for a Congolese Indigenous person to be displayed at Bronx Zoo in 1906. Similar examples from numerous countries. <sup>83</sup>	Zoos and scientific societies examine their history to enable truth-telling <sup>84</sup> and work with the relevant Indigenous peoples to negotiate redress and reparation
Protection from the removal of human remains (Article 7, 11). Burial sites robbed of human remains for scientific collections	The National Museum of Australia holds the remains of more than 700 Indigenous people, most returned from overseas scientific collections. <sup>85</sup>	Repatriate remains to communities where possible; collaborate with Indigenous people to establish appropriate resting places where repatriation is impossible. <sup>86</sup>
Protection from removal of cultural objects without Free, Prior and Informed Consent (FPIC) (Article 11)	British Museum holds an extraordinary collection of objects taken from Australian Indigenous Peoples without FPIC. <sup>87</sup> Vast collections of Indigenous artefacts are held in museums across the world.	Repatriate cultural objects, <sup>88</sup> link artefacts to Indigenous people where return is not possible, <sup>89</sup> supporting Indigenous-led cultural heritage research and curation <sup>90</sup>
Protection from the removal of fossils (Article 11). Archaeological sites robbed, local communities/scientists excluded from studying them through cultural/structural discrimination	Publications on Jurassic–Cretaceous fossils from NE Brazil over the last three decades include several studies based on fossils illegally repositied in foreign collections, particularly in Germany and Japan. <sup>91</sup>	Keep fossils in the country/places of origin, acknowledge history, equitable, reciprocal partnerships that develop in-country expertise, participatory and Indigenous-led research, FPIC processes <sup>92</sup>
Rights to traditional medicines and control of knowledge (Articles 24, 31). Knowledge of medicinal plants recorded by scientists who then have ownership	Aztec/Mayan knowledge of plants recorded by colonial scientists; publications (Codex) largely destroyed and remaining ones held in overseas collections. <sup>93</sup>	Collaboration to return knowledge to communities <sup>94</sup> ; legal changes to recognise the prior ownership by Indigenous peoples of their Indigenous Cultural and Intellectual Property (ICIP); application of the Nagoya Protocol going forward
Right to control and develop manifestations of their sciences (Article 31). ‘Parachute science’ removes control of Indigenous peoples’ sciences	‘Parachute science’ occurs when scientists from non-local agencies conduct research or deploy programmes and fail to invest in, fully partner with, or recognise local governance, capacity, expertise, and social structures <sup>95</sup>	Decolonise science through supporting Indigenous-led initiatives, mutually beneficial partnerships and knowledge co-production <sup>96</sup>

for repatriation from scientific collections of human remains<sup>36</sup> and cultural objects<sup>37</sup> is under way. Some progress is occurring in terms of Indigenous-led heritage science and partnerships between Indigenous and Western science in curating and displaying scientific collections.<sup>38</sup> Recent outrage over the ongoing colonial approach to collection of fossils has triggered interest in decolonising palaeontology.<sup>39</sup> New methods for protection of Indigenous cultural and intellectual rights from exploitation of Western scientists are gaining traction<sup>40</sup> (Table 1). These initiatives are examples of what Porsdam and Porsdam<sup>41</sup> refer to as ‘science diplomacy from within’, whereby scientists and scientific organisations have taken responsibility to mediate in a divisive issue, regardless of the policy position of state actors in this domain, or scientists’ lack of legally-defined roles as duty-bearers under the HRS.

Free, prior and informed consent from Indigenous peoples for participation in and access to their sciences from those outside the Indigenous community, such as scientific



organisations, is emerging as a foundational premise in these ways forward. CESCR in its General Comment No. 21 on the UNDRIP<sup>42</sup> notes that state parties should respect the principle of free, prior and informed consent (FPIC) of Indigenous peoples in all matters covered by their specific rights, including the rights over manifestations of their sciences. The UN Permanent Forum on Indigenous Issues (PFII) advises that ‘free’ means without coercion, ‘prior’ means before any activities are started, ‘informed’ requires that information be accessible, accurate and in a language able to be understood, and ‘consent’ requires that Indigenous peoples participate in decision-making using their own freely chosen representatives and customary or other institutions.<sup>43</sup> Where Indigenous peoples have given FPIC for release of their scientific knowledge into the broader public arena, the principles of the HRS regarding accessibility can fully apply. This condition is similar to the Western scientific processes of peer review and publication before research results are considered science that should be broadly accessible. States have a duty to put in place a framework that supports both Western and Indigenous scientific activities of peer review and FPIC through funding relevant organisations, and training for Western and Indigenous scientists.<sup>44</sup>

For Indigenous peoples inside communities involved in FPIC to release their scientific information, the UNDRIP also sets out (Article 34) that any decision-making institutions must function ‘within international human rights standards’ and therefore not practice discrimination based on gender, age or other categories of difference. Here is where we encounter the ‘universal’, the ways in which Indigenous peoples are the same as all peoples. This sameness does not, however, imply that all Indigenous knowledge should therefore be available to all people or all members of an Indigenous community – Indigenous peoples maintain that adherence to their own diverse knowledge protocols under their diverse customary laws are vital for knowledge sharing. For example, some knowledge can only be shared with people who hold specific rights to traditional territories, other knowledge can only be shared through special ceremonies, and following such knowledge protocols is regarded by them as vital for Indigenous peoples’ cultural safety and obligations.<sup>45</sup> The Indigenous institutions that determine these rules do, however, need to operate in accordance with international human rights standards with each community, and ensure equality of opportunity for decision-making about FPIC. In practice, evidence is growing that implementation of the UNDRIP is strengthening democracy and equality, showing that diverse collective units with different identities can equally participate in the governing institutions under which they live.<sup>46</sup> States therefore have a duty to ensure that their frameworks support participation in such Indigenous scientific practices through funding, training and activities that engage Indigenous individuals from the relevant groups in fulfilling their responsibilities within these scientific institutions.

