Prong 3: Re-thinking Incentive Structures
Blockchain/DLT Supported Incentives for Sustainable Seed Innovations?

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As discussed by Greg Radick in Prong 2, the move from IP-Narrow, which focusses only on pigeon holes of existing intellectual property rights and 'priority claims', it is necessary to make a shift towards IP-Broad systems that respect 'productivity claims.' In a broad sense, productivity claims are a kind of 'right to attribution.' Within existing intellectual property rights regimes, however, only copyright law (within its 'moral rights' framework) recognizes and protects the right to attribution. Within patents and plant breeders' rights regimes, such a system does not exist – these regimes operate on a 'first come' basis. Other legislations, notably the CBD, the Nagoya Protocol and the Seed Treaty, have attempted to establish systems that recognize and reward a type of "productivity claim", particularly of communities that have contributed their PGRs for further downstream research and development. However, as is seen in the context of global attempts to mandate access and benefit sharing regimes vis-à-vis access and use of PGRs under these regulations, protecting the right to attribution, and thereby recognizing and rewarding productivity claims, has not been easy in practice. In fact, the system has met with little, if any, success. In this section, we look at the key features of an emerging technological solution, namely Digital Ledger Technologies (DLT), and a more recently evolved version of DLTs, namely, blockchain, to see if technology can assist in implementing the letter and spirit of well-meaning international treaties such as the CBD and the Seed Treaty. Forthcoming blog posts (and Section III of the Position Paper) will then look at what changes are needed in existing legal regimes to ensure smooth roll out of the three prongs, to further strengthen the technological systems and to ensure that these are themselves subject to optimal legal regulation and ethical codes to avoid any misuse.

However, research has shown that farmer-custodians of agrobiodiversity have little incentive to continue using, cultivating and improving landraces, locally suited indigenous/traditional seeds or planting materials and farmers' varieties (and thereby conserving the PGRs therein), especially when faced with the option of cultivating formally improved, high yielding varieties.[1] This situation is exacerbated as farmers are unable to secure a regular market and good price for their varieties, in part, because farmers' varieties are inappropriate candidates for protection under existing intellectual property protection regimes, especially in their current narrow/formal construction (as discussed in Prong 2).[2]

The culture of sharing prevalent among farmers,[3] coupled with their inability to monitor the chain of transfer of ownership as well as the specific end use(s) to which their varieties are put (e.g. simple consumption or downstream research), also currently act as barriers preventing the emergence of robust and profitable marketplaces that support sustainable use and monetization of PGRs,[4] especially for the benefit of small and marginal farmers, that are by far, especially, but not exclusively in countries like India, the sole or primary custodians, generators and in situ improvers of PGRs.[5] While several regulations in India (and globally), notably the Biodiversity Act, 2000 as well as the Protection of Plant Varieties and Farmers Rights Act, 2001 seek to secure benefits for farmers via 'benefit sharing' mechanisms, according to research, the number of cases of benefit sharing have been low to non-existent.[6] These regulations, have, in short, been unable to facilitate the tracing and/or honest and comprehensive documentation of uses to which farmers' PGRs have been put. It has been challenging, to say the least, to implement access and benefit sharing (ABS) systems, including those

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1 Kochupillai, (2016); Goeschl and Swanson, (2003).
2 Kochupillai, (2016); Salazar, Louwaars, and Visser, (2007); Correa, (2000); MacLeod and Radick, (2013).
3 McGuire and Sperling, (2016).
4 Kochupillai, (2019a).
5 Ruiz and Vernooy, (2012); De Boef et al., (2013); Bisht, Mehta, and Bhandari, (2007).
6 Tsioumani, (2018); Venkataraman and Latha, (2008); Brahmi, Saxena, and Dhillon, (2004); Ramanna and Smale, (2004); McManis, (2012).

established under the CBD, the Seed Treaty, as well as under various national laws that implement its letter and spirit.[7]

