REVIEW

A literature review analysis of engagement with the Nagoya Protocol, with specific application to Africa

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The 2010 Nagoya Protocol is an international framework for access and benefit sharing (ABS) of the use of genetic and biological resources, with particular focus on indigenous communities. This is especially important in Africa, where local communities have a close reliance on environmental resources and ecosystems. However, national legislation and policies commonly lag behind international agreements, and this poses challenges for legal compliance as well as practical applications. This study reviews the academic literature on the Nagoya Protocol and ABS applications, and then considers the implications of this analysis for research in Africa. Results show that there is uneven engagement with the principles of the Nagoya Protocol across different academic disciplines; local communities are sometimes sidelined in these studies; and only 8% of researchers in the literature analysed are located in Africa. Future developments should focus on ensuring national compliance with the Nagoya Protocol, and that researchers and industry work in partnership with local African communities on ABS issues.

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The 2010 Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilisation, herein termed the Nagoya Protocol, is an international framework for access and benefits sharing (ABS) arising from the use of genetic and biological resources.[1,2] The Nagoya Protocol builds from the 2002 Bonn Guidelines of the Convention on Biological Diversity.[3] The Nagoya Protocol came into force in October 2014,[4,5] and its applications and limitations have been discussed in several studies.[6,7] Globally, 136 countries are now parties to the Nagoya Protocol (as of July 2022), including 48 African countries or territories. The Nagoya Protocol provides an enhanced framework for ABS because it has a particular focus on indigenous communities and traditional (indigenous) knowledge systems (TKS) related to the use of genetic and biological resources. Traditional knowledge refers to the types of traditional, customary and culturally influenced knowledge held by indigenous communities.[8] ABS as a process is useful because it brings together different stakeholders and user communities, and these relations can be expressed through signing of agreements on: (*i*) mutually agreed terms; (*ii*) intellectual property (IP) rights; (*iii*) the nature and scope of community benefits; (*iv*) the import/export of biological materials; and (*v*) contributions to biobanks and genebanks.[9,10] ABS agreements thus allow for access and benefits to be shared among different stakeholders.[11-13] This can lead to greater equity in research and industrial partnerships, emphasising the importance of local communities in the custodianship of TKS.[9,14] The Nagoya Protocol, as a development of the Convention on Biological Diversity is also important for strategies towards enhancing both local and global biodiversity and ecosystem functions that promote climate change resilience and sustainability.[15-17] Reporting of compliance with the provisions of the Nagoya Protocol is done at a national level through the Access and Benefit Sharing Clearing-House (ABSCH), and according to the requirements of article 18, paragraph 3, of the Convention on Biological Diversity.

However, national-scale legislation and policies for ABS often lag behind international agreements such as the Nagoya Protocol.[18,19] This may pose challenges with respect to national compliance with the Nagoya Protocol and other such agreements, even for countries that are parties to them.[20-23] By contrast, the actions of researchers in the field of genetic and biological resources tend to be more nimble and responsive, and field-based researchers are well placed to test the applicability and usefulness of national and international guidelines, to liaise with key stakeholder communities such as local people, and develop strategies for ABS.[24-26] These issues are particularly important in the developing world, where exploitation of ecosystems, and therefore the use of genetic and biological resources by local communities, is critical for regional socioeconomic development as well as for cultural practices and identity.[27-29]

There are several international and African-focused strategies on sharing expertise and knowledge, in particular in the area of ABS. For example, a joint Dutch-German ABS capacity-building initiative was developed in 2006 in order to work with indigenous communities

and other stakeholders in the development and exploitation of plant genetic and biological data for medical and health applications.[30] The relationship between such an initiative and African forest resources in particular (in which forests are areas of high genetic and biological diversity) is shown by co-ordination of work with the Central Africa Forest Commission (COMIFAC) that has resulted in a regional ABS strategy for COMIFAC countries. There is also an African Union strategic guideline framework document for ABS activities.[31] Several other studies also describe the broader links between ABS, sustainable development and the United Nations Sustainable Development Goals.[32,33] The African Regional Intellectual Property Organization (ARIPO) includes many (but not all) southern African countries, and has also developed a framework document for ABS.[34] However, this is more of a statement of general principles rather than offering member countries specific guidelines. The Swakopmund Protocol on the Protection of Traditional Knowledge and Expressions of Folklore,[8] which is also part of the African Regional Intellectual Property Organization group, briefly mentions genetic resources and traditional knowledge, but no details are given. Thus, there exist regional-scale guidelines on both the Nagoya Protocol and ABS, but these generally lack clear methodologies around community engagement, and do not adequately define the scope of ABS.