### **Navigating the benefits of sciences across knowledge systems**

The negative impacts and legacies of Western scientific practices that breach human rights summarised above contribute in part to the notable marginalisation of Indigenous peoples from science-derived technologies that may be of benefit. For example, Native Hawaiians and other Pacific Islanders’ lower rate of uptake of COVID-19 vaccines is associated with a distrust of official sources of information, not their cultural



background.<sup>47</sup> This distrust exacerbates social and economic factors that have led to a disproportionate impact of the COVID-19 pandemic on Indigenous peoples, including inequalities and exclusions from employment, lack of access to basic services including water and energy, educational disadvantage, and loss of access to land, territories and traditional knowledge.<sup>48</sup>

The World Health Organization's recently announced plan for a 'vaccine hub' is an important initiative to overcome barriers to vaccine access in the developing world. Undoubtedly, implementation of the HRS in this context of Indigenous disadvantage requires addressing issues of inequitable distribution of resources and power.<sup>49</sup> The health equity framework illuminates how implementation of human rights in the health domain is influenced by the historical and life course trajectory and by systems of power (policies/practices) that determine access to resources and opportunities, as well as the more familiar individual, physiological and social factors.<sup>50</sup> While policies broadly across social, economic, cultural and environmental domains are required to overcome persistent disadvantage, specific capacity-building actions are vital to overcome distrust of official sources of information in science, technology, engineering and maths (STEM).

In Australia, for example, 'Two-Way Science' education that links the Indigenous sciences with Western sciences in school programmes has proved successful for increasing engagement by Indigenous peoples in STEM.<sup>51</sup> Scholarships and support are critical for Indigenous people in STEM to study at undergraduate and postgraduate levels at university. Australia's national science agency is implementing an Indigenous Science Program based on recognition and respect for Indigenous sciences and people, together with employment and training strategies and a commitment to deep community engagement.<sup>52</sup> Deep community engagement in turn is underpinned by principles of transparency; iterative, community level, free prior and informed consent; and the sharing of power through the co-development of science and technology.<sup>53</sup>

On the other hand, Indigenous peoples are moving beyond FPIC as the foundation enabling co-existence between both individual and collective human rights, and discovering their own ways to benefit from Western science-derived technologies, usually with support of non-Indigenous allies (Table 2). For example, Indigenous-led research has demonstrated how co-developed protocols helped navigate potential tensions around the use of drones for landscape monitoring.<sup>54</sup> Indigenous content creators and developers are using digital and online technologies for revitalisation of languages.<sup>55</sup> Epidemiology for and with Indigenous peoples is providing ways around the barriers posed by distrust and inequities.<sup>56</sup> Indigenous data sovereignty has established new CARE principles (Table 2) to ensure that big and open data sets can be used by Indigenous peoples in beneficial ways.<sup>57</sup> Co-production across knowledge systems has demonstrated how Western scientific knowledge can be made available to Indigenous peoples through presentations by community members in their local languages.<sup>58</sup>

These examples (Table 2) show that a range of mechanisms, all underpinned by Indigenous peoples' agency, leadership and governance, are important for delivering the potential benefits: co-produced protocols, knowledge co-production, Indigenous methodologies, Indigenous cultural governance, a critical lens on colonial practices and deeply respectful partnerships. Thus an appreciation of differences between Western and Indigenous sciences allows mutually respectful collaboration that enables navigation

**Table 2.** Examples of beneficial use by Indigenous people of Western science-derived technologies and key mechanisms for benefits.

Western science-derived technology	Example of beneficial use by Indigenous peoples	Key mechanisms
Aerial drones	Used in monitoring biocultural landscape of in northern Australia's Kakadu National Park	Co-developed protocols <sup>97</sup>
Digital and online technologies for Indigenous languages	Review highlighting numerous Indigenous-led online sites and Indigenous coders working on language revitalisation	Indigenous socio-technological self-determination, Indigenous content creators, developers, and visionaries are becoming increasingly visible and influential <sup>98</sup>
Epidemiology using quantitative and statistical methods to document health concerns	Epidemiology for and by Indigenous people is an emerging field globally	Indigenous methodologies, Indigenous-centred courses, linkages with communities, countering racialised stereotypes, critical lens on colonial practices <sup>99</sup>
Big data (largely digital data sets held by governments/international organisations) and open data (free public access)	The Global Indigenous Data Alliance highlights how Indigenous data sovereignty can support Native Nation rebuilding ( <a href="https://www.gida-global.org/">https://www.gida-global.org/</a> )	CARE principles – collective benefit, authority to control, responsibility and ethics – sit alongside the FAIR principles – findable, accessible, interoperable, reusable <sup>100</sup>
Adaptation to climate change impacts	Co-production between local Arrente people of central Australia and scientists of knowledge about climate change, including a presentation in Arrente language	Respectful partnerships, cultural governance, Indigenous connection to traditional territories, a relationship with the nation-state that empower local decision-making, not central control <sup>101</sup>

of key challenges. A final important difference of Indigenous peoples, relevant to the HRS, is that they hold their own governance systems, based on unique customary institutions – their rights to maintain and develop these institutions are protected under the UNDRIP.

### Anticipatory co-governance to identify risks and benefits in the context of diverse sciences

Anticipatory governance is gaining recognition as a key way forward to consider risks and benefits in complex situations such as that posed by the HRS.<sup>59</sup> Anticipatory governance refers here to a diverse set of practices of producing, contesting and analysing social constructions of what the future might look like in order to pre-emptively respond to potential negative outcomes.<sup>60</sup> Initiatives like the European Union's Responsible Research and Innovation (RRI) programme guide anticipation of risk in science and technology<sup>61</sup> through production and practices of norms. However, anticipation can also be based on democratic processes, aimed at identifying values and perspectives on which anticipatory governance needs to be anchored.<sup>62</sup> Such processes can mobilise the strength of intersectional universality to recognise differences in the context of colonial histories, governance systems and encounters across diverse sciences.

