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"Regional blocks of ABS": how the blockchain technology could enable a regional solution to transboundary situations

"Blocos regionais de ABS": como a tecnologia blockchain pode possibilitar uma solução regional para situações transfronteiriças

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Resumo

A evolução dos hábitos de consumo, em busca de produtos mais naturais, exige cada vez mais o uso de recursos genéticos para satisfazer as demandas da sociedade. Considerando que muitos desses recursos são provenientes de espécies transfronteiriças e que o acesso a elas e seu emprego em pesquisa e desenvolvimento tecnológico é regulado primeiramente pelos regimes internacionais de ABS, o presente artigo expõe alguns dos limites das normas internacionais, em especial do Protocolo de Nagoya, ao tratar dessas situações em particular, identificando a intenção na elaboração dos regimes. A partir dessa análise, propõe-se uma solução regional, aliada a existente tendência de elaboração de normas nesse nível de governança, a fim de assegurar a efetividade dos regimes. Para a instrumentalização dessa solução, sugere-se a utilização da tecnologia blockchain na criação de plataformas distribuídas, que possam atender aos diversos países, povos tradicionais e usuários envolvidos nas atividades com recursos genéticos e conhecimentos tradicionais associados. A tecnologia permite garantir maior transparência, rastreabilidade e descentralização de dados, além de permitir a automatização e a redução de custos de várias operações, dentre outros atributos, ainda que não esteja isenta de limites, desafios e críticas.

Palavras-chave: ABS, Protocolo de Nagoia, situações transfronteiriças, tecnologia blockchain, soluções regionais

Abstract

The evolution of consumption habits, in search of more natural products, increasingly requires the use of genetic resources to satisfy the demands of society. Considering that many of these resources come from transboundary species and that access to them and their use in research and technological development is primarily regulated by international ABS regimes, the article exposes some of the limits of international standards, especially the Nagoya Protocol, when dealing with these situations in particular, identifying the intention in the elaboration of the regimes. Based on this analysis, a regional solution is proposed, allied to the existing trend towards the elaboration of norms at this level of governance, in order to ensure the effectiveness of the regimes. To implement this solution, the use of blockchain technology is suggested to create distributed platforms that can serve different countries, traditional peoples and users involved in activities with genetic resources and associated traditional knowledge. The technology allows for greater transparency, traceability and decentralization of data, in addition to allowing automation and cost reduction of several operations, among other attributes, although it is not free of limits, challenges and criticisms.

Keywords: *ABS; Nagoya Protocol; transboundary situations; blockchain technology; regional solutions*

Contents

1. Introduction

The movement for leading more "natural" and "clean" lives has seen an exponential growth over the past years (ELBOGHDADY, 2020), and the COVID-19 pandemic might have helped push this agenda even further, as isolated people have started analyzing more intently what and how they are consuming and in which way their consumption habits affect their health and the environment (LATHAM, 2021; ACCENTURE, 2020). The boom of natural and organic beauty products is a clear example of this. Consumers are favoring formulations that explore natural assets and are produced from renewable raw materials over chemical-laden ones, that are perceived both dangerous for human health and for the planet (MARTINS, 2018). This translates in a race within the beauty industry for natural ingredients, where companies rush to develop entire product lines in order to meet and benefit from this demand.

The research and technological development of products from natural assets is inserted in what the Nagoya Protocol to the Convention on Biological Diversity defines as the "utilization of genetic resources" (UNITED NATIONS, 2010, Article 2, item 'c'). Nonetheless, the cosmetics industry is not the only one that largely benefits from natural actives, accompanied by the pharmaceutical, the food and agriculture, amongst various other sectors. These sectors, however, while taking advantage from the resources nature provides, may get involved with what is referred to as biopiracy or bioprospecting. Described as an exploitative manner of utilizing natural resources, it implies the appropriation of biodiversity and traditional knowledge for control and monopolization, through patenting and other forms of intellectual property rights (FREDRIKSSON, 2017, p. 1). It is carried out violating regulation on access to genetic resources and associated

traditional knowledge and benefit sharing (ABS), which usually means without consent or proper compensation.

Established to ensure that the utilization of genetic resources is done respecting the rights of the countries and populations that constitute origin or providers of these resources, the ABS debate has its foundation on the Convention on Biological Diversity, which entered into force in 1993, later expanded and reinforced by the Nagoya Protocol. Almost thirty years later, however, the fight against biopiracy and to promote the providers' rights remains arduous and complex, as one of the main issues for the conservation of biodiversity.

More layers of uncertainty are added to this matter when transboundary situations are analyzed. Involving genetic resources and traditional knowledge that are not confined to a single country, the recognition of sovereign rights and the assignment of responsibilities and obligations become blurred in these cases, as the provisions of international regimes do not provide a concrete answer, but alternatives that end up raising more than solving users' questions.

The search for solutions to improve the monitoring of access to these assets and ensure greater effectiveness in benefit sharing is a constant concern of the actors involved with ABS. In this sense, and considering the intense digitization human relationships have experienced in recent years, this article proposes the focuses on the questions risen by transboundary situations and on whether technologies such as the blockchain, created to establish secure and distributed means of transaction, can be used to achieve these goals, promoting awareness and granting new possibilities to the ABS discussion.

2. The international legal framework for access and benefit-sharing

The discussion about ownership and responsibility over genetic resources largely precedes the establishment of the international regimes that nowadays constitute the framework to the debates involving access and benefit-sharing. Concern with the environment was and is, as mentioned, a growing movement and, since the first global environmental conference, a series of international declarations, conventions and other instruments have been adopted by states in an effort to build awareness,

set goals and develop strategies to implement change and contain and reverse damage.

The Stockholm and Rio Declarations, as results of the first and second international environmental conferences held by the United Nations in 1972 and 1992, respectively, are significant milestones in the evolution of international environmental law (HANDL, 2012, p. 1) and constitute the foundation of the legal and political advocacy for sustainable development.