To develop a better understanding of the extent to which researchers, as 'first responders', are engaging with the principles of the Nagoya Protocol, this study analyses the peer-reviewed literature that discusses or applies the principles of the Nagoya Protocol in research contexts, with particular reference to Africa. This review emphasises the strategies employed for genetic and biological resource research and management, the role of stakeholders, local communities and TKS, and the roles and limitations of governmental institutions and practices in ABS. This approach is taken because these elements are most relevant in a developing world context where there are close and long-standing relationships between local communities and their use of ecological resources, and which are thus settings where the Nagoya Protocol has most relevance.[33]

Methods

The present study presents and discusses the results of a literature review undertaken using two academic search engines of the Web of Knowledge (http://apps.webofknowledge.com/) and Scopus (https://www.scopus.com/) in July 2022. The search term 'Nagoya Protocol' was used in both instances. The results of this search are examined with respect to the number of research articles published over time, their geographical and thematic focus, and the country of affiliation of authors. The results are discussed with specific reference to research applications in Africa.

Results

Literature analysis

There is significant literature on the Nagoya Protocol internationally. The search engine results identify 320 academic journal articles using Web of Knowledge (with the earliest record from 2011), and 414 academic journal articles using Scopus (with the earliest record from 2010) (Table 1). The relevant academic literature was then accessed and analysed for this review. There is a general increase in academic discussion of the Nagoya Protocol after it came into force in 2014 (Table 1).

In terms of academic discipline, there has been most discussion of the Nagoya Protocol in the context of plant science, in particular with respect to plant genetics (Table 2). It is also notable that there has been discussion of the legal and regulatory framework of the Nagoya Protocol (Table 2), and with respect to engagement at a national level with this framework through legislation as described in the ABSCH. There is also extensive discussion in the literature on the advantages, limitations, opportunities and policy gaps at the national level,[25,35] although there is patchy information for many African countries, and how these map on to other international treaties and structures.[21] Concern in other academic disciplines (Table 2) has focused mainly on implications of the Nagoya Protocol for research activities and cross-border access to genetic materials relevant to those disciplines, such as genetic data on marine organisms[36,37] or in microbiology.[38,39]

Examination of the country of institutional affiliation of the article authors is presented in Table 3. This indicates a clear dominance by researchers in the developed world, in particular in Europe. This may reflect the historical and colonial dominance of these countries in work on plant genetics, ecology, biomedicine, microbiology and biochemistry, but may also reflect the importance placed on the Nagoya Protocol by researchers engaging with the export of biological and genetic materials on a global scale, from field research sites in biodiversity hotspots in South America, Africa and Asia. In terms of authorship, only 50 out of 679 authors (7.36%) from the Web of Knowledge database are from Africa (53 of 708 (7.48%) from Scopus). Of those from Web of Knowledge, only 15 (30%) are from South Africa (SA), with the next highest (6 (12%)) from Kenya. This figure belies the important role of biological resources and biodiversity in Africa. However, in total 18 (22%) African countries feature on the list of author affiliations, from the 81 countries or territories that are listed as author affiliations, in both databases.

Application of the Nagoya Protocol to specific disciplines

The practical applications of the principles of the Nagoya Protocol to different academic disciplines, and to research activities more generally, have been examined in several studies, in particular in the fields of microbiology and biomedicine. These studies show that the principles of the Nagoya Protocol cannot be uncritically deployed across different disciplines,[26] such as the nature or role of ABS as applied to the development of pharmaceutic products.[38,40] Smith *et al*.[39] describe the limitations of researchers being able to use certain genetic resources in the field of microbiology. They demonstrate how the Nagoya Protocol and other instruments might negatively influence the global research landscape, directing research into certain countries while hindering the development of research in others, according to the robustness of national regulatory frameworks developed in compliance with the Nagoya Protocol. There is also a lack of clarity in the relationship between the Nagoya Protocol and the 1982 United Nations Convention on the Law of the Sea for research into the marine environment, both within and outside of national exclusive economic zones.[36,37] Open-access genetic libraries have been proposed as one way to increase co-operation between researchers and countries, particularly in the field of medical bioprospecting.[41] Other work has emphasised the application of the Nagoya Protocol towards developing stakeholder rights and ABS.[28,42]

Table 1. Numbers of academic journal articles that discuss the Nagoya Protocol from Web of Knowledge and Scopus (accessed 7 July 2022)

Year	Web of Knowledge	Scopus
2022 (to date)	15	23
2021	67	56
2020	50	52
2019	47	43
2018	35	49
2017	32	38
2016	21	30
2015	19	28
2014	17	31
2013	9	44
2012	3	7
2011	5	10
2010	0	3
Total	320	414

Table 2. Top 10 listing of subject areas of academic journal articles from the Web of Knowledge search engine (accessed 7 July 2022) that discuss the Nagoya Protocol*

Subject area	Articles, *n*
Plant Science	59
Law	41
Environmental Studies	36
Biotechnology and Applied Microbiology	27
Zoology	25
Ecology	23
Environmental Sciences	22
Pharmacology/Pharmacy	22
Biodiversity Conservation	21
Chemistry – Medical	20
(Other subject areas)	24
Total	320

*Scopus is not considered here because it does not classify subject areas in the same way as Web of Knowledge, but only under broad categories such as Social Science, or Medicine.