Science and technology-induced risks can be anticipated through various future thinking techniques such as scenarios, creating future visions, planning and strategic foresight.<sup>63</sup> Democratic processes of anticipation bring to the fore questions of whose visions are articulated in anticipation processes, what kind of futures they point to and how these visions have implications for actions in the present. Pluralistic future thinking

processes, which recognise the diversity of worldviews and perspectives about the future, can support intersectional universality in the anticipation of risk and benefit.<sup>64</sup> Participatory processes, whereby power about decision-making in future thinking for anticipation of risk and benefit is equitably shared between stakeholders and rightsholders, help support pluralistic anticipation across knowledge systems.<sup>65</sup> Indeed, participation rather than governance by Indigenous peoples is emphasised in General Comment 25 of the Committee on Economic, Social and Cultural Rights.<sup>66</sup>

The mechanisms identified above (Table 2) that enable benefits to derive from science and technology have at their core Indigenous peoples' governance. In this context, participation falls short, as it implies the relevant duty holders, states, reaching out to engage Indigenous peoples in their processes of anticipation, rather than a state-based governance to Indigenous people-based governance relationship. In order to address the different contexts of Indigenous peoples, engagement activities need to be designed, conducted and analysed in ways that confront longstanding power imbalances and enable Indigenous governance to be empowered.<sup>67</sup> Anticipatory co-governance with Indigenous peoples provides for recognition of shared duty and power to utilise tools such as knowledge co-production, protocols and Indigenous methodologies to better understand risks and benefits, and account for different perspectives on the HRS.

Co-governance with Indigenous peoples in the anticipation of risks and benefits underpins many of the successful initiatives described above (Table 2). For example, the co-developed protocols to manage the risks and benefits of drone technology occurred at Kakadu, a co-governed National Park in northern Australia. The project was overseen by the Kakadu Indigenous Research Committee, with representatives from all the major Indigenous clan and language groups in the region. Outside contexts of territorial co-governance, anticipatory co-governance with Indigenous peoples is currently best developed in the field of climate science, as key state and international actors begin to appreciate the governance value of Indigenous knowledge.<sup>68</sup>

The Great Barrier Reef Foundation in Australia, for example, is currently undertaking a participatory scenario exercise supporting Traditional Owners to develop their own visions of how to anticipate and respond to climate change impacts, and then to bring these together with technologically driven anticipation and innovation (e.g. building shades on the reef). Among Māori Indigenous peoples in New Zealand/Aotearoa many of their land- and ocean-based resources are governed through Māori-specific authorities, whose focus on community planning has identified the need to strengthen institutional capacity to anticipate risks.<sup>69</sup> A Māori Climate Platform is now being developed in partnership between the national government and the National Iwi (tribal groups) Chairs Forum who have established an eight-member (all Māori) Ministerial Advisory Committee to design the platform during 2023, with an intention for launch in 2024.<sup>70</sup> This platform is intended to support collaborative leadership of the anticipation of risk. At the global level, the Local Communities and Indigenous Peoples Platform, established under the United Nations Framework Convention on Climate Change, seeks to facilitate the incorporation of Indigenous knowledge into the states' anticipation and response processes.<sup>71</sup>

Many international organisations (IOs) are involved in different forms of anticipatory governance, including the International Labour Organization (ILO), the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development

(OECD), the United Nations Institute for Disarmament Research (UNIDR) and the United Nations Education, Scientific and Cultural Organisation (UNESCO).<sup>72</sup> These efforts have the potential to be enhanced by anticipatory co-governance with Indigenous peoples. The UNIDR, for example, is currently involved in activities to anticipate the risks of autonomous weapons systems (AWS). Experiences of the destructive power of nuclear weapons (currently lacking for AWS) are credited with driving the treaties to ban such weapons.<sup>73</sup> However, these atomic weapon experiences disproportionately affected Indigenous peoples – all of the main sites where over 500 atomic weapons were tested between 1945 and 1980, except one (the Monte Bello islands), were on Indigenous peoples' territories.<sup>74</sup> People have returned to live at Enewetak (Marshall) Atoll after 67 atomic tests, but are unable to eat the food and depend on quarterly food supplies from the government of the USA.<sup>75</sup> In the absence of direct experiences of the impacts of AWS, UNIDR is supporting the development of anticipatory norms through assembling knowledge from experts, translating complex information to make it more available, and representing this information to states, inviting them to imagine creatively how AWS could render both risks and benefits.<sup>76</sup> A turn towards co-governance with Indigenous peoples in this context could be supported through dialogue between the 16 members of the UN Permanent Forum on Indigenous Issues (UNPFII) and the 14 members of the Board of Trustees of the UNIDR to co-design the assembly, translation and representation of information about AWS to Indigenous peoples (as well as states). Such co-governed processes of norm-development would take account of Indigenous sciences and perspectives on human rights, and help avoid future disproportionate impacts of vulnerable Indigenous (and other) populations.

Anticipatory co-governance with Indigenous peoples at both national and international levels also needs to counter the influence of market and other exclusionary forms of governance. Potatoes are a prime example of a genetic resource that has been stewarded by Indigenous peoples of the Andes for millennia under local common property resource regimes – but continue to be regarded by some as a global commons, without boundaries. Beumer et al.<sup>77</sup> recently investigated how corporate-based and commons-based modes of governance of genetic resources may both shape the future of hybrid potato breeding. They concluded that to fully reap the benefits of this innovation requires (global) commons-based modes of governance.<sup>78</sup> By way of contrast, the original Indigenous stewards of the genetic diversity in the Potato Park of the Andes approach innovation with three focuses: (1) mutual reciprocity among human and non-human nature, (2) a collective deliberation process, and (3) ecological boundaries.<sup>79</sup> Anticipatory co-governance could enable a future that navigates differences in understanding of what constitutes innovation and enables mutual benefits from both local and global forms of common property resource regimes.<sup>80</sup>

Co-governance of the anticipation of risks and benefits requires sharing power in the decision-making process – power over whose visions are articulated, what kind of futures they point to and how these visions have implications for actions in the present. This type of co-governance can support the open public reasoning in a cross-cultural context that enables the institutions (and associated organisations and their representatives) that manage both Indigenous and Western scientific knowledge systems to consider anticipation of risk and benefit. This is not simply about making sure one or two Indigenous people are able to speak at a forum otherwise designed through Western norms. Rather, I

refer here to the sorts of co-designed dialogues championed by SwedBio – for example, their collaborative ‘Dialogue across Indigenous, Local and Scientific Knowledge Systems Reflecting on the IPBES Assessment on Pollinators, Pollination and Food Production’ which was supported by UNESCO and other agencies.<sup>81</sup> The UNPFII could be a useful body to initiate open public reasoning among diverse Indigenous peoples, their perspectives on the HRS, and their diverse sciences, and to co-host such a dialogue across diverse scientific knowledge systems.