The declaration that emerged from the United Nations Conference on the Human Environment in Stockholm was a first attempt at setting a basic and common viewpoint on acknowledging and addressing the obstacles towards the preservation of the environment and the improvement of human relationships with it, and gave rise to a number of broad principles. Stockholm also resulted in an Action Plan for the Human Environment and in a few resolutions (HANDL, 2012, p. 1).

The following twenty years, however, showed a rise in awareness and in the demand for more normative international commitments. The United Nations Conference on Environment and Development (UNCED) introduced the Rio Declaration and set ground for several other legal and policy instruments, reaffirming and building upon the principles stated in Stockholm (HANDL, 2012, p. 3). One of these documents, also introduced in the UNCED, is the Convention on Biological Diversity (CBD), "the first attempt by the international community to address biological diversity as a whole in a global legal instrument" (GREIBER et al., 2012, p. 3).

The Convention is foundational to the international discussion of access to genetic resources and associated traditional knowledge and benefit-sharing (ABS), set as one of its three main objectives. Also aiming for the conservation of biological diversity and the sustainable use of its components, the CBD proposes a broad ecosystem approach rather than a focused one on sites or species (GREIBER et al., 2012, p. 3), in an effort to conciliate the interests of developed and developing countries concerning biodiversity. As more than 70% of the world's biodiversity is held by seventeen countries (MORGERA; TSIOUMANI; BUCK, 2015, p. 7), most of them still under development, many states, particularly from "the South", demanded that the costs and benefits arising from its utilization and the technology developed from it be shared, as well as advocated for support for their traditional communities (GREIBER et al., 2012, p. 4).

These multiple interests eventually came together in the text of the Convention, which addressed not only the environmental concern, but also the global social justice issue related to it (FREDRIKSSON, 2021, p. 723). In its effort to be as comprehensive as possible, the Convention defines 'biological diversity' as "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems" (UNITED NATIONS, 1992, Article 2).

The instrument then proceeds to define 'genetic material' ("any material of plant, animal, microbial or other origin containing functional units of heredity") and 'genetic resources' ("genetic material of actual or potential value") (UNITED NATIONS, 1992, Article 2). These definitions enable the understanding of the scope of the Convention, being, as mentioned, an extensive one, excluding human genetics from its jurisdiction. They also evidence the pillars that supported, in 2010, the adoption of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity, as well as other Protocols to the Convention.

The CBD has expressly reaffirmed and recognized, in its Preamble and in Article 15, the sovereign rights of states "over their own biological resources", and has established that "the authority to determine access to these resources rests with the national governments and is subject to national legislation" (UNITED NATIONS, 1992, Preamble and Article 15), as was the highly advocated demand of developing countries. This sovereignty is also reassured by the Nagoya Protocol, stating that countries have rights over their natural resources and access to them is subject to domestic legislation and regulatory requirements (UNITED NATIONS, 1992, Article 6).

Furthermore, the Convention also establishes a principle:

> Article 3. Principle
> States have, in accordance with the Charter of the United Nations and the principles of international law, *the sovereign right to exploit their own resources pursuant to their own environmental policies*, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas

> beyond the limits of national jurisdiction. (UNITED NATIONS, 1992) (Emphasis added)

Martin Fredriksson presents a relevant history of the change in understanding regarding sovereignty over genetic resources, explaining that "a cornerstone of the CBD was to nationalize the ownership of genetic resources" (FREDRIKSSON, 2021, p. 724), which were previously considered "a common heritage of humankind" (WIRTÉN, 2008 apud FREDRIKSSON, 2021, p. 724). This common heritage doctrine emerged in the 1960s resulting from a global social justice movement, rooted in the assumption that global biodiversity could be better preserved if freely collected and stored. The environmentalist movement, however, became increasingly apprehensive about the alarming possibility of mass extinction of species and the developing countries were demanding means to approach the issue of bioprospecting, or biopiracy as it is also referred to. As bioprospecting spread in the 70s and 80s, promoted especially by multinational corporations, the concern of "the South" grew (FREDRIKSSON, 2021, p. 722).

The doctrine of common heritage applied only to non-manipulated germplasm found in nature, and the expanding movement of scientific research, development and patent protection urged the revision of the idea, as it was criticized for endorsing a colonial practice that depreciated and privatized the work of traditional and indigenous communities over generations. As Fredriksson states, "apart from reinforcing global material injustices, biopiracy also has potential cultural repercussions since it tends to decontextualize resources – both the plants themselves and the locally held knowledge on how to use them – that play an important role in local traditions and cultures" (2021, p. 722).

Thus, a strategy to prevent and counter exploitative bioprospecting was first delineated by the Convention in 1992, as it established "the fair and equitable sharing of the benefits arising out of the utilization of genetic resources" as its third objective (UNITED NATIONS, 1992, Article 1). In order to support this provision, the CBD goes on to acknowledge, among other topics, the sovereign rights of states "to control and refuse other parties access to genetic resources found within their borders" (WIRTÉN, 2008; OBERTHÜR and KRISTIN ROSENDAL, 2014; ROSENDAL and ANDERSEN, 2016

apud FREDRIKSSON, 2021, p. 725), permanently halting the 'common heritage' approach. By empowering the sovereign states, the Convention intended to repress the more predatory forms of privatization of genetic resources as it affirmed states' right to establish the conditions under which national and foreign actors would be granted access to their resources (FREDRIKSSON, 2021, p. 725).

This history clarifies the intentions of the CBD, and of the Protocol by extension, when stating the rights of the countries to "exploit their own resources pursuant to their own environmental policies" (UNITED NATIONS, 1992, Article 3) and to establish laws and regulations to enable access to them. While it could be viewed as a victory for biodiversity-rich developing countries, the binding of these international instruments to national sovereignty is also regarded as a limitation, preventing the full acknowledgement of the social and cultural values of genetic resources due to the Western discourse that polarizes culture and nature as non-relatable matters (FREDRIKSSON, 2021, p. 729).

Additionally, some have understood the adoption of the ABS provision, especially on the CBD, "as a bargain between biodiversity-rich developing countries and technology-rich developed countries: a condition on which providing countries would allow developed countries continued access to their genetic resources", so that they would at least receive a small part of the results of the exchanges they have historically been subjected to (FREDRIKSSON, 2021, p. 728). Nevertheless, it is possible to conclude that, although not ideal, the national sovereignty principle is far less harmful than the common heritage doctrine where providers' rights are concerned, and was the possible and acceptable foundation at the moment of signing the Convention.