Table 3. Top 10 countries of affiliation of authors of academic journal articles that discuss the Nagoya Protocol, from Web of Knowledge and Scopus (accessed 7 July 2022)*

Country	Web of Knowledge articles, *n*	Scopus articles, *n*
UK	**68**	59
USA	55	52
Germany	52	**60**
France	51	32
Australia	37	40
Belgium	31	39
Spain	24	18
Netherlands	22	22
Brazil	22	19
Switzerland	19	24
(Others)	298	343
Total	679	708

*The modal class in both instances is in bold.

A critique of the Nagoya Protocol and approaches to stakeholder engagement

A key element of the Nagoya Protocol, as emphasised in the ABS, is active and collaborative engagement with different stakeholder groups, including indigenous communities. However, the definition of who stakeholders are, and who indigenous communities are, is controversial and multifaceted.[43-45] Some national reports for some African countries, as given in the ABSCH, state incorrectly that no indigenous communities are present. The degree of stakeholder engagement may also reflect how vocal certain groups are, and that the voices of some indigenous communities may be muted or ignored altogether.[46]

Such issues with respect to TKS and the Nagoya Protocol may pose problems for (*i*) how genetic and biological research activities are managed in individual countries; and (*ii*) how these management frameworks then feed into ABS.[10,19,47] A narrative on the Nagoya Protocol negotiation process highlights the disparate viewpoints taken by different actors, and the precise role and meaning of ABS.[47] This highlights the contested, multifaceted and contextual nature of ABS. The broader role of TKS with respect to distributive and social justice is a globally relevant issue, and is based on community use of ecosystem properties and services.[48,49] One key element is the challenge of formalising the dynamics of traditional, informal and vernacular cultural systems because these are the means by which indigenous communities have historically made use of genetic and biological resources.[27,29] Formalising these relationships with national governments and with other stakeholder agencies is necessary before all stakeholders, collectively, can work towards agreeing ABS and achieving conformity with the Nagoya Protocol.[45]

It is notable that establishing a robust framework for developing collaborative partnerships and management of research data is lacking in many countries, and there is still a lack of communication between relevant stakeholders.[50,51] An exception is a study by Rakotondrabe and Girard,[45] who showed how local biocultural community protocols, as a framework for articulating the viewpoints of local communities in ABS negotiations, have been successfully deployed in Madagascar. Several studies have also examined stakeholder relationships from a top-down approach, and discussed the disconnect between the requirements of the Nagoya Protocol and applying these requirements to the varying needs of different indigenous communities, who should not be considered as a homogeneous global group.[11] There are also inconsistencies with the 2007 United Nations Declaration on the Rights of Indigenous Peoples, which talks about the role of customary laws and the importance of self-determination, but not about the nature of data sharing or its legal implications, including ABS and IP. Several studies have discussed potential ways to move forward on these issues, including establishing IP protocols for biological resources[23] and informed consent strategies for ethnobotanical research,[52,53] but these ideas are still not well developed in the literature and require inputs from many different disciplinary perspectives (legal, ecological, ethnographic, biomedical, linguistic).

Benefits sharing

The meaning and conceptual basis of 'benefits' is problematic because benefits may vary from short to long term, direct and indirect, and for both people (individuals, communities, nation states) and the

environment (climate, biodiversity, water quality, etc.). The identification within the Nagoya Protocol of monetary and non-monetary benefits is one way of classifying benefits,[54] but it may not be the only or best way since it does not explicitly refer to, for example, aspects of community cohesion, well-being or environmental impacts.[2,43] This contested nature of 'benefits' therefore means that they should be considered in several different ways, which has not been done with respect to ABS and the Nagoya Protocol and is, indeed, difficult to formalise in written agreements. This is because the Nagoya Protocol deals with benefits in only a limited sense, and is specifically related to the transfer of data on genetic and biological materials.[11] Other potential long-term, indirect or non-material benefits are not considered, or lie outside the scope of the Nagoya Protocol, and thus are often not considered as an element of ABS. Additionally, by definition, confirmation of benefits can only be undertaken in hindsight, and in some cases proposed benefits may not materialise, while other unforeseen benefits or drawbacks may arise. The peer-reviewed literature on ABS focuses mainly on the administrative procedures for data sharing[1,26,55,56] and not the real, lived experiences of these stakeholders or their recognition of ABS, especially by local communities.[45]