## Conclusion

Consideration of the anticipation of risks and benefits of science from this perspective of the interface between knowledge systems highlights several implications for guidance on implementation of the HRS. Application of the principles of intersectional universality enables a focus on how Indigenous peoples are both different and the same under the HRS. First, Indigenous peoples differ in their strong links to territories, frequently based on millennia of occupation, and distinct cultures, beliefs, political and knowledge systems that include diverse sciences. This difference highlights the need for recognition and respect for these diverse Indigenous sciences, alongside respect for Western and other scientific systems, and the duty of states to provide a framework that supports diverse sciences. Second, Indigenous peoples share disproportionately in negative impacts of colonial Western scientific practices that have breached their human rights, including for example through becoming living collections displayed by scientific organisations. This difference requires a focus on ending colonial scientific practices, and supporting redress and reparation by scientific organisations, a process which has begun in several organisations across the world. Third, Indigenous people face great disadvantage in terms of inequalities and exclusions from employment, lack of access to basic services including water and energy, educational disadvantage, and loss of access to land, territories and traditional knowledge. This difference requires specific attention to capacity building for Indigenous communities and individuals to engage in science.

Finally, Indigenous peoples have their own governance systems, and display agency and leadership in navigating the potential benefits and risks of science, taking account of their own perspectives on the HRS. This difference is leading to examples of co-governance in the anticipation and management of risks and benefits. Such co-governance arrangements operate on the same foundation – that all decision-making institutions need to be consistent with universal human rights, and free from discrimination based on gender, ethnicity, race or other categories. Anticipatory co-governance arrangements between states and Indigenous peoples, among international and domestication organisations, can provide a fertile ground for the types of future thinking that will diligently anticipate risks and benefits.

This examination of the content, scope and bearers of the various duties and responsibilities to anticipate risks and benefits of science highlights the existence of multiple sciences embedded in diverse knowledge systems and therefore of multiple duty holders. States hold duties to support the cultural norms and protocols that govern Indigenous sciences as well as those of Western sciences and will benefit from anticipatory co-governance at both domestic and international levels of the HRS.

## Notes

1. A.K. Salomon, D.K. Okamoto, K.B.J. Wilson, H. Tommy Happynook, Mack W.A. Wickannish, et al., 'Disrupting and Diversifying the Values, Voices and Governance Principles that Shape Biodiversity Science and Management', *Philosophical Transactions of the Royal Society B: Biological Sciences* 378 (1881): 20220196; T.K. Moko-Painting, L. Hamley, D. Hikuroa, J. Le Grice, T. McAllister, G. McLellan, et al., '(Re)emergence of Pūtaiao: Conceptualising Kaupapa Māori Science', *Environment and Planning F* 2, no. 1–2 (2023): 11–37; J.T. Johnson, J.P. Brewer, M.K. Nelson, M.H. Palmer and R.P. Louis, 'Indigenous Research Sovereignities: Sparking the Deeper Conversations We Need', *Environment and Planning F* 2, no. 1–2 (2023): 3–10; M. Ienca and E. Vayena, 'Dual Use in the 21st Century: Emerging Risks and Global Governance', *Swiss Medical Weekly* (2018): 148; Y. Xue, H.Z. Yu and G. Qin, 'Towards Good Governance on Dual-Use Biotechnology for Global Sustainable Development', *Sustainability* 13, no. 24 (2021).
2. G. Sculthorpe, J. Carty, H. Morphy, M. Nugent, I. Coates and L. Bolton, et al., *Indigenous Australia Enduring Civilisation* (London and Canberra: British Museum and National Museum Australia, 2015); J. Poskett, *Horizons, A Global History of Science* (London: Penguin, 2022); G. Gryseels, P. Blanchard, M. Couttenier, M.Z. Etambala, T. Mazine, S. Ysebaert, et al., 'Human Zoo. The Age of Colonial Exhibitions', *MuseumTalks* (AfricaMuseum Discussion Panel), 2021, [https://www.africamuseum.be/en/learn/museumtalks/humanzoo\\_15november2021](https://www.africamuseum.be/en/learn/museumtalks/humanzoo_15november2021) (accessed July 22, 2022).
3. S. Díaz, S. Demissew, J. Carabias, C. Joly, M. Lonsdale, N. Ash, et al., 'The IPBES Conceptual Framework – Connecting Nature and People', *Current Opinion in Environmental Sustainability* 14, no. 1 (2015): 1–16; R. Hill, Ç. Adem, W.V. Alangui, Z. Molnár, Y. Aumeeruddy-Thomas, P. Bridgewater, et al., 'Working with Indigenous, Local and Scientific Knowledge in Assessments of Nature and Nature's Linkages with People', *Current Opinion in Environmental Sustainability* 43 (2020): 8–20.
4. Díaz et al. 'The IPBES Conceptual Framework'.
5. K. Maclean, E. Woodward, D. Jarvis, G. Turpin, D. Rowland and P. Rist, 'Decolonising Knowledge Co-production: Examining the Role of Positionality and Partnerships to Support Indigenous-led Bush Product Enterprises in Northern Australia', *Sustainability Science* 17, no. 2 (2022): 333–50.
6. A. Sen, 'Elements of a Theory of Human Rights', in *Justice and the Capabilities Approach* (Abingdon: Routledge, 2017), 221–62.
7. P. Jones, 'Group Rights', in *The Stanford Encyclopedia of Philosophy*, ed. E.N. Zalta and U. Nodelman (Stanford: Stanford University, 2022), <https://plato.stanford.edu/archives/fall2022/entries/rights-group/> (accessed January 5, 2022).
8. Hill et al. 'Working with Indigenous, Local and Scientific Knowledge'.
9. M. Tengö, E. Brondizio, T. Elmqvist, P. Malmer and M. Spierenburg, 'Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance: The Multiple Evidence Base Approach', *AMBIO* 43 (2014): 579–91, <https://link.springer.com/article/10.1007/s13280-014-0501-3> [English]; M. Tengö, R. Hill, P. Malmer, C.M. Raymond, M. Spierenburg, F. Danielsen, et al., 'Weaving Knowledge Systems in IPBES, CBD and Beyond – Lessons Learned for Sustainability', *Current Opinion in Environmental Sustainability* 26–27 (2017): 17–25.
10. Jones, 'Group Rights'; Hill et al., 'Working with Indigenous, Local and Scientific Knowledge'.
11. SwedBio, *The Multiple Evidence Base Approach*. SwedBio: A Programme at the Stockholm Resilience Centre, 2023, <https://swed.bio/meb/> (accessed August 30, 2023).
12. E.S. Brondizio, Y. Aumeeruddy-Thomas, P. Bates, J. Carino, Á. Fernández-Llamazares, M.F. Ferrari, et al., 'Locally Based, Regionally Manifested, and Globally Relevant: Indigenous and Local Knowledge, Values, and Practices for Nature', *Annual Review of Environment and Resources* 46, no. 1 (2021): 481–509; P. McElwee, Á. Fernández-Llamazares, Y. Aumeeruddy-Thomas, D. Babai, P. Bates, K. Galvin, et al., 'Working with Indigenous