Accordingly, in addition to recommending large scale (re)education, the SSI 1.0 expert working groups made several observations and recommendations highlighting the relevance of the traceability of any and all indigenous seeds to source. It is relevant to note here that unlike proprietary seeds that can be recognized by unique, uniform features that are registered in the Plant Variety Register, the inherent variability of traditional/indigenous seeds, which is also their greatest asset, lead them to display varying phenotypic characteristics in each growing season,[8] and in every different location they are cultivated in,[9] making it difficult to recognize their true origin. While these seeds may be, broadly speaking, more easily identifiable by their unique nutritional or other features when grown in specific regions and soils, they will inevitably change their appearance, which is the currently the most important (and the quickest) means through which infringements of plant breeders rights are recognized.[10] Absence of any means of tracking/tracing farmers' indigenous seeds to source, leads, again, to lack of any means of ensuring monetary benefits for those who are originators and preservers/improvers of indigenous seeds in various/diverse locations. This, again, systematically removes all monetary incentives for (small) farmers to engage with in situ agrobiodiversity conservation, improvement and dissemination. In the following sub-section, we look at how an emerging technology may be able to assist in overcoming problems of trust, traceability and lack of incentives that currently prevent optimal and sustainable seed innovations by and for the benefit of small farmers.

Parts 2 and 3 of this 3 part blog post discuss how key features of DLT/Blockchain technology can potentially help overcome each of the above identified hurdles.

<u>Part 2 of Blog Post</u>

(i) Digital Ledger Technologies/Blockchain: A Brief Introduction

Blockchain technology, a special version of the more generic 'digital ledger technologies' (DLTs), came into being around 10 years ago with Satoshi Nakomoto's white paper on Bitcoin.[11] More recently, these technologies have been in the media, not only because of ongoing efforts of the Indian government to ban cryptocurrencies, but also because several supporters of these technologies claimed early on that they hold at least the potential of resolving "virtually every human problem in existence"[12], notably problems associated with trust (or the lack of it!). While a lot of what is associated with blockchain is labelled as 'hype', blockchain based applications and platforms have emerged and are continuing to emerge rapidly, and are being embraced, not only by companies, but are also increasingly gaining acceptance by national governments who are choosing to permit blockchain based businesses, while covering them under existing[13] or new regulations.[14] Various corporations and governments worldwide have also embraced several blockchain based business models and usecases ranging from supply chain management,[15] land registry management to voting systems[16] and e-governance.[17]

[7] Welch, Shin, and Long, (2013); Aravanopoulos, (2011); Kamau, Fedder, and Winter, (2010).
[8] Girard and Frison, (2018); Berg and Raaijmakers, (2018).
[9] Louette, Charrier, and Berthaud, (1997); Serpolay et al., (2011); Ceccarelli, (1996).
[10] Jondle, Hill, and Sanny, (2015).
[11] Nakamoto, (2008).
[12] Walch, (2019).
[13] Allen, (2018); Partz, (2019).
[14] Zmudzinski, (2019); vom Brocke et al., (2018).
[15] Agrawal, Sharma, and Kumar, (2018); Casado-Vara, (2018); Perboli, Musso, and Rosano, (2018); Queiroza, (2019).
[16] Ayed, (2017); Hanifatunnisa and Rahardjo; Aste, Tasca, and Di Matteo, (2017).
[17] Zago, (2018); Partz, (2019); Zuckerman, (2018).

While its usecases in agriculture mostly revolve around supply chain management ("from farm to fork"),[18] a recent paper[19], discusses a new conceptual understanding of these technologies, under which they can be used as a means of promoting and incentivizing research and in situ innovation with agrobiodiversity. As discussed elsewhere, in situ conservation is a pre-requisite to in situ sustainable seed innovations (especially by farmers/informal sector)[20]. This technology, especially when combined with Artificial Intelligence (AI) applications, can also help small farmers like Jitul Saikia (See Box 2), farmers engaged with seed storage using traditional as well as locally adapted traditional (and sustainable) means (See Box 1), as well as farmers and farmer communities engaged with preserving and improving *in situ*, rare and highly nutritious seeds like Sona Moti (See Box 3). When traded with the assistance of these technologies, small farmers can sell or share (individually or collectively) their indigenous/traditional seeds in "digital marketplaces", better assured of traceability and 'benefit sharing'. These technologies can also help monetize the sharing of know-how associated with the cultivation of these in unique local conditions.[21]

These technologies hold significant promise although they are, relatively speaking, in a nascent stage of development. The following sub-section attempts to describe, in the simplest terms possible, the features of these technical solutions, particularly of Blockchain/DLTs that make them promising for the purpose of promoting and incentivizing Sustainable Seed Innovations, especially by farmers. Part 2 of the Position Paper (coming soon!), also discusses how these technologies can also be used to incentivize and raise funds for research on and with PGRs in a way that enhances farmers' incomes. It also highlights the legal and ethical issues that need to be addressed in order to ensure that the technology leads to equitable and desirable outcomes, rather than inequitable, and illegal ones.