A comparison of benefit-sharing mechanisms employed by different countries shows that substantial disagreement exists on the definition and scope of ABS, whereas there is much more agreement on issues such as capacity building and technology transfer.[57,58] It is also noted that many African countries have benefit-sharing mechanisms in place, but sometimes these are without the national legislative framework to legally guide such activities.[59,60] Studies with different stakeholders also reveal variable levels of understanding or expectations of benefit sharing.[56,61,62] In addition, different disciplines may have different requirements for ABS, and this might limit the extent to which the Nagoya Protocol can apply in all situations.[60,63,64] Likewise, Smith *et al*.[18] identified inconsistencies between the Nagoya Protocol and EU Regulation No. 511/2014 on ABS that may have implications for cross-country data sharing in international projects. These studies highlight that there is no single solution for reconciling the requirements of the Nagoya Protocol with national legal and regulatory frameworks while also ensuring that ABS is done systematically, equitably, and with reference to ensuring openness and appropriate IP.[57,65]

Discussion

Limitations of the Nagoya Protocol

Studies highlight that international research collaborations, in particular through the exchange or transfer of biological and genetic materials, may at least initially be hindered by the requirements of the Nagoya Protocol.[25] Regulations for biosafety and biosecurity (highlighted by the present context of COVID-19) have been flagged as a major positive outcome of applying the Nagoya Protocol,[66,67] but most of the literature highlights discipline-specific problems with the Nagoya Protocol rather than its advantages. Key issues include the role of different institutions nationally and internationally. This is because some regulatory frameworks and national legislation predate the Nagoya Protocol[59] and thus there may be multiple contexts in which biological and genetic resources are used and managed.[21,60,68] Indeed, the conceptual basis for the identification of biological and genetic resources is multifaceted because of the varied ways in which these resources can be used by different communities.[69] However, it is notable that the Nagoya Protocol specifically discusses genetic and biological resources only, and the wider agroecosystem context is missing, and areas of overlap or thematic gaps between the Nagoya Protocol and other existing research and regulatory frameworks are not well articulated.[21,70] These are key limitations in the ways in which the Nagoya Protocol has been developed, and the potential for individual countries to adopt the principles of the Protocol while also adapting these principles to their existing laws,[1] or the practical needs of researchers in different disciplines in their countries.[71]

Applications to Africa

The presence of African researchers and decision-makers in ABS activities, including the Nagoya Protocol, is significantly less than that from other regions (Table 3).[14] Therefore, it can be said that African voices are less influential in shaping international debates on ABS despite the importance of genetic and biological resources for indigenous communities in Africa. Deplazes-Zemp *et al*.[72] describe how inequalities in the development and application of Nagoya Protocol negotiations could negatively impact on the global south, enhancing such inequalities. This may be particularly the case concerning African genetic resources, where bioprospecting and biotrading are important issues that have implications for legitimate and equitable ABS, but also where indigenous communities may not be involved as equal partners in decision-making and management.[68,73] One example of the involvement of indigenous communities in ABS is the Rooibos Benefit Sharing Agreement signed by the San, Khoi and the SA rooibos producers' industry in 2019.[74] This agreement, which arose out of nine years of negotiations between these stakeholders, is a good example of how the principles of the Nagoya Protocol can be applied to a specific industry and involving the relevant stakeholders, with reference to IP, social and distributive justice, and sustainability.[14] This shows how different stakeholders in an African context can work collaboratively towards an equitable solution for producers, communities, industry and researchers alike.[74]

Exploitation of environmental resources and the global commons

Air, water, soils and vegetation can be considered as global commons, and thus are key resources that governments should collaboratively manage and steward for future generations, both locally and globally.[16,20,75-77] Several studies have examined the uneasy relationship between the local and global contexts of resource management and stewardship.[20,68] These studies recognise that policies towards resource management may be contradictory and geopoliticised, and include international law, access, IP and state sovereignty. For example, environmental decision-making is based on national-scale priorities, and non-co-operation between individual countries can lead to overproduction, overconsumption and overpollution.[78] Game theory has been used to consider the likelihood of successful intergovernmental environmental negotiations,[20,78] and this has implications for the potential success of Nagoya Protocol-framed negotiations between individual countries. There have also been studies that explicitly consider the global commons of genomic resources, focusing in particular on the development of methodologies for data sharing.[59,68,79] These approaches range from self-regulation by data holders[80] to collective

decision-making,[77] to market-driven trading mechanisms,[75] to hybrid commons and private regulation of different resource types.[76] These different approaches may be useful with respect to the management of biological and genetic resources.