Further analyzing the context in which the CBD and the Protocol were elaborated and adopted, and taking into account the agenda proposed especially by developing countries during the discussions, it can be argued as well that these international regimes aim to preserve the ownership of states and their peoples over resources that exist *naturally* within their territories, meaning that it applies even to cultivated resources, if the country constitutes the resource's natural habitat or is where it has developed distinctive properties (UNITED NATIONS, 1992, Article 2). That is because, by acknowledging sovereign rights and distinguishing countries of origin from providing ones, these instruments aim at restoring the power of

biodiversity-rich countries over resources that are native to them, but were being accessed and explored for centuries by advanced capitalist nations without permission or compensation, helping them redress the asymmetry in these relationships (FREDRIKSSON, 2021, p. 725).

Moreover, these circumstances enable the understanding that the instruments do not limit this ownership only to resources accessed directly in their original land. The very choice to define the term 'country of origin', which will be further discussed below, is already an indication that the place of origin of the natural resource needs to be acknowledged and respected by users, and that these countries have the right, as set out in Articles 5 and 6 of the Protocol, to control access and to share in the benefits from the utilization.

Therefore, it could then be inferred that regardless of where a genetic resource is cultivated or domesticated – be it a center of origin or not –, and then collected and used for research, development and other applications (UNITED NATIONS, 2010, Article 2, item 'c'), if the place of origin is known and if the resource has not acquired distinctive properties in this new location, users should seek to observe and comply with the laws and regulations of the country of origin, if established.

As demonstrated, the Convention is but the framework to the ABS discussion, with its issues being comprehensively recognized, debated and translated into rights, commitments and rules almost twenty years later, by the provisions of the Nagoya Protocol. With currently 196 Parties to the Convention (CONVENTION, List of Parties), it is possible to say that essentially the entire world recognizes and has decided to commit to push forward its agenda of conservation, sustainable use and benefit-sharing. In this context, the Nagoya Protocol has gained strength in the last few years as well, with 131 Parties at the moment (ACCESS AND BENEFIT-SHARING CLEARING HOUSE, List of Countries).

The Nagoya Protocol is the output of eight years of discussions and negotiations since the parties to the CBD determined, in 2002, the setup of an international regime on ABS. Aimed at preventing biopiracy, the Protocol was elaborated to implement especially Articles 8(j)[1] and 15[2] of

[1] "*Article 8. In-situ Conservation*
Each Contracting Party shall, as far as possible and as appropriate: (…)
(j) Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the

the Convention, dedicated to traditional knowledge and access to genetic resources.

Committing to the international regime established by the Protocol, however, is more challenging than signing and adopting the provisions of the Convention, mostly due to the more legally binding profile of the Protocol's dispositions. While it does not demand countries to implement regulations, it is required that the Parties respect such regulations where they exist (FREDRIKSSON, 2021, p. 725), also ensuring that their citizens follow the rules of the country of origin or the providing country of the resource they utilize, wherever the activities are performed.

Although the decision to remain unregulated is in accordance with the states' overall sovereignty and jurisdiction, it poses a number of challenges when the use of genetic resources is involved. First, the lack of rules or the implementation of provisions excessively permissive goes against the rights, interests and concerns of traditional and indigenous communities, as less concerned states and its legislators control the level of protection – or the total absence of it – granted to the traditional knowledge associated with the resources (DALY, 2015 apud FREDRIKSSON, 2021, p. 725 and 726). Moreover, failing to regulate properly or choosing not to do it altogether poses a challenge to benefit-sharing even when

conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices;" (UNITED NATIONS, 1992)

[2] "*Article 15. Access to Genetic Resources*

1. Recognizing the sovereign rights of States over their natural resources, the authority to determine access to genetic resources rests with the national governments and is subject to national legislation.
2. Each Contracting Party shall endeavour to create renditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties and not to impose restrictions that run counter to the objectives of this Convention.
3. For the purpose of this Convention, the genetic resources being provided by a Contracting Party, as referred to in this Article and Articles 16 and 19, are only those that are provided by Contracting Parties that are countries of origin of such resources or by the Parties that have acquired the genetic resources in accordance with this Convention.
4. Access, where granted, shall be on mutually agreed terms and subject to the provisions of this Article.
5. Access to genetic resources shall be subject to prior informed consent of the Contracting Party providing such resources, unless otherwise determined by that Party.
6. Each Contracting Party shall endeavour to develop and carry out scientific research based on genetic resources provided by other Contracting Parties with the full participation of, and where possible in. such Contracting Parties.
7. Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, and in accordance with Articles 16 and 19 and, where necessary, through the financial mechanism established by Articles 20 and 21 with the aim of sharing in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilization of genetic resources with the Contracting Party providing such resources. Such sharing shall be upon mutually agreed terms." (UNITED NATIONS, 1992)

traditional owners are not involved, as it opens space for the signing of a series of "bilateral, market-oriented arrangements" (KLOPPENBURG, 1988 [2004] apud FREDRIKSSON, 2021, p. 725), giving rise to another social justice issue as it allows the commercialization of genetic resources as mere intellectual property.

Furthermore, when resources are found in what the Protocol calls as a "transboundary situation", efforts of a few countries to regulate access, utilization and benefit-sharing may be rendered ineffective by the lack of action of others. This particular situation shall be the object of a closer analysis.

3. The Nagoya Protocol and the awareness of transboundary situations

It is not a rare situation for species to be natively spread amongst large areas or regions, regardless of political territorial limits. While endemism attains high rates especially in islands, and contributes immensely to the variability of worldwide biodiversity, it is a less common phenomenon, or at least with lower rates, when mainland regions are analyzed. Endemism, as the exclusive occurrence of a species within a specific marked territory (KIER et al., 2009; VERON et al., 2019), provides for easier and clearer interpretations of ABS standards, as users and providers are not faced with the issue of "choosing" between multiple legislations of the countries of origin or the providing country. The circumstances are not as simple when accessing and utilizing transboundary resources.