(ii) Digital Ledger Technologies/Blockchain: Overview of Key Features Relevant for incentivizing Sustainable Seed Innovations

Blockchain technology or DLTs are technologies that can be understood and explained in many ways, at various levels of abstraction. For our current purposes, it is useful to think of blockchain/DLT as a technology that permits secure data collection, arrangement, storage and transfer in an immutable or change sensitive manner (so called 'immutable record keeping').[22] The data typically entered into a blockchain is often data about transactions – i.e., who gave what to who, when, where, in what quantity etc. This feature, namely, immutable record keeping, is one of the central and most important features of the technology for our purposes, namely, the purpose of promoting sustainable seed innovation. The technology permits the traceability of the source of any transacted good (e.g. seeds), to its origin.[23] It can perhaps already be stated, however, that because, originally, blockchain was a technology designed primarily for digital (transactional) data, its use for tracing physical transfer of goods has to be accompanied with a plethora of other technologies and safeguarding measures, including, for example, tamper proof packaging, IoT devices, and in case of seeds, technologies such as biomarker technologies.

Beyond the 'immutable' record keeping feature, a second valuable feature of DLT or Blockchain, is its 'distributed' (as opposed to 'centralized') structure.[24] This means that because data stored on a blockchain is in digital (and not physical) form, blockchain creates a systems where multiple copies of the data can be simultaneously stored (and the transaction history automatically updated, albeit, currently with some time lag) on various computers in different parts of the globe (each computer that has a copy of the full transaction history, is called a 'node').[25] This distributed structure ensures that

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[18] Lin et al; Lin, (2017); Leng et al., (2018); Tian, 2016;
[19] Kochupillai, (2019a).
[20] Kochupillai, 2016
[21] Kochupillai, (2019b).
[22] Drescher, (2017).
[23] Kim, (2018); Tian, "An Agri-Food Supply Chain Traceability System for China Based on Rfid & Blockchain Technology."; Queiroza, (2019).
[24] Dorri et al., (2017); Ølnes, Ubacht, and Janssen, (2017).
[25] Zyskind and Nathan; Puthal et al., (2018).

no one ‘node’ can tamper with the data or transaction history without changing the record in all other nodes. The larger the number of nodes in a blockchain ecosystem, therefore, the more difficult it is to tamper with (change) transaction history. This feature makes the network much more trustworthy than any current ‘centralized’ third party intermediary. For this reason, blockchain technology is said to eliminate the problem of (lack of) trust that disincentivizes certain types of transactions.

In addition to the above two features (i.e. immutable record keeping and distributed/multiple digital ledger copies), an additional feature that can optionally be added to any blockchain system, is the feature of so called “smart contracts”. It is noteworthy here that ‘smart contracts’ are neither ‘smart’ nor truly ‘contracts.’ They are, essentially, self-executing software, i.e., software that automatically triggers a series of digital occurrences/happenings as soon as a pre-determined set of conditions is fulfilled.[26] Thus, for example, a blockchain software could (soon) be so coded as to make sure that as soon as a bar or QR code on a package of seeds is scanned by a specific system at a specific location (e.g. the buyer’s premises), a transfer of payment is automatically made from account A to account B. Although this system is extremely complicated, it has been successfully deployed to ensure payments to specific parties as soon as certain conditions are fulfilled, without the need for a third-party intermediary (such as a bank).[27] The system, or the code underlying the system, then replaces the “trusted third party intermediary”, reduces transaction costs, delays and a host of other problems, including problems that may be result of corruption or breakdown of one of the nodes/computers in the system.