Conclusions

The Nagoya Protocol offers a consistent and globally applicable framework for ABS, and is particularly significant for regions such as Africa where local communities have a close socioeconomic and cultural relationship with environmental resources, including ecosystems and biodiversity. Despite these opportunities, there are variable degrees of engagement and compliance with the Nagoya Protocol at the national level, both in Africa and globally, and this is a significant limitation to how these principles can be applied in practice. Key future developments with respect to Africa should include: (*i*) ensuring the compliance of national legislation and governance policies with the Nagoya Protocol; (*ii*) national and international research and industry applications to work in partnership with local communities, as co-collaborators and as change agents; (*iii*) working with stakeholders in recognising and negotiating ABS; (*iv*) viewing such partnerships as a means of increasing community resilience and protecting TKS; and (*v*) recognising the relationship of the Nagoya Protocol to wider issues such as the Sustainable Development Goals.

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Conflicts of interest. None.

1. Kariyawasam K, Tsai M. Access to genetic resources and benefit sharing: Implications of Nagoya protocol on providers and users. J World Intellect Prop 2018;21(5-6):289-305. https://doi.org/10.1111/jwip.12095
2. Avilés-Polanco G, Jefferson DJ, Almendarez-Hernández MA, Beltrán-Morales LF. Factors that explain the utilisation of the Nagoya Protocol framework for access and benefit sharing. Sustainability 2019;11(20):5550. https://doi.org/10.3390/su11205550.
3. Secretariat of the Convention on Biological Diversity. Bonn guidelines on access to genetic resources and fair and equitable sharing of the benefits arising out of their utilisation. Secretariat of the Convention on Biological Diversity, Montreal, 2002.
4. Zainol ZA, Amin L, Akpoviri F, Ramli R. Biopiracy and states' sovereignty over their biological resources. Afr J Biotechnol 2011;10(58):12395-12408. https://doi.org/10.5897/AJB11.1059
5. Sirakaya A. Is the Nagoya Protocol designed to conserve biodiversity? Plants People Planet 2022;4(1):6875. https://doi.org/10.1002/ppp3.10221
6. Lajaunie C, Morand S. Nagoya Protocol and infectious diseases: Hindrance or opportunity? Front Public Health 2020;8:238. https://doi.org/10.3389/fpubh.2020.00238.
7. Sherman B, Henry RJ. The Nagoya Protocol and historical collections of plants. Nature Plants 2020;6(5):430-432. https://doi.org/10.1038/s41477-020-0657-8
8. African Regional Intellectual Property Organization. Swakopmund Protocol on the Protection of Traditional Knowledge and Expressions of Folklore. Swakopmund: ARIPO, 2010.
9. Aguilar Delgado N, Perez-Aleman P. Inclusion in global environmental governance: Sustained access, engagement and influence in decisive spaces. Sustainability 2021;13(18):10052. https://doi.org/10.3390/su131810052
10. Zheng X. Empowering indigenous peoples and local communities: A human rights-based appraisal of the compliance mechanism of the Nagoya Protocol. RECIEL 2021;30(1):61-72. https://doi.org/10.1111/reel.12343
11. Arjjumend H. Recognition of indigenous peoples in access and benefit sharing (ABS) legislation and policies of the parties to the Nagoya Protocol. BRICS Law J 2018;5(3):86-113. https://doi.org/10.21684/2412-2343-2018-5-3-86-113
12. Mekonnen DK, Spielman DJ. Changing patterns in genebank acquisitions of crop genetic materials: An analysis of global policy drivers and potential consequences. Food Pol 2021;105:102161. https://doi.org/10.1016/j.foodpol.2021.102161
13. Vogel JH, Ruiz Muller M, Angerer K, et al. Bounded openness: A robust modality of access to genetic resources and the sharing of benefits. Plants People Planet 2022;4(1):13-22. https://doi.org/10.1002/ppp3.10239