- and Local Knowledge (ILK) in Large-scale Ecological Assessments: Reviewing the Experience of the IPBES Global Assessment', *Journal Applied Ecology* 57, no. 9 (2020): 1666–76.
13. Gryseels et al., 'Human Zoo'; R.M. McLeod, ed., *Nature and Empire: Science and the Colonial Empire* (Chicago: University of Chicago Press, 2001).
  14. Gryseels et al., 'Human Zoo'; L.H. Brockway, *Science and Colonial Expansion: The Role of the British Royal Botanical Gardens* (New Haven and London: Yale University Press, 2002); L. Schiebinger and C. Swan, eds, *Colonial Botany: Science, Commerce and Politics in the Early Modern World* (Philadelphia: University of Pennsylvania Press, 2005).
  15. Gryseels et al., 'Human Zoo'.
  16. CESCR, General Comment No. 25 (2020) on Science and Economic, Social and Cultural Rights (article 15 (1) (b), (2), (3) and (4) of the International Covenant on Economic, Social and Cultural Rights). (United Nations Economic and Social Council, Committee on Economic, Social and Cultural Rights, E/C.12/GC/25, 2020), <https://www.ohchr.org/en/documents/general-comments-and-recommendations/general-comment-no-25-2020-article-15-science-and/> (accessed January 5, 2023).
  17. C. Tutt, *The First Scientists: Deadly Inventions and Innovations from Australia's First Peoples* (Sydney: Hardy Grant Explore, 2021); Duane Hamacher with Elders and Knowledge Holders, *The First Astronomers: How Indigenous Elders Read the Stars* (Sydney: Allen & Unwin, 2022).
  18. C. Deslandes, S. Deslandes, D. Broun, C. Hugh, F. Walsh, F. Bradshaw, et al., *Two-way Science: An Integrated Learning Program for Desert Aboriginal Schools, Science Pathways for Indigenous Communities Program* (Melbourne: CSIRO Publishing, 2019).
  19. R.W. Kimmmerer, R. Lapier, M.K. Nelson, K.P. Whyte, N. Petterson, P. Loew, et al., *Let our Indigenous Voices Be Heard* (SUNY College of Environmental Science and Forestry Center for Native People and the Environment, 2017), [https://www.esf.edu/indigenous-science-letter/Indigenous\\_Science\\_Declaration.pdf](https://www.esf.edu/indigenous-science-letter/Indigenous_Science_Declaration.pdf).
  20. M. Tengo, E.S. Brondizio, T. Elmqvist, P. Malmer and M. Spierenburg, 'Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance: The Multiple Evidence Base Approach', *AMBIO* 43, no. 5 (2014): 579–91.
  21. McElwee et al., 'Working with Indigenous and Local Knowledge (ILK) in Large-scale Ecological Assessments'.
  22. Jones, 'Group Rights'; Hill et al., 'Working with Indigenous, Local and Scientific Knowledge'.
  23. A. Poelina, T. Webb, Dhimurru Aboriginal Corporation, Aunty Shaa Smith, N. Smith, S. Wright, et al., 'Foundations of Our Knowledge Our Way', in *Our Knowledge Our Way in Caring for Country Indigenous-led Approaches to Strengthening and Sharing our Knowledge for Land and Sea Management Best Practice Guidelines from Australian Experiences*, ed. E. Woodward, R. Hill, P. Harkness, R. Archer (Cairns: NAILSMA and CSIRO, 2020), 1–20, <https://www.nespnorthern.edu.au/wp-content/uploads/2020/11/Our-Knowledge-Our-Way-Guidelines.pdf>.
  24. L. Ford, E. Woodward, R. Hill, M. Tengö and P. Harkness, 'Actions towards Best Practice to support Our Knowledge Our Way', in *Our Knowledge Our Way in Caring for Country Indigenous-led Approaches to Strengthening and Sharing our Knowledge for Land and Sea Management Best Practice Guidelines from Australian Experiences* (Cairns: NAILSMA and CSIRO, 2020), [https://www.csiro.au/-/media/LWF/Files/OKOW/OKOW-Guidelines\\_FULLL.pdf](https://www.csiro.au/-/media/LWF/Files/OKOW/OKOW-Guidelines_FULLL.pdf); G. Nicholas, 'Protecting Indigenous Heritage Objects, Places, and Values: Challenges, Responses, and Responsibilities', *International Journal of Heritage Studies* 28, no. 3 (2022): 400–22.
  25. T. Janke, *True Tracks Respecting Indigenous Knowledge and Culture* (Sydney: New South Publishing, 2021).
  26. H. Al-Faham, A.M. Davis and R. Ernst, 'Intersectionality: From Theory to Practice', *Annual Review of Law and Social Science* 15, no. 1 (2019): 247–65.
  27. H.Y. Choo and M.M. Ferree, 'Practicing Intersectionality in Sociological Research: A Critical Analysis of Inclusions, Interactions, and Institutions in the Study of Inequalities', *Sociological Theory* 28, no. 2 (2010): 129–49.