Part 3 of blogpost

(iii) Blockchain/DLT and In Situ Innovations with Agrobiodiversity

As discussed in above, three major hurdles that need to be overcome in order to facilitate sustainable seed innovations (especially by small farmers) as well as monetization of sustainable seed innovations for the benefit of small farmers and their rural communities are: (i) the issue of traceability: the origin of indigenous seeds is rather difficult to trace to source, in part because such seeds often don’t have one common or popular name with which they are known across a nation or region, and in part because the phenotypic characteristics of such seeds are very likely to change with every new season or every new region or condition (climate, soil) in which they are cultivated; (ii) the issue of trust: lack of trust among farmers as well as national governments, that persons or institutions that take ‘samples’ of the seeds will indeed share benefits with farmers, results in farmers’ growing unwillingness to share seeds (or know-how associated with their cultivation) with scientists, as well as national governments’ adoption of incredibly strict bureaucratic hurdles for any party that seeks to access (agro)biodiversity from within their territories; and (iii) the general lack of monetary incentives to cultivate using indigenous seeds (as discussed above).[28] Adding to this lack of monetary incentives, is the lack of adequate education/know how among several farmers on how cultivating indigenous seeds using TEK based farming systems can help maximize environmental and economic gains of farmers (see Prongs 1 and Prong 2); currently, because of the systematic ‘education’ of farmers solely in support of ‘conventional farming’ since the Green Revolution, farmers see economic gains only in high yields promised by “improved/proprietary” varieties.

These hurdles not only lead to sub-optimal in situ innovation with and conservation of agrobiodiversity, but also disincentivize R&D with agrobiodiversity, and/or honest access and use practices.[29] In both instances, the loser is the farmer – (i) sub-optimal incentives and know-how (education) on why and how to cultivate crops using indigenous seeds and TEK based farming systems (that also support agrobiodiversity conservation and improvement), leads to dependence on capital intensive farming that, over time, can lead to severe soil degradation[30] and also progressive

[26] Iansiti and Lakhani, (2017); Law, (2017); Kim, (2018).
[27] Nofer et al., (2017).
[28] See Section II of the Position Paper above. Also see Kochupillai, (2018); (2016).
[29] DeLonge, Miles, and Carlisle, (2016).
[30] Zhang et al., (2007); Lal and Stewart, (1990); Oldeman, Hakkeling, and Sombroek, (2017); Bhattacharyya et al., (2015).

economic indebtedness of farmers,[31] and (ii) lack of research on and with agrobiodiversity or lack of honest disclosure of source of researched agrobiodiversity, prevents farmers from getting monetary benefits in the form of royalties or 'benefit sharing,' leading to further lack of incentives to continue cultivating indigenous seeds. It is also likely that lack of trust and competition among farmers will disincentivize farmer to farmer sharing of indigenous seeds, to the detriment of beneficial spread and region-specific evolution of agrobiodiversity, as well as the erosion of cultures of seed sharing.[32]

The features of blockchain/DLT technology discussed above, can help overcome the issues of lack of trust and traceability (see Annex 3 and Annex 4 for examples of how this can potentially be done[33]). However, to provide stronger economic incentives for agrobiodiversity conservations and associated research and in situ sustainable seed innovations, it is necessary also to link blockchain technologies, not only with automated payment systems, but also automated (monetary) reward systems.

In this context, it is necessary, at the outset, to distinguish digital currencies from cryptocurrencies (commonly linked with blockchain). Currencies, including digital currencies, are essentially a medium of storing and trading 'value'.[34] In fact, digital currencies are already very much in use in several (or even most) parts of the globe. These digital currencies exist in two forms: in the form of digital payment systems (such as credit cards), and in the form of digital reward points (such as airline mileage points, grocery and other marketplace purchase points or customer loyalty points, all of which are examples of digital currencies that are then used to purchase other products or services, e.g. upgrades on airlines). Cryptocurrencies are not yet in widespread use, but across the globe, several countries have either already embraced them, or are in the process of so doing.[35] This is so from a legal as well as technological perspective - Switzerland, for example, is very active is developing and adopting legislation supporting cryptocurrencies. Corporations such as Facebook (albeit under severe legal/regulatory scrutiny and mistrust) recently launched their own cryptocurrency (or 'virtual money') based payment system backed (apparently/allegedly) by blockchain technology and the US dollar (to prevent problems of volatility that cause a significant part of the public and regulatory discomfort with the technology).[36]

Leaving aside the uncomfortable topic of cryptocurrencies, it is worth investigating whether blockchain facilitated mechanisms to incentivize research and in situ innovation with agrobiodiversity can be linked with a simpler (non-cryptographic and low energy consuming) automated point granting systems similar to the "carbon points" system that can support what is commonly known as "carbon trading" or "emission trading." Such points can then be used to get real cash from one or more of several possible sources, such as:

(i) established funds like the 'Gene Fund' or the 'Biodiversity Fund' under various Indian laws,

(ii) from a fund maintained through the collection of a possible 'biodiversity tax' from sellers of non eco-friendly (uniform) seeds;

(iii) or, from exchanging points for money from industries that would want to acquire biodiversity points to avoid paying the biodiversity tax. In other words, systems can be put into place that require seed, fertilizer and chemical pesticide industries to pay a biodiversity tax, unless they can show legitimate acquisition of "biodiversity points" from research institutions and farmers engaged in research and in situ innovation with agrobiodiversity. Industries looking to move to more sustainable business models can

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[31] Dudley, (2000); Glover and Kusterer, (2016).