14. Coolsaet B, Pitseys J. Fair and equitable negotiations? African influence and the international access and benefit-sharing regime. Glob Env Pol 2015;15(2):38-56. https://doi.org/10.1162/GLEP_a_00297
15. Koskela J, Vinceti B, Dvorak W, et al. Utilisation and transfer of forest genetic resources: A global review. Forest Ecol Manag 2014;333:22-34. https://doi.org/10.1016/j.foreco.2014.07.017
16. Davidson MD. Equity and the conservation of global ecosystem services. Sustainability 2017;9(3):339. https://doi.org/10.3390/su9030339
17. Coolsaet B, Dawson N, Rabitz F, Lovera S. Access and allocation in global biodiversity governance: A review. Int Env Agree 2020;20(2):359-375. https://doi.org/10.1007/s10784-020-09476-6
18. Smith D, Hinz H, Mulema J, Wey P, Ryan MJ. Biological control and the Nagoya Protocol on access and benefit sharing – a case of effective due diligence. Biocontr Sci Technol 2018;28(10):914-926. https://doi.org/10.1080/09583157.2018.1460317
19. Humphries F, Lawson C, Benzie JAH, Morrison C. African aquaculture: Genetic resource and traditional knowledge access and benefit sharing measures. Rev Fish Sci Aquacult 2022(epub). https://doi.org/10.1080/23308249.2022.2027866
20. Bodnar T, Salathé M. Governing the global commons with local institutions. PLoS ONE 2012;7(4):e34051. https://doi.org/10.1371/journal.pone.0034051
21. Oberthür S, Pozarowska J. Managing institutional complexity and fragmentation: The Nagoya Protocol and the global governance of genetic resources. Glob Env Pol 2013;13(3):100-118. https://doi.org/10.1162/GLEP_a_00185
22. Pauchard N. Access and benefit sharing under the convention on biological diversity and its protocol: What can some numbers tell us about the effectiveness of the regulatory regime? Resources 2017;6(1):11. https://doi.org/10.3390/resources6010011
23. Eimer TR, Bartels T. From consent to consultation: Indigenous rights and the new environmental constitutionalism. Env Pol 2020;29(2):235-256. https://doi.org/10.1080/09644016.2019.1595884
24. Welch EW, Shin E, Long J. Potential effects of the Nagoya Protocol on the exchange of non-plant genetic resources for scientific research: Actors, paths, and consequences. Ecol Econ 2013;86:136-147. https://doi.org/10.1016/j.ecolecon.2012.11.019
25. Nijar GS, Louafi S, Welch EW. The implementation of the Nagoya ABS Protocol for the research sector: Experience and challenges. Int Env Agree 2017;17(5):607-621. https://doi.org/10.1007/s10784-016-9328-7
26. Friso F, Mendive F, Soffiato M, et al. Implementation of Nagoya Protocol on access and benefit-sharing in Peru: Implications for researchers. J Ethnopharmacol 2020;259:112885. https://doi.org/10.1016/j.jep.2020.112885
27. Robinson DF, Raven M. Recognising indigenous customary law of totemic plant species: Challenges and pathways. Geogr J 2020;186(1):31-44. https://doi.org/10.1111/geoj.12320
28. Fredriksson M. Dilemmas of protection: Decolonising the regulation of genetic resources as cultural heritage. Int J Heritage Stud 2021;27(7):720-733. https://doi.org/10.1080/13527258.2020.1852295
29. Robinson D, Raven M, Makin E, et al. Legal geographies of Kava, Kastom and indigenous knowledge: Next steps under the Nagoya Protocol. Geoforum 2021;118:169-179. https://doi.org/10.1016/j.geoforum.2020.11.001
30. BMZ. The ABS capacity development initiative 2006-2016: Supporting the implementation of access and benefit-sharing. Bonn: BMZ, 2016.
31. African Union Commission. African Union Practical Guidelines for the Coordinated Implementation of the Nagoya Protocol in Africa. Addis Ababa: African Union, 2015.
32. United Nations Development Program. ABS in Genetic Resources for Sustainable Development. New York: UNDP, 2018.