28. S. Atrey, 'Beyond Universality: An Intersectional Justification of Human Rights', in *Intersectionality and Human Rights Law*, ed. S. Atrey and P. Dunne (Oxford: Hart Publishing, 2020), <https://doi.org/10.5040/9781509935321.ch-001> (Downloaded from Bloomsbury Collections, <http://www.bloomsburycollections.com>, November 6, 2022); S. Atrey, 'Women's Human Rights: From Progress to Transformation, An Intersectional Response to Martha Nussbaum', *Human Rights Quarterly* 40 (2018): 859.
29. Tengo et al., 'Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance'.
30. PFII, *Who are Indigenous Peoples? Fact Sheet* (United Nations Economic and Social Council, Permanent Forum on Indigenous Issues, undated), [http://www.un.org/esa/socdev/unpfi/documents/5session\\_factsheet1.pdf](http://www.un.org/esa/socdev/unpfi/documents/5session_factsheet1.pdf) (accessed January 6, 2023).
31. Jones, 'Group Rights'; Hill et al., 'Working with Indigenous, Local and Scientific Knowledge'.
32. J. Burger, 'After the Declaration: Next Steps for the Protection of Indigenous Peoples' Rights', *The International Journal of Human Rights* 23, no. 1–2 (2019): 22–33.
33. Sen, 'Elements of a Theory of Human Rights'.
34. Hill et al., 'Working with Indigenous, Local and Scientific Knowledge'; J.C. Cisneros, N.B. Raja, A.M. Ghilardi, E.M. Dunne, F.L. Pinheiro, O.R.R. Fernandez, et al., 'Digging Deeper into Colonial Palaeontological Practices in Modern Day Mexico and Brazil', *Royal Society Open Science* 9 no. 3 (2022).
35. Gryseels et al., 'Human Zoo'.
36. P. Turnbull, 'International Repatriations of Indigenous Human Remains and its Complexities: The Australian Experience', *Museum and Society* 18, no. 1 (2020): 6–19.
37. F. Sarr and B. Savoy, *Rapport sur la restitution du patrimoine culturel africain. Vers une nouvelle éthique relationnelle* (Paris, France: Philippe Rey, 2018), [http://restitutionreport2018.com/sarr\\_savoy\\_en.pdf](http://restitutionreport2018.com/sarr_savoy_en.pdf) (accessed July 22, 2022); J. Weiss, 'The Era of Endless Repatriation', *Anthropologica* 63, no. 2 (2021).
38. Sculthorpe et al., *Indigenous Australia Enduring Civilisation*; S. Hemming and D. Rigney, 'Decentring the New Protectors: Transforming Aboriginal Heritage in South Australia', *International Journal of Heritage Studies* 16, no. 1 (2010): 90–106.
39. M. Lenharo and M. Rodrigues, 'Movement to Decolonize Fossil Science Gains Steam', *Nature* 605, no. 7908 (2022): 18–19.
40. Hamacher with Elders and Knowledge Holders, *The First Astronomers*.
41. H. Porsdam and S. Porsdam Mann, *Diplomacy (with)in Science: Activating the Right to Science for Science Diplomacy* (Brocher Workshop, 2023).
42. CESCR, General comment No. 21. Right of Everyone to Take Part in Cultural Life (art. 15, para. 1 (a), of the International Covenant on Economic, Social and Cultural Rights). (United Nations Economic and Social Council, Committee on Economic, Social and Cultural Rights, E/C.12/GC/21, 2009), <https://www.refworld.org/docid/4ed35bae2.html> (accessed January 5, 2023).
43. PFII, Report of the International Workshop on Methodologies Regarding Free, Prior and Informed Consent and Indigenous Peoples (New York, January 17–19, 2005), <https://digitallibrary.un.org/record/544406?ln=en> (accessed January 6, 2023), United Nations Economic and Social Council, Permanent Forum on Indigenous Issues, E/C.19/2005/1, 2005.
44. A.-M. Hubert, *Between Scylla and Charybdis: The Implications of the Human Right to Science for Regulating the Harms and Benefits of Environmental Science and Technology* (Brocher Workshop, 2023).
45. Gryseels et al., 'Human Zoo'.
46. D. Cambou, 'The UNDRIP and the Legal Significance of the Right of Indigenous Peoples to Self-determination: A Human Rights Approach with a Multidimensional Perspective', *The International Journal of Human Rights* 23, no. 1–2 (2019): 34–50.
47. R. Juarez, K. Phankitnirundorn, M. Okihiro and A.K. Maunakea, 'Opposing Role of Trust as a Modifier of COVID-19 Vaccine Uptake in an Indigenous Population', *Vaccines* 10, no. 6 (2022).