Articles 5 and 6 of the Nagoya Protocol set the common ground for all access activities concerning genetic resources and for the benefit-sharing arising from it. Based on the principle of sovereignty of countries over their resources, it is determined that access to genetic resources shall be carried out with prior informed consent "of the Party providing such resources that is the country of origin of such resources or a Party that has acquired the genetic resources in accordance with the Convention, unless otherwise determined by that Party" (UNITED NATIONS, 2010, Article 6, item '1'). Users are then urged to share benefits, fairly and equitably, through mutually agreed terms, with one of these Parties (UNITED NATIONS, 2010, Article 5, item '1').

The content of mutually agreed terms may vary from Party to Party, as well as the obligation to seek prior informed consent or not. In spite of this, the actors involved in both activities – access and benefit-sharing – are already established: the user and the country(ies) of origin or the providing country(ies). Reaffirming the definitions laid down by Article 2 of the CBD, the Protocol's provisions were built in the sense that access should be sought from and benefits directed to *either* "the country which possesses those genetic resources in in-situ conditions" – being the 'country of origin' – or "the country supplying genetic resources collected from in-situ sources, including populations of both wild and domesticated species, or taken from ex-situ sources, which may or may not have originated in that country" – being the 'providing country' (UNITED NATIONS, 1992, Article 2). In this regard, 'in-situ conditions' are understood by the CBD, and the Protocol by extension, as "conditions where genetic resources exist within ecosystems and natural habitats, and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties" (UNITED NATIONS, 1992, Article 2).

Although the intentions of the Protocol are admirable, as it aims to ensure that ABS operations are conducted with fairness and respect to sovereignty, the vague manner in which these Articles were written leaves users with the still answered question of which country should their actions be directed to, when both the origin and the provider are known. This issue acquires even more uncertainty when transboundary species are involved.

Transboundary species are a concern common to many Parties, which explains the decision of having this circumstance expressly included in the Nagoya Protocol (UNITED NATIONS, 2010, Articles 10 and 11). Countries that share not only borders, but also ecosystems with their neighbors are bound to see themselves in a situation where they have to "compete" with others for the possibility to claim ownership over a genetic resource and be able to regulate access to it and the sharing of benefits arising from their utilization. This issue is also the subject of working groups within the Conference of the Parties, as they attempt to advance on deciding on the best practices to deal with the matter.

A transboundary situation is understood by the Protocol as one where "the same genetic resources are found in situ within the territory of more than one Party" or where "the same traditional knowledge associated with genetic resources is shared by one or more indigenous and local

communities in several Parties” (UNITED NATIONS, 2010, Article 11). By applying the definitions of countries and in-situ conditions to the provisions above on access and benefit-sharing and then reflecting on circumstances involving transboundary species specifically, a few possible interpretations rise. It should be noted that the conclusions below are derived from the assumption that the user is willing to comply with ABS regulations, and does not intently ignore them in favor of practicing biopiracy.

The Protocol does not establish a hierarchy or any sort of guidance on how should the user “choose” the country from which to seek access and with which to share benefits. Therefore, a first alternative that ascends is that the user has absolute freedom to select which country shall be the subject of his activities with a given resource, be it one of the countries of origin or the providing one – or one of them, if multiple providers. It is reasonable to conclude that most users, given this liberty, will choose only one country to negotiate with, possibly the one that offers a less complicated process of ABS or that does not regulate the theme at all. In other words, the one that involves less obligations and lower costs.

A second point of view when interpreting Articles 5 and 6, would be that users are required to seek access and share benefits with the country of origin, following the Convention’s and the Protocol’s intention on guaranteeing sovereignty of countries over their own genetic resources, existing naturally within their borders. However, when users are faced with transboundary situations, it is unclear whether, once more, they should “choose” one amongst the countries of origin or they should pursue compliance with all the countries involved.

Still considering the international regimes intentions, but acknowledging situations in which users are not able to detect where the resource is originally from or in which the resource is considered cosmopolitan, then a third option rises, being that users shall carry out ABS obligations with the providing country. If collected from multiple countries, however, the question of which providing country should be chosen or if all should be involved is once again posed.

A fourth alternative, in which users should favor seeking access and sharing benefits with the providing country(ies) instead of the country(ies) of origin, seems contrary to the spirits of the Convention and the Protocol, as it could signify, in essence, opening the way for users to comply mainly with ABS regulations, if existing, from large commodity producing

countries, which are not necessarily the countries of origin of the species. This may, in fact, constitute a veiled and institutionalized practice of biopiracy, as traditional peoples and countries of origin would, for the most part, continue to be excluded from decisions regarding access and benefit-sharing.

All of these possibilities of interpretation gain another layer of uncertainty when associated traditional knowledge is concerned, given that not only must the user attempt to understand which country should be the subject of their compliance, but they must as well identify which traditional community(ies) also have rights over the knowledge in which there is interest.

It should be noted that the interpretation of Articles 5 and 6 can be challenging, and is here explored in the sense that users are not able to draw an objective conclusion from these provisions about which country should be the subject of its activities of ABS regulation compliance and benefit-sharing. That is because, if bearing in mind the principle of sovereignty of countries over genetic resources, one cannot simply discard the rights of other countries who possess the same resource inside their borders, in in-situ conditions, in favor of the right of one country of origin chosen. This choice, as stated above, is even more problematic when, with knowledge of the countries of origin, one advocates for the choice of the providing country to be the one subject of a user's actions of compliance concerning ABS.

In this sense, aware of the importance of the discussion, especially where transboundary situations are concerned, the delegations and experts involved in the elaboration of the Nagoya Protocol acknowledged the circumstance on its text and attempted to provide possible solutions or at least guidance to this issue.