33. Laird SA, Wynberg R. Connecting the dots: Biodiversity conservation, sustainable use and access and benefit sharing. BioInnovation Africa, University of Cape Town, 2021.
34. African Regional Intellectual Property Organization. Policy Framework on Access and Benefit Sharing Arising From the use of Genetic Resources in the ARIPO Member States: A Guide for ARIPO Member States. ARIPO, Harare, 2016.
35. Rosendal K, Andresen S. Realizing access and benefit sharing from use of genetic resources between diverging international regimes: The scope for leadership. Int Env Agree 2016;16(4):579-596. https://doi.org/10.1007/s10784-014-9271-4
36. Lallier LE, McMeel O, Greiber T, et al. Access to and use of marine genetic resources: Understanding the legal framework. Nat Product Rept 2016;31(5):612-616. https://doi.org/10.1039/c3np70123a
37. Xiao N, Ahagon N, Kubo Y, Morioka H. Preparing for the new age of the Nagoya Protocol in scientific ocean drilling. Scientific Drill 2018;24:51-59. https://doi.org/10.5194/sd-24-51-2018
38. Overmann J, Scholz AH. Microbiological research under the Nagoya Protocol: Facts and fiction. Trends Microbiol 2017;25(2):85-88. https://doi.org/10.1099/mic.0.000425
39. Smith S, da Silva M, Jackson J, Lyal C. Explanation of the Nagoya Protocol on access and benefit sharing and its implication for microbiology. Microbiology 2017;163(3):289-296.
40. Keiper F, Atanassova A. Regulation of synthetic biology: Developments under the convention on biological diversity and its protocols. Front Bioeng Biotech 220;8:310. https://doi.org/10.3389/fbioe.2020.00310
41. Skirycz A, Kierszniowska S, Méret M, et al. Medicinal bioprospecting of the Amazon rainforest: A modern Eldorado? Trends Biotech 2016;34(10):781-790. https://doi.org/10.1016/j.tibtech.2016.03.006
42. Halewood M, Villanueva AB, Rasolojaona J, et al. Enhancing farmers' agency in the global crop commons through use of biocultural community protocols. Agric Human Val 2021;38(2):579-594. https://doi.org/10.1007/s10460-020-10164-z
43. Sirakaya A. A balanced ABS System: Stakeholder perception on ABS Goals. Sustain Develop 2020;28(3):495-503. https://doi.org/10.1002/sd.2040
44. Sirakaya A, De Brucker K, Vanagt T. Designing regulatory frameworks for access to genetic resources: A multi-stakeholder multi-criteria approach. Front Genetics 2020;11:549836. https://doi.org/10.3389/fgene.2020.549836
45. Rakotondrabe M, Girard F. Protecting traditional knowledge through biocultural community protocols in Madagascar: Do not forget the 'B' in BCP. Sustainability 2021;13(18):10255. https://doi.org/10.3390/su131810255
46. Karger EJ, Scholz AH. DSI, the Nagoya Protocol, and stakeholders' concerns. Trends Biotech 2021;39(2):110-112. https://doi.org/10.1016/j.tibtech.2020.09.008
47. Suiseeya KRM. Negotiating the Nagoya Protocol: Indigenous demands for justice. Glob Env Pol 2014;14(3):102-124. https://doi.org/10.1162/GLEP_a_00241
48. Savaresi A. REDD+ and human rights: Addressing synergies between international regimes. Ecol Soc 2013;18(3):5. https://doi.org/10.5751/ES-05549-180305
49. Sikor T, Martin A, Fisher J, He J. Toward an empirical analysis of justice in ecosystem governance. Conserv Lett 2014;7(6):524-532. https://doi.org/10.1111/conl.12142
50. Cámara-Leret R, Paniagua-Zambrana N, Svenning J-C, et al. Geospatial patterns in traditional knowledge serve in assessing intellectual property rights and benefit-sharing in Northwest South America. J Ethnopharmacol 2014;158(A):58-65. https://doi.org/10.1016/j.jep.2014.10.009
51. Parks L. Challenging power from the bottom up? Community protocols, benefit-sharing, and the challenge of dominant discourses. Geoforum 2018;88:87-95. https://doi.org/10.1016/j.geoforum.2017.11.011
52. McCune LM. The protection of indigenous peoples' seed rights during ethnobotanical research. Ethnobiol Lett 2018;9(1):67-75. https://doi.org/10.14237/ebl.9.1.2018.1076
53. Uehara T, Sono M, Tsuge T, Onuma A. Can prior informed consent create a virtuous cycle between biodiversity conservation and genetic resources utilisation? J Env Manag 2021;300:113767. https://doi.org/10.1016/j.jenvman.2021.113767
54. Jonas H, Bavikatte K, Shrumm H. Community protocols and access and benefit sharing. Asian Biotech Develop Rev 2010;12(3):49-76.
55. Davis K, Smit MF, Kidd M, et al. An access and benefit-sharing awareness survey for botanic gardens: Are they prepared for the Nagoya Protocol? S Afr J Bot 2015;98:148-156. https://doi.org/10.1016/j.sajb.2015.01.015
56. Heinrich M, Scotti F, Andrade-Cetto A, et al. Access and benefit sharing under the Nagoya Protocol – quo vadis? Six Latin American case studies assessing opportunities and risk. Front Pharmacol 2020;11:765. https://doi.org/10.3389/fphar.2020.00765
57. Sirakaya A. Balanced options for access and benefit-sharing: Stakeholder insights on provider country legislation. Front Plant Sci 2019;10:1175. https://doi.org/10.3389/fpls.2019.01175