48. J. Lastro-Bravo, 'Indigenous Peoples, Uncertainty and Exclusion in the Global South in Periods of the Pandemic', in *Anxiety, Uncertainty, and Resilience During the Pandemic Period*, ed. F. Gabrielli and F. Irtelli (Intechopen, 2021), 34, 10.5772/intechopen.95017.
49. D. Ludwig and P. Macnaghten, 'Traditional Ecological Knowledge in Innovation Governance: A Framework for Responsible and Just Innovation', *Journal Responsible Innovation* 7, no. 1 (2020): 26–44.
50. A. Peterson, V. Charles, D. Yeung and K. Coyle, 'The Health Equity Framework: A Science- and Justice-Based Model for Public Health Researchers and Practitioners', *Health Promotion Practice* 22, no. 6 (2021): 741–6.
51. Gryseels et al., 'Human Zoo'.
52. L. Jeckells, *Indigenous Science Solutions for Tomorrow* (Commonwealth Scientific and Industrial Research Organisation (CSIRO), 2022), <https://blog.csiro.au/indigenous-science-solutions> (accessed July 22, 2022).
53. D.R. George, T. Kuiken and J.A. Delborne, 'Articulating "Free, Prior and Informed Consent" (FPIC) for Engineered Gene Drives', *Proceedings of the Royal Society B-Biological Sciences* 286, no. 1917 (2019).
54. J.M. Macdonald, C.J. Robinson, J. Perry, M. Lee, R. Barrowei, B. Coleman, et al., 'Indigenous-led Responsible Innovation: Lessons from Co-developed Protocols to Guide the Use of Drones to Monitor a Biocultural Landscape in Kakadu National Park, Australia', *Journal Responsible Innovation* 8, no. 2 (2021): 300–19 [English].
55. P.J. Meighan, 'Decolonizing the Digital Landscape: The Role of Technology in Indigenous Language Revitalization', *Alternative* 17, no. 3 (2021): 397–405.
56. E. Prussing, 'Through a Critical Lens: Expertise in Epidemiology for and by Indigenous Peoples', *Sci Technol Hum Values* 45, no. 6 (2020): 1142–67. PubMed PMID: WOS:000496363500001.
57. M. Walter, R. Lovett, B. Maher, B. Williamson, J. Prehn, G. Bodkin-Andrews, et al., 'Indigenous Data Sovereignty in the Era of Big Data and Open Data', *Australian Journal of Social Issues* (2020): 14 [English].
58. R. Hill, F.J. Walsh, J. Davies, A. Sparrow, M. Mooney, Central Land Council, et al., 'Knowledge Co-production for Indigenous Adaptation Pathways: Transform Post-colonial Articulation Complexes to Empower Local Decision-making', *Global Environmental Change* 65 (2020): 102161, <https://doi.org/10.1016/j.gloenvcha.2020>.
59. K. Muiderman, M. Zurek, J. Vervoort, A. Gupta, S. Hasnain and P. Driessen, 'The Anticipatory Governance of Sustainability Transformations: Hybrid Approaches and Dominant Perspectives', *Global Environmental Change* 73 (2022): 102452.
60. J. Berten and M. Kranke, 'Anticipatory Global Governance: International Organisations and the Politics of the Future', *Global Society* 36 no. 2 (2022): 155–69.
61. E. Fisher, 'RRI Futures: Ends and Beginnings', *Journal Responsible Innovation* 8, no. 2 (2021): 135–8; B. Prem, 'Governing through Anticipatory Norms: How UNIDIR Constructs Knowledge about Autonomous Weapons Systems', *Global Society* 36, no. 2 (2022): 261–80.
62. D. Ruggiu, 'Models of Anticipation Within the Responsible Research and Innovation Framework: The Two RRI Approaches and the Challenge of Human Rights', *NanoEthics* 13, no. 1 (2019): 53–78; F. Shaheed, 'Report of the Special Rapporteur in the Field of Cultural Rights, Farida Shaheed. The Right to Enjoy the Benefits of Scientific Progress and Its Applications' (Human Rights Council, United Nations, General Assembly A/HRC/20/26 2012), <https://digitallibrary.un.org/record/730844?ln=en>.
63. L. Pereira, J.J. Kuiper, O. Selomane, A.P.D. Aguiar, G.R. Asrar, E.M. Bennett, et al., 'Advancing a Toolkit of Diverse Futures Approaches for Global Environmental Assessments', *Ecosystems and People* 17, no. 1 (2021): 191–204; L. Kimbell and L. Vesnic-Alujevic, 'After the Toolkit: Anticipatory Logics and the Future of Government', *Policy Design and Practice* 3, no. 2 (2020): 95–108; S. Cork, C. Alexandra, J.G. Alvarez-Romero, E.M. Bennett, M. Barbés-Blázquez, E. Bohensky, et al., 'Exploring Alternative Futures in the Anthropocene', *Annual Review of Environment and Resources* 48, no. 1 (2023).
64. Lastro-Bravo, 'Indigenous Peoples, Uncertainty and Exclusion'.

65. P. Zaratini, D. Bertorello, R. Guglielmino, D. Devigili, G. Bricchetto, V. Tageo, et al., 'The MULTI-ACT Model: The Path Forward for Participatory and Anticipatory Governance in Health Research and Care', *Health Research Policy and Systems* 20, no. 1 (2022): 22.
66. McElwee et al., 'Working with Indigenous and Local Knowledge'.
67. R. Taitingfong and A. Ullah, 'Empowering Indigenous Knowledge in Deliberations on Gene Editing in the Wild', *Hastings Center Report* 51 (2021): S74–S84.
68. N.J. Wilson, M.G. Lira and G. O'Hanlon, 'A Systematic Scoping Review of Indigenous Governance Concepts in the Climate Governance Literature', *Climatic Change* 171, no. 3–4 (2022); K. Whyte, 'What do Indigenous Knowledges do for Indigenous Peoples?', in *Traditional Ecological Knowledge: Learning from Indigenous Practices for Sustainability*, ed. M.K. Neslon and D. Shilling (Cambridge: Cambridge University Press, 2018).
69. M. Manning, J. Lawrence, D.N. King and R. Chapman, 'Dealing with Changing Risks: A New Zealand Perspective on Climate Change Adaptation', *Regional Environmental Change* 15, no. 4 (2015): 581–94.
70. Ministry for the Environment Manatū Mō Te Taiao, Māori Climate Platform (New Zealand/ Aotearoa Government Ministry for the Environment Manatū Mō Te Taiao, 2022), <https://environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/maori-climate-platform/> (accessed January 6, 2023).
71. Muiderman et al., 'The Anticipatory Governance of Sustainability Transformations'.
72. Ludwig and Macnaghten, 'Traditional Ecological Knowledge in Innovation Governance'.
73. See note 71 above.
74. S.L. Simon and A. Bouville, 'Health Effects of Nuclear Weapons Testing', *Lancet* 386, no. 9992 (2015): 407–9 [English]; K. Davies, A. Rajvanshi, Y.-C. Youn, J.C. Choe, A. Choi, R. Cooney, et al., 'Chapter 2: Nature's Contributions to People and Quality of Life', in *The IPBES Regional Assessment Report on Biodiversity and Ecosystem Services for Asia and the Pacific*, ed. M. Karki, S. Senaratna Sellamuttu, S. Okayasu and W. Suzuki (Bonn: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2018), 67–174, [https://www.ipbes.net/system/tdf/2018\\_asia\\_pacific\\_full\\_report\\_book\\_v3\\_pages.pdf?file=1&type=node&id=29507](https://www.ipbes.net/system/tdf/2018_asia_pacific_full_report_book_v3_pages.pdf?file=1&type=node&id=29507) (accessed January 7, 2023).
75. B.A. Takala, 'Ejab Maron ERUB: Recentering Traditional Marshallese Knowledge Systems (MKS)', in *IPBES-JBF Sub-regional Dialogue Workshop Report on Indigenous and Local Knowledge (ILK) for Pacific sub-region, New Zealand (1–4 Nov 2016)*, ed. R. Hill, H. Scheyvens and T. Shortland (Tokyo: Institute for Global Environmental Strategies, 2017), <https://pub.iges.or.jp/pub/ipbes-jbf-sub-regional-dialogue-workshop-1> (accessed January 7, 2023).
76. See note 71 above.
77. K. Beumer, D. Stemerding and J.A.A. Swart, 'Innovation and the Commons: Lessons from the Governance of Genetic Resources in Potato Breeding', *Agriculture and Human Values* 38, no. 2 (2021): 525–39.
78. Kimbell and Vesnic-Alujevic, 'After the Toolkit'.
79. A. Jimenez, D. Delgado, R. Merino and A. Argumedo, 'A Decolonial Approach to Innovation? Building Paths Towards Buen Vivir', *Journal of Development Studies* (2022).
80. E. Ostrom, *Governing the Commons* (Cambridge: University of Cambridge Press, 1990); E. Ostrom, 'Collective Action and the Evolution of Social Norms', *Journal of Economic Perspectives* 14, no. 3 (2000): 137–58.
81. P. Malmer, M. Tengö, A. Fernández-Llamazares, E. Woodward, N. Crawhall, R. Hill, et al., 'Dialogue across Indigenous, Local and Scientific Knowledge Systems Reflecting on the IPBES Assessment on Pollinators, Pollination and Food Production', 21th to 25th January 2019, Chiang Mai and Chiang Rai, Thailand, Workshop Report (Stockholm: SwedBio at Stockholm Resilience Centre, 2019). <https://swed.bio/reports/pollinators-dialogue-report/>.
82. Tengö et al., 'Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance'.