4. The alternatives given by the Protocol and the possibility of seeking a regional solution

The Nagoya Protocol recognizes the challenge of genetic resources and traditional knowledge that occur in transboundary conditions as one that should be addressed through cooperation between the Parties (UNITED NATIONS, 2010, Article 11). The Protocol also encourages Parties to consider the establishment of a "global multilateral benefit-sharing mechanism" (UNITED NATIONS, 2010, Article 10) as another means of

approaching these situations, together with ones that prevent the grant or obtaining of prior informed consent.

Both suggested solutions, however, have yet to be effectively implemented, be it either through the exercise of cooperation by drawing up bilateral or multilateral agreements between Parties to set the standards for ABS concerning these species and traditional knowledge[3] or the actual design and adoption of a global mechanism for the sharing of benefits. The mechanism was possibly envisioned with inspiration by the Multilateral System conceived for the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), from 2001 (UNITED NATIONS, 2001, Part IV). Nevertheless, differently from the ITPGRFA's System, the global mechanism proposed by the Nagoya Protocol was only conceived to address benefit-sharing, leaving access to genetic resources and traditional knowledge out of the instrument.

Currently, users and countries are still faced with questions and fragile attempts of regulating these types of situations individually, even with the adoption in 2002, by the Parties to the Convention, of the Bonn Guidelines, prepared specifically to assist Parties, governments and other actors when establishing legislations, policies or other administrative measures or setting arrangements on ABS (SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY, 2002).

The efforts already made, however, may not produce the expected results when a few try to follow the regulation path while others, that possess the same resources in in-situ conditions, do not oppose any barriers or control to the access and utilization. To this sense, Daly and Fredriksson alert that "a 'race to the bottom' may arise, in which the lowest level of protection sets the standard" (DALY, 2015 apud FREDRIKSSON, 2021, p. 726).

In order to operationalize the CBD and the Nagoya Protocol, a wide range of multi-level governance is required, encompassing actions from local, national and global perspectives. The executive power, however, lies with nation states, as they have the authority to elaborate and pass policies and regulations on ABS. Even though the Convention and the Protocol attempt to address colonialism-sponsored asymmetries between countries,

[3] The research for this article was not able to find records of such agreements amongst Parties of the Nagoya Protocol.

they only go as far as international regimes incorporated by national legislation, due to the limited instruments made available to the UN by a global governance system designed and sustained by sovereign states (FREDRIKSSON, 2021, p. 726).

When, however, national regulations fail to outline the rights and responsibilities of users and providers, or do not establish any standards concerning the matter, it is possible that users will not take any action in order to comply with ABS principles and rules. As the CBD and the Protocol are not binding to individuals or legal entities, the absence of national legislation renders countries more susceptible to biopiracy. For transboundary situations, the threat is even greater, as users will continue to utilize genetic resources and actively avoid accessing them in states that have regulations in place, profiting from the lack of rules from their neighbors and the complete absence of obligations.

Therefore, the dependence on national bodies to put in place policies and legislations to address these activities allows biodiversity's harmful exploitation to continue. In order to face these challenges, solutions such as the Protocol's "global multilateral benefit-sharing mechanism" are proposed. Global solutions, however, can be even more limited and difficult to implement than national measures, given that too many interests have to be taken into account.

In a global structure lead by independent nation states, global agreements and coordinated actions demand long discussions and many concessions, inevitably leaning towards the impossibility of establishing truly *global* and *effective* mechanisms. Thus, one of the two main arguments of this article is that regional mechanisms – rather than a global multilateral one – could be smaller, but easier steps to be taken. Regional instruments demand the convergence of fewer countries, which are able to better identify themselves with each other due to with similar histories and current socioeconomic circumstances that are more alike, and wish to move forward with better aligned goals.

Being a middle ground between national standards and global agreements, the establishment of regional agreements or mechanisms, could be an efficient manner of testing the potential of this sort of instruments and pave the way – or demonstrate the reasons not – to implement the global mechanism proposed by the Nagoya Protocol. A smaller step before a bigger, broader one.

Furthermore, in attempting to find specific solutions to transboundary situations, the ecosystems' coverage area must be held into account and, likely, it will not be spread all over the globe. Therefore, regional mechanisms seem to be more fit to accommodate the needs, expectations and rights of countries that share specific natural habitats and their biodiversity.

It should be considered, however, that, in order to be truly encompassing and efficient, these regional instruments must also address the access to genetic resources and associated traditional knowledge, enabling the coordination of the actions of the countries that take part in it. To focus solely on benefit-sharing, as the Protocol's global mechanism seems to suggest, still renders Parties vulnerable to predatory exploitation of their resources.

The definition of this matter could be especially important and beneficial for greatly biodiverse countries such as Brazil, that together with Bolivia, Colombia, Ecuador, Guyana, French Guiana, Peru, Suriname and Venezuela, is home to innumerable species native from the Amazon region. It may also be advantageous to formally established regional arrangements along the lines of the European Union, which members already converge in their approach to ABS through the Union's regulations of 2014 and 2015[4], or the Andean Community, that has also adopted common legal framework addressing the theme[5]. The establishment of regional provisions seems to be a solution acknowledge by many countries in regards to transboundary cooperation (MORGERA, 2015, p. 5 and 6).

Nonetheless, regional legislations are not a failsafe measure, as they can still face obstacles of implementation. The recent referring of Italy to the Court of Justice of the EU due to its "dysfunctional system" of access to genetic resources from non-EU countries (EUROPEAN COMISSION, 2020)

[4] The European Union (EU) has established legislation to regulate access and benefit-sharing. The Regulation (EU) 511/2014, frequently referred to as the EU ABS Regulation, is the overarching framework meant to implement the obligations stated by the Nagoya Protocol. The Implementing Regulation (EU) 2015/1866 complements the Regulation 511, and a Guidance document on the scope of application and core obligations of Regulation (EU) No 511/2014 was also developed by the Commission to assist users (UN ENVIRONMENT WORLD CONSERVATION MONITORING CENTRE, 2019, p. 81 to 96).