[32] Research has shown that in regions where improved/uniform seeds become the norm, the culture of seed sharing and seed exchange starts to become less prominent, perhaps because 'uniform' (HYV and hybrid) seeds need to be purchased afresh from the market each season and do not give desired yields in subsequent generations of cultivation (F2 onwards). See Kochupillai, (2016)., pp. 208-212 and pp. 50-63.

[33] (2019a).

[34] Yermack, (2015); Allee, (2008).

[35] Peters, Panayi, and Chapelle, (2015); Bucko, Palová, and Vejacka; ŞANLISOY and ÇİLOĞLU.

[36] Naughton, (2019); Dillet, (2019).

eventually also become partners (nodes) within any blockchain ecosystem created for incentivizing sustainable seed innovations.

The cash collected from any of the above sources in return for biodiversity points, can then be put to various uses by those who encash them. For example, farmer communities that obtain points in the system, can use the cash obtained from exchanging them, for rural community development or to support pension payments for aging farmers etc. Researchers or the scientific community that gets such points can use the cash obtained from their exchange, for further research supporting the cause of sustainable seed innovations. The points-based rewards system can thus support the institutionalization of productivity claims (see the blog post on Prong 2).

It is necessary to explain here that a smart contract facilitated payment-based system (e.g. a one-time payment or an automatic payment of royalty to originators of seed innovations, namely small farmers) must also be supported by a point-based rewards system, because the point-based rewards system creates incentives for downstream users and researchers to use rather than avoid the blockchain facilitated system. The point-based reward system would do so in two ways: (i) by ensuring that points collected can be exchanged for cash from one (or more) of the above suggested sources, and (ii) by permitting the specific contribution of each farmer/farmer community and research institutions to be immutably recorded and known to the rest of the world. Therefore, if any research and innovation with PGRs is done 'outside' the system (e.g. through illegally acquired PGRs), neither the farmer contributor of the PGRs, nor the downstream researchers (whether these be other farmers or scientists) will get point-based rewards for value addition.[37] Here, is it noteworthy that while blockchain supports anonymization of users if so designed, systems can also be designed that facilitate (limited or conditional) disclosure of identities of contributing parties, if they so desire, or in case of need (e.g. for purposes of legal enforcement, facilitation of payments/encashment and/or correction of technical glitches).

It is perhaps relevant to note here that in order for the world (including, especially, the small and marginal farmers of the world) to truly benefit from cryptocurrencies or even from a (biodiversity) point based incentive mechanisms facilitated by blockchain technology, it is necessary to re-think and re-understand the meaning of the term 'value'.[38] Blockchain is called the internet of value. Yet, the meaning of 'value' is not only broad and context driven, but is also very subjective.[39] Indeed, it has been rightly said that "something has value primarily because people believe it has value." Blockchain as a broader technology (beyond bitcoin) permits the capture, store, release and trading of value like never before.[40] With this understanding, actively engaging with and using this technology under appropriately designed regulations and ethics codes, to create applications and infrastructure focused on incentivizing sustainable seed innovations, and creating new markets for agrobiodiversity and plant genetic resources may therefore lead to very promising results, enhancing environmental health, small farmer incomes, as well as national GDP.

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[37] For a more detailed explanation of how blockchain can incentivize value creation and value addition to agrobiodiversity, see Kochupillai, (2019a).
[38] Ibid.
[39] Ibid.
[40] Kochupillai, (2019a).
[41] Ibid.
[42] Ibid.

trading of value like never before.[43] With this understanding, actively engaging with and using this technology under appropriately designed regulations and ethics codes, to create applications and infrastructure focused on incentivizing sustainable seed innovations, and creating new markets for agrobiodiversity and plant genetic resources may therefore lead to very promising results, enhancing environmental health, small farmer incomes, as well as national GDP. Preliminary frameworks recommending the means in which this technology can be deployed for promoting sustainable seed innovations have been described in this article here, and under Annex 3 and Annex 4 of the forthcoming Position Paper.

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[43] Kochupillai, (2019a).

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