83. RareHistoricalPhotos.com, Human Zoos: The Western World's Shameful Secret, 1900–1958 (2021), <https://rarehistoricalphotos.com/human-zoo-history-pictures-1900-1958/> (accessed July 23, 2022); P. Blanchard, N. Bancel, E. Deroo and S. Lemaire, eds, *Human Zoos: Science and Spectacle in the Age of Colonial Empires* (Liverpool: Liverpool University Press, 2008).
84. Gryseels et al., 'Human Zoo'.
85. Ford et al., 'Actions towards Best Practice to support Our Knowledge Our Way'.
86. Ibid.
87. Sculthorpe et al., *Indigenous Australia Enduring Civilisation*.
88. Janke, *True Tracks Respecting Indigenous Knowledge and Culture*.
89. H. Morphy, 'Encounters at the National Museum of Australia: A Moment in an Ongoing Process of Engagement', *International Journal of Heritage Studies* 23, no. 9 (2017): 875–8; H. Robinson, 'Is Cultural Democracy Possible in a Museum? Critical Reflections on Indigenous Engagement in the Development of the Exhibition Encounters: Revealing Stories of Aboriginal and Torres Strait Islander Objects from the British Museum', *International Journal of Heritage Studies* 23, no. 9 (2017): 860–74.
90. Al-Faham et al., 'Intersectionality'.
91. Poelina et al., 'Foundations of Our Knowledge Our Way'.
92. Choo and Ferree, 'Practicing Intersectionality in Sociological Research'; P.M. Monarrez, J.B. Zimmt, A.M. Clement, W. Gearty, J.J. Jacisin, K.M. Jenkins, et al., 'Our Past Creates Our Present: A Brief Overview of Racism and Colonialism in Western Paleontology', *Paleobiology* (2021).
93. Poskett, *Horizons*.
94. S.A. Garcia and C.I. Marquez, 'Cultivating Positive Health, Learning, and Community: The Return of Mesoamerica's Quetzalcoatl and the Venus Star', *Genealogy* 5, no. 2 (2021).
95. A. de Vos and M.W. Schwartz, 'Confronting Parachute Science in Conservation', *Conservation Science and Practice* 4, no. 5 (2022): e12681.
96. P.V. Stefanoudis, W.Y. Licuanan, T.H. Morrison, S. Talma, J. Veitayaki and L.C. Woodall, 'Turning the Tide of Parachute Science', *Current Biology* 31, no. 4 (2021): R184–R5; A. de Vos, 'Stowing Parachutes, Strengthening Science', *Conservation Science and Practice* 4, no. 5 (2022): e12709.
97. PFII, Report of the International Workshop on Methodologies Regarding Free, Prior and Informed Consent and Indigenous Peoples.
98. Hubert, *Between Scylla and Charybdis*.
99. Gryseels et al., 'Human Zoo'.
100. Cambou, 'The UNDRIP and the Legal Significance of the Right of Indigenous Peoples to Self-determination'.
101. Juarez et al., 'Opposing Role of Trust as a Modifier of COVID-19 Vaccine Uptake in an Indigenous Population'.

## Acknowledgements

Many thanks to the Brocher Foundation and the Geneva Science and Diplomacy Anticipator for hosting this important and timely workshop on the Human Right to Science and supporting my attendance. Many thanks to Monica Plozza for introducing me to the literature on intersectional universality and to Samantha Besson for very helpful comments on an earlier version of this manuscript. Thanks also to Maria Tengö for wonderful collaboration and permission to use and adapt a figure from previous work, and to anonymous reviewers who commented on the article for this journal. I would like to also thank the many Indigenous colleagues and their non-Indigenous supporters and allies in science, government and community organisations with whom I have had the honour to collaborate and develop the ideas in this article. I acknowledge, thank and respect the First Peoples, Traditional Owners, custodians and knowledge-holders across our globe and their Elders past, present and emerging future leaders. I thank them for their ongoing efforts to create a just and sustainable future.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

This work was supported by Foundation Brocher.

## Notes on contributor

*Dr. Rosemary Hill* is an internationally recognised expert in the science of ecosystem governance and multiple knowledge systems for sustainability and global environmental change, including rights-based approaches, futures thinking and social justice. She has extensive experience in systems-thinking, relational interactions, transdisciplinary applied science and cross-cultural research with Indigenous peoples. Ro has published more than 60 peer-reviewed journal articles on these topics. She holds an honorary position as Professor in Tropical Environments and Societies with James Cook University in Australia. Ro is a member of the IUCN Commission on Environment Economic and Social Policy, the World Commission on Protected Areas, and has served on global assessments for the Intergovernmental Platform on Biodiversity and Ecosystem Services.