[5] The Andean Community has established a regional framework for its members (Bolivia, Colombia, Ecuador and Peru) in order to regulate the access to genetic resources, their by-products and associated intangible component. In this regard, the Decision 391/1996 sets a Common Regime on Access to Genetic Resources, while the Decision 486/2000 provides the Common Regime on Intellectual Property (MORGERA, 2015, p. 5 and 6; UN ENVIRONMENT WORLD CONSERVATION MONITORING CENTRE, 2019, p. 10 and 33).

and the challenges faced by the Andean Community to adjust their process of ABS to be more efficient and less complex (GÓMEZ-MEJÍA, [2007?]; UN ENVIRONMENT WORLD CONSERVATION MONITORING CENTRE, 2019), demonstrate the challenges. Therefore, the implementation of tangible mechanisms, that incorporate the rules established and truly allow users to understand their responsibilities, rights and obligations, could be an important contribution in the intent of guaranteeing that genetic resources and traditional knowledge are accessed and utilized in a fair, equitable and respectful way.

Reflecting on possibilities for this sort of mechanisms, emerging technologies such as blockchain, at first sight associated with the financial sector and cryptocurrencies, may provide the tools to ensure higher levels of legal certainty, compliance and distribution of results arising from the utilization of transboundary species and traditional knowledge, owing to the way they are structured and operated.

5. Instrumentalizing a regional ABS mechanism through blockchain

Initially conceived as a distributed structure for monetary transactions, the blockchain technology has evolved in its uses and capabilities over the 13 years since it was first introduced (BRASIL, 2020, p. 6). Displaying characteristics which can be understood as present in "General Purposes Technologies", the blockchain has proven to be a disruptive innovation able to accommodate a variety of actions and interests, as it exhibits an ability for constant improvement; is highly pervasive, being introduced in many sectors of the economy; and inspires and favors the creation of further innovations (KANE, 2017). As countries and organizations search for ways to ensure better implementation of the CBD's and the Nagoya Protocol's provisions on ABS, this technology has been cogitated in recent years, but still timidly and mostly theoretically.

In order to understand how it could be implemented and which would be its effects in the ABS universe, a definition of blockchain and its operation is necessary. Blockchain is a form of distributed ledger technology, which acts as an open and authenticated record of transactions from one party to another. As Berryhill, Bourgery and Hanson explain, it differentiates itself from other operational systems as information is not centralized in a database maintained by an authority, but is rather shared

by all users through the network. All users running the blockchain software have access to a copy of every transaction – and every update concerning it – performed within the blockchain. The transactions are stored in ledgers within the technology, and copies and updates are distributed within seconds or minutes (BERRYHILL; BOURGERY; HANSON, 2018, p. 10).

From a more technical point of view, a blockchain is a data structure that stores transactions organized in blocks, which are sequentially chained together, serving as a distributed system of records (BRASIL, 2020, p. 10). In the blockchain network, the “nodes” are responsible for reviewing and validating each transaction in order for it to be verified and then effectively recorded, if a majority of nodes, i.e., a consensus, considers it legitimate. A node is simply a user or a computer that runs the blockchain software and is connected to its network, Berryhill, Bourgery and Hanson clarify. Nodes can have different roles on the network, whether it is to store copies of ledgers, receive, validate and pass data to others – performed by “full nodes” –; carry out the tasks of full nodes, but also publish new blocks to the blockchain through the mining process – by “mining nodes” –; or simply send data to full nodes for processing and validation, without storing full copies of ledgers – by “lightweight nodes” (BERRYHILL; BOURGERY; HANSON, 2018, p. 11).

Transactions are maintained secured in the blockchain through cryptography and, by allowing all nodes to inspect each one of them, Berryhill, Bourgery and Hanson note that trust in the information contained in the blockchain is high, given that tampering requires reaching a contradictory consensus, a coordinated action that proves to be quite difficult considering the high degree of distribution of these networks. Cryptography converts the received data into codes to keep them confidential, possessing a format that can only be read by authorized users (BERRYHILL; BOURGERY; HANSON, 2018, p. 11).

Each block in the chain contains a specific set of validated transactions, which each possess a cryptographic fingerprint referred to as a “hash”, and all the transactions contained in a block are also hashed to create a unique hash code for the block. Transactions remain accessible to nodes, but cannot be altered (BERRYHILL; BOURGERY; HANSON, 2018, p. 15 to 17). Structurally, every block is divided into two parts: header and data. The header comprises metadata such as a unique number that references the block, the block's creation time, and a pointer to the previous block's

hash, in addition to the block's own hash. The data typically refer to a list of valid transactions and party addresses, so that users can associate a transaction with the parties involved (source and destination) (BRASIL, 2020, p. 10). Given that each block presents the hash of the previous one as well as its own, blocks are not independent from one another, being linked in linear, sequential order by these “fingerprints”, shaping the chain. Every hash is a unique fixed-length code for any given input, and will remain the exact same so long as every part of the input remains intact. Each and all change to the input will generate an entirely different and specific hash code, which would also change the block’s hash code, allowing adulterations to be easily detected across the entire network of nodes (BERRYHILL; BOURGERY; HANSON, 2018, p. 15 to 17).

Applying the concept of blockchain to the establishment of a regional mechanism for transboundary situations seems to be a valid possibility considering the technology gathers a number of functionalities and attributes that may ensure the effectiveness of its goals: to serve as an accessible and effective structure where access to transboundary genetic resources and traditional knowledge could be granted and registered and through which benefit-sharing could be performed and directed.

The structural composition, organization and functionalities of the blockchain allow the technology to display key characteristics that, as mentioned above, differentiate it from other existing systems. Its distributed and shared nature enables the reduction or even elimination of the need for intermediaries or central bodies to administer the system, providing access to identical and fully updated copies of data to all members, without distinction (BERRYHILL; BOURGERY; HANSON, 2018, p. 10 to 13). This allows for “improved data integrity, decentralization and disintermediation of trust, and reduced transaction costs” (KRAWIEC et al., 2016 apud BERRYHILL; BOURGERY; HANSON, 2018, p. 11).

In the regional ABS mechanisms here envisioned, this feature is particularly attractive, as countries would not need to debate which one or ones would control the system or how shared control would be carried out, nor would have to elaborate extra security measures to ensure truthfulness and reliability to the data informed. States could each operate as validating nodes (either “full” or “mining”) in the network, actively guaranteeing that their rights and norms are respected by all the actors involved in access and utilization of transboundary resources and knowledge.