58. Silvestri L, Sosa A, McKay F, et al. Implementation of access and benefit-sharing measures has consequences for classical biological control of weeds. BioControl 2020;65(2):125-141. https://doi.org/10.1007/s10526-019-09988-4
59. Crouch NR, Douwes E, Wolfson MM, et al. South Africa's bioprospecting, access and benefit-sharing legislation: Current realities, future complications, and a proposed alternative. S Afr J Sci 2018;104(9-10):355-366.
60. Michiels F, Feiter U, Paquin-Jaloux S, et al. Facing the harsh reality of access and benefit sharing (ABS) legislation: An industry perspective. Sustainability 2022;14(1):277. https://doi.org/10.3390/su14010277
61. Dedeurwaerdere T, Melindi-Ghidi P, Broggiato A. Global scientific research commons under the Nagoya Protocol: Towards a collaborative economy model for the sharing of basic research assets. Env Sci Pol 2016;55(1):1-10. https://doi.org/10.1016/j.envsci.2015.08.006
62. Wang SW, Lee WK, Brooks J, Dorji C. Awareness of the convention on biological diversity and provisions regarding access and benefit sharing among multiple stakeholder groups in Bhutan. Oryx 2020;54(5):735-742. https://doi.org/10.1017/S0030605318000819
63. Humphries F, Benzie JAH, Morrison C. A systematic quantitative literature review of aquaculture genetic resource access and benefit sharing. Rev Aquacult 2019;11(4):1133-1147. https://doi.org10.1111/raq.12283
64. Ambler J, Diallo AA, Dearden PK, et al. Including digital sequence data in the Nagoya Protocol can promote data sharing. Trends Biotech 2021;39(2):116-125. https://doi.org/10.1016/j.tibtech.2020.06.009
65. Smyth SJ, Macall DM, Phillips PWB, de Beer J. Implications of biological information digitisation: Access and benefit sharing of plant genetic resources. J World Intellect Prop 2020;23(3-4):267-287. https://doi.org/10.1111/jwip.12151
66. Oliva MJ. Sharing the benefits of biodiversity: A new international protocol and its implications for research and development. Planta Medica 2011;77(11):1221-1227. https://doi.org/10.1055/s-0031-1279978
67. Beeckman DSA, Rüdelsheim P. Biosafety and biosecurity in containment: A regulatory overview. Front Bioeng Biotech 2020;8:650. https://doi.org/10.3389/fbioe.2020.00650
68. Wynberg R, Laird S, van Niekerk J, Kozanayi W. Formalisation of the natural product trade in southern Africa: Unintended consequences and policy blurring in biotrade and bioprospecting. Soc Nat Res 2015;28(5):559-574. https://doi.org/10.1080/08941920.2015.1014604
69. Deplazes-Zemp A. 'Genetic Resources', an analysis of a multifaceted concept. Biol Conserv 2018;222:86-94. https://doi.org/10.1016/j.biocon.2018.03.031
70. Leung K, Ras E, Ferguson KB, et al. Next-generation biological control: The need for integrating genetics and genomics. Biol Rev 2020;95(6):1838-1854. https://doi.org/10.1111/brv.12641
71. Vindigni G, la Terra G, Bellia C. The complex framework of access and benefit sharing under the international policy arena. Qual Access Success 2017;18(S2):468-472.
72. Deplazes-Zemp A, Abiven S, Schaber P, et al. The Nagoya Protocol could backfire on the global south. Nature Ecol Evol 2018;2(6):917-919. https://doi.org/10.1038/s41559-018-0561-z
73. Moody OO. The Nagoya Protocol: A possible solution to the protection of traditional knowledge in biodiverse societies of Africa. LLM dissertation. Cape Town: University of the Western Cape, 2011.
74. Schroeder D, Chennells R, Louw C, et al. The Rooibos Benefit Sharing Agreement – breaking new ground with respect, honesty, fairness, and care. Cambr Quart Healthcare Ethics 2020;29(2):285-301. https://doi.org/10.1017/S0963180119001075
75. Corson C, MacDonald KI. Enclosing the global commons: The convention on biological diversity and green grabbing. J Peasant Stud 2012;39(2):263-283. https://doi.org/10.1080/03066150.2012.664138
76. Halewood M. What kind of goods are plant genetic resources for food and agriculture? Towards the identification and development of a new global commons. Int J Commons 2013;7(1):278-312. https://doi.org/10.18352/ijc.412
77. Sievers-Glotzbach S, Christinck A. Introduction to the symposium: Seed as a commons—exploring innovative concepts and practices of governing seed and varieties. Agric Human Val 2021;38(2):499-507. https://doi.org/10.1007/s10460-020-10166-x
78. Bréchet T, Hritonenko N, Yatsenko Y. Domestic environmental policy and international cooperation for global commons. Res Energy Econ 2016;44:183-205. https://doi.org/10.1016/j.reseneeco.2016.03.002
79. Bond MR, Scott D. Digital biopiracy and the (dis)assembling of the Nagoya Protocol. Geoforum 2020;117:24-32. https://doi.org/10.1016/j.geoforum.2020.09.001
80. Pálsson G, Prainsack B. Genomic stuff: Governing the (im)matter of life. Int J Commons 2011;5(2):259-283. https://doi.org/10.18352/ijc.247

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