The nature of blockchain technology would also appeal to the private sector, as it would detach the mechanism from governments' exclusive authority (UNDP-GEF GLOBAL ABS PROJECT, 2021a). As a decentralized and distributed platform, private actors could be involved in regional mechanisms' projects since its conception, collaborating to design instruments that meet the needs and interests of the various parties. In this sense, these mechanisms would not be just another government imposition, but rather effective shared tools that facilitate the conduct of relationships and promote the *fair and equitable* use of resources.

The immutability of blockchain transactions is an equally important characteristic, as it provides trustworthiness to the data it receives, preventing transactions from being undone, erased or altered, remaining intact over time (BERRYHILL; BOURGERY; HANSON, 2018, p. 13). For an ABS mechanism designed to receive and process data from different actors in varied locations, this attribute is essential to maintain governments', companies' and citizens' confidence in the instrument and to encourage them to make use of it and promote it further, so that it expands and evolves to their needs.

Perfect transparency is then an outcome of these features, since all users and all validated transactions are visible to the whole network, and users can understand each other's capacity and interest in carrying out new operations, as well as analyze what has already been executed (BERRYHILL; BOURGERY; HANSON, 2018, p. 13). As seen with the immutability, the transparency provided by the blockchain technology would permit confidence and accountability to be maintained amongst all parties of the regional mechanism, decentralizing chains of command, supervision and auditing.

Another benefit of the technology is its capacity of allowing for pseudonymity, but without permitting full anonymity, meaning that users identities may be anonymous, but their accounts and transactions remain accessible to others. This possibility, however, is susceptible of restriction depending on the format of the blockchain's ledgers – either permissioned ("private") or permissionless ("public"). Public networks allow for anyone to access and propose transactions, whereas private ledgers restrict contributions to a number of participants that have been given rights, and transactions can also have their visualization limited. Each format enables different kinds of consensus models, with distinct rules for identifying

users' powers and rights, such as the Proof of Work model, the Proof of Stake, the Proof of Authority, the Round Robin, and others (BERRYHILL; BOURGERY; HANSON, 2018, p. 18 and 19).

For a regional ABS mechanism, perhaps a suitable format would be to design it with permissioned ledgers, allowing for users to be more thoroughly identified and given specific transaction rights, restricting the entry of users not involved in ABS activities, for example. The rules for the operation of permissioned ledgers are adaptable, and can be decided on and programmed up front (BERRYHILL; BOURGERY; HANSON, 2018, p. 19). For blockchains involving the public sector, such as the one envisioned in this article, their design could take into consideration national legislation and policy mandates, and establish different levels of user permissions for those utilizing the ledgers. Moreover, in permissioned formats, consensus models such as Proof of Authority – where only authorized users, called 'validators', who are known and have been verified, are allowed to validate and publish new blocks – or Round Robin – where users take turns in validating and publishing or are randomly selected to do it – would be better suited (BERRYHILL; BOURGERY; HANSON, 2018, p. 48).

Given these qualities and capacities, the blockchain technology appears to be a valid alternative for designing an ABS mechanism, seeing that it provides, through the registering of every transaction in linked blocks, the means of documenting every transfer of an asset from its origin (BERRYHILL; BOURGERY; HANSON, 2018, p. 26), enabling a clear traceability of the genetic resource or traditional knowledge accessed by a user.

Furthermore, improvements could be provided to the mechanism with the utilization of Smart Contracts and the tokenization of assets. Smart Contracts are small computer programs that are executed through blockchain, also constituting transactions that can be stored and passed across all nodes. They enable the creation of "self-executing contracts (or workflows) with the terms of the agreement between the parties being directly written into lines of software codes" and operate on an "if/then" automated basis, with specific triggers (BERRYHILL; BOURGERY; HANSON, 2018, p. 19). It could be a particularly useful feature for obtaining prior informed consent (PIC), signing mutually agreed terms (MAT) and for executing benefit-sharing obligations, improving the automation of these operations (UNDP-GEF GLOBAL ABS PROJECT, 2021a).

The tokenization of assets involves representing pre-existing, real assets on the digital ledger “by linking or embedding by convention the economic value and rights derived from these assets into digital tokens created on the blockchain” (OECD, 2020, p. 11). These tokens act as stores of value in the blockchain, carrying the rights of the asset through the network. Tokenizing genetic resources and traditional knowledge could allow for benefits in terms of cost and speed efficiencies, transparency and liquidity of these assets (OECD, 2020, p. 16). It could also aid with traceability, as samples of genetic resources or files documenting traditional knowledge could be tokenized and tracked through the entire chain of research or technological development since the access, indicating changes in ownership, shipments across borders and enabling the identification of the links in the chain responsible for benefit-sharing, among other activities.

Recognizing the possibilities the blockchain technology can bring to the ABS universe, a pilot project is currently under development, as of July 2021, headed by the United Nations Development Programme (UNDP) in partnership with the Global Environment Facility (GEF), within its Global ABS Project (2021b), and should provide important insight into the real feasibility of mechanisms based on it. The project, however, will be conducted only in India (UNDP-GEF GLOBAL ABS PROJECT, 2021b), meaning that interactions between countries with shared biodiversity and its users will continue to be theoretical, at least for the time being.

Nonetheless, the presentation of the product vision of the pilot project has already brought relevant topics of debate and analysis, as well as other advantages of blockchain to meeting ABS goals. The researchers have indicated issues that need to be addressed by the platform based in blockchain, beyond the functionalities appointed earlier, such as the necessity of it acting as an incentive and as a facilitator to ensure time bound access to genetic resources; the possibility of creating digital repositories of genetic resources and traditional knowledge; and the capability of the platform to be integrated and interoperable with other digital technologies and existing systems (UNDP-GEF GLOBAL ABS PROJECT, 2021a).

As for other advantages, it is highlighted the fact that it would not constitute an exclusive government solution, as mentioned previously, allowing a better participation of the private sector in the entire process of

creation, development and operation. Furthermore, the use of blockchain technology for ABS instruments should facilitate prescription of rules in countries with robust Nagoya Protocol systems, and should ease the operationalization of the spirit of the Protocol in countries with less strong systems (UNDP-GEF GLOBAL ABS PROJECT, 2021a).

In essence, the second main argument of this article is that the use of blockchain technology for the design and implementation of ABS mechanisms can be of great value, especially at the regional level, considering its ability to ensure transparency, immutability and shared and distributed control of transactions, preventing frauds in the chains; to improve and strengthen the traceability of resources and knowledge and compliance with Protocol rules and national legislation; to reduce bureaucratic obstacles and facilitate the participation of private and foreign actors; and to automate and reduce costs of many of the ABS operations that today rely on inefficient or even paper-based systems.

However, the limitations and criticisms of both the creation of a global or of regional mechanisms and of the use of blockchain technology to develop them cannot be ignored, and should be part of the debate, in order to build truly effective instruments to promote greater acceptance and implementation of the provisions of the CBD, the Nagoya Protocol and national ABS rules, especially for the protection of the rights of countries of origin over transboundary resources.

6. Limits, challenges and final considerations

Since the entry into force of the Nagoya Protocol, the creation of a global multilateral benefit-sharing mechanism, as proposed in its Article 10, has been a theme of discussion for Parties, organizations, experts and other actors involved with ABS. The development and establishment of implementation mechanisms is a constant point of discussion in the Conferences of the Parties to the Convention. For instance, the Subsidiary Body on Implementation (SBI) established by the Parties issued at its third meeting, in July 2020, a draft note concerning Article 10 of the Protocol, with a recommendation to the establishment by the Parties of an Ad Hoc Technical Expert Group on a Global Multilateral Benefit-Sharing Mechanism (CONVENTION, SBI, 2020a, p. 9 to 11). The Article is also the theme of a Study currently under peer-review, commissioned by the Executive Secretary at the request of the Conference of the Parties, to identify

specific cases of the situations covered by the Article (CONVENTION, SBI, 2020b). Furthermore, "mechanisms for planning, monitoring, reporting and review" of the implementation of the post-2020 global biodiversity framework are one of the items on the provisional agenda of the fifteenth meeting of the Conference, which will take place in Kunming, China, in October 2021 and April and May 2022 (CONFERENCE, 2021).

Experts have also been discussing the issue in various platforms, inside and outside of the UN, and have acknowledged that the proposition of a global multilateral benefit-sharing mechanism does not come without its challenges and limitations. Concerns revolve around seemingly simple but yet foundational inquiries such as what type of resources should be encompassed by the mechanisms – whether "genetic resources" in transboundary situations should be understood as the physical material only or as the information contained in the material or a combination of both – or which date should be understood as the "relevant date" to trigger the application of the Protocol's provisions, identifying at least seven possibilities (ANGERER et al., 2015). It then expands to more complex questions, involving how the global mechanism would be integrated with bilateral and multilateral agreements for a particular ABS relationship, and its interoperability with regional agreements over regionally-distributed genetic resources and associated traditional knowledge (ANGERER et al., 2015).

In more morally inclined debates, academics and organizations question the Nagoya Protocol' role as contributor "to a 'neoliberalisation of nature' as it promotes privatization, commodification and marketization of natural resources" (ROBINSON, 2014 apud FREDRIKSSON, 2017, p. 14), reducing resources and traditional knowledge to intellectual property (FREDRIKSSON, 2021, p. 727 to 730). The paradox of seeking to implement international instruments that attempt to guarantee the fair and equitable use of genetic resources and associated traditional knowledge, the sharing of benefits and the conservation of biodiversity as a whole through a technology such as the blockchain, which is considered harmful to the environment for its high rate of energy consumption, is also raised by organizations and scholars (SCHMIDLEHNER, 2020). In relation to this specific point, however, it is important to note the fact that blockchain design can be adapted to employ mining processes and consensus models that require less energy to be operated, as non-Proof of Work models are

considered far more environmentally acceptable (SEDLMEIR et al, 2020, p. 603 to 606), for example, and that this possibility is often overlooked in these criticisms.

Nonetheless, the blockchain technology does not come without limits and challenges, as issues such as data confidentiality; interoperability between blockchains platforms; being a field still with a lot of experimentation; permissioned formats still in consolidation; not fully decentralized, as code developers, engineers and other decisionmakers are still required; having a small range of experienced professionals; data storage; higher short-term costs and others remain to be better addressed (BERRYHILL; BOURGERY; HANSON, 2018, p. 29 to 33; BRASIL, 2020, p. 31 to 36).

In the current scenario, in which citizens, companies and even governments are looking for more natural and sustainable development alternatives, the access and use of genetic resources and associated traditional knowledge has its potential even more highlighted and explored. With this, the demand for tools that ensure respect for the sovereign rights of countries of origin and traditional communities, providers of these goods, as is the spirit of the CBD and the Nagoya Protocol, becomes increasingly greater and more urgent. In this sense, combining revolutionary and constantly evolving technologies such as the blockchain with mechanisms that seek to guarantee the implementation of ABS regulations is an alternative that deserves to be explored, with more in-depth studies, such as the one initiated by initiative of the UNDP and GEF Global ABS Project. This article then proposes that blockchain technology has the attributes and a special potential to become a great solution to adequately and robustly address gray areas, such as transboundary situations, even if it faces its limitations, as it is able to better integrate governments and users in transparent and versatile platforms, reducing barriers, mistrust, costs and time spent.

After nearly thirty years of asserting the sovereignty of states and peoples over their genetic resources and associated knowledge, with a world that increasingly suffers the consequences of nature exploitation without responsibility, the need and importance of implementing effective ABS mechanisms are evident. More than guaranteeing sovereign rights, ensuring the conservation of biodiversity, its fair, equitable and sustainable use, and the due compensation for the benefits received, allied and

instrumentalized by the new possibilities brought about by technological advances, is a matter of socioeconomic sustainable development and of assuring the respect to human rights, especially to the more fragile and most biodiverse regions of the world.

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