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Contribution by UNIDO

to the CSTD 2020-2021 priority theme on "Harnessing blockchain for sustainable development: prospects and challenges"

PRIORITY THEME 1: Harnessing blockchain for sustainable development: prospects and challenges

United Nations Commission on Science and Technology for Development (CSTD)

Dear international organization/UN entity/agency,

As you are aware, the CSTD 23rd annual session selected "Harnessing blockchain for sustainable development: prospects and challenges" as one of the priority themes for its 24th session (2020-21 period).

In an increasingly digitalized economy and society, the security and accountability of data transactions are critical elements for creating trust and enabling breakthrough innovations in the digital world. In this regard, blockchain technology has been perceived as a game-changer, with the potential to revolutionize processes from finance to pharmaceutical industries, from humanitarian work to development aid. The Blockchain serves as the base technology for cryptocurrency, enabling open (peer-to-peer), secure and fast transactions. The application of Blockchain has expanded to include various financial transactions (online payments and credit and debit card payments) as well as IoT, health and supply chain. However, issues associated with scalability, privacy concerns, uncertain regulatory standards and difficulties posed by the technology in integration with existing applications are some of the potential market constraints. The priority theme will focus on the importance of developing a local financial infrastructure that avoids financial exclusion of the most vulnerable communities. There is also the risk that the potential of Blockchain for solving developmental problems had been somewhat inflated by its early adopters and the tech media and may not be as applicable for developing and least developed countries. What are the emerging uses of Blockchain that can be breakthroughs in accelerating progress towards the SDGs? What are the potential negative unintended social and economic effects of this technology? How could governments maximize the opportunities and minimize the risks? The CSTD could consider this priority theme to examine the potential of harnessing Blockchain for sustainable development.

The CSTD secretariat is in the process of drafting an issues paper on the theme to be presented at the CSTD inter-sessional panel meeting. In this context, we would like to solicit inputs from international organizations, UN entities and agencies on this theme. We would be grateful if you could kindly answer the following questions based on your organization's work.

1. Could you share specific examples, projects or initiatives that have used or plan to use blockchain technology for the SDGs? What are the main challenges confronted while trying to implement these projects/initiatives? (Examples may include blockchain solutions for financial inclusion, trade facilitation, supply chains, health, energy, e-Government, etc.)

UNIDO developed a methodological framework to assess the readiness of a commodity value chain to adopt blockchain technology. The objective of the methodology is to both address a general approach to assessing a value chain from a data sharing perspective, and at the same time to go into the specific requirements that come with implementing blockchain technology. The methodology has been set up in such a way that it can be applied to assess the feasibility and readiness to adopt blockchain for any commodity value chain from any sourcing country.

UNIDO started conducting a pilot test to assess the readiness of the cocoa value chain in Ghana to integrate Blockchain.[1] Thus, the methodology goal to provide recommendations for each implementation step is currently being tested. The methodology will suggest what type of Blockchain is suitable for the specific value chain considering the characteristics of the actors under study, due to the limited knowledge of Blockchain from the actors it will involve building awareness on the pros and cons of permissioned or permissionless Blockchain. However, UNIDO foresees that the suggestions emanating from the methodology will be mostly permissioned eco-systems as the sustainability will depend on the actor's engagement in the specific value chain. The platform technology to be used is not defined yet since it will depend on the consensus of the actors in the particular value chain.

[1] European Supermarket Magazine 2020. UNIDO And SIM Test the Readiness of Value Chains for Blockchain Technology. Accessed on Apr 8, 2020.

Similarly, UNIDO is developing an SDG accelerator fund to streamline financial opportunities to the advantage of SMEs moving towards the circular economy. The project leverages from Blockchain to conduct impact investment verification activities. The project has been recently renamed as Sustainable Development Goal Impact Investment Platform (SIIP) and is currently under review.[2]

The methodology will also provide guidance on the key performance indicators to be considered in the selection of the specific technology, for example, security issues, privacy, scalability, performance transactions, integration to actors' systems, interface and visualization of data. The methodology will not evaluate existent offers in the market, but it will only aim to provide guidance.

The methodology considers all actors in the value chain, (e.g. smallholder farmers, cooperatives, aggregators, distributors, manufacturers, transporters, retail stores, shops, etc.) as implementing parents. Each actor will have writing rights and reading rights, electronic signatures on the data and transactions. Data inputs will vary across the value chain, for example, the origin of produce, product type, weight, volume, transaction price, certification, lab tests, humidity, quality, time, place, etc. Technology partners are not defined in the methodology as once the eco-system is specified, it will be up to the stakeholders to embark. Further support from UNIDO to guide the implementation of the application is also considered.

The methodology includes a step by step guide on how to identify the nodes, the data points, the key transactions, responsibilities and obligations etc. It will also look at how to solve "the last mile problem". It will also provide to a general level a suggested eco-system for the implementation of Blockchain. It will be to the subsequent use of the result of the methodology to agree with all stakeholders to embark on such a project.

2. What are the challenges that governments have faced or may face for promoting innovation and competence building in Blockchain, to contribute to their national development priorities and accelerate the progress towards the SDGs?

One of the challenges that most developing countries have and continue to face is to counteract the effects of the global concentration dynamics in the production and development of technology.[3] Blockchain innovations are no exception. A handful of transnational companies hold a large majority of related patents. While the above does not prevent governments from leveraging from Blockchain to accelerate their progress towards the SDGs, it does have significant implications in the associated costs of such an undertaking. The most crucial challenge is then to promote competence building in Blockchain in such a way that the country develops the capacity to use, but also to create customized versions (soft and hard forks) suited to their conditions and needs.

Another key challenge is the misconception of what new technologies can do, particularly on blockchain is is generally believed that is about bringing full transparency to transactions. Blockchain can do this if required but is not entirely truth that everything will be transparent. Another misconception is that it only serves for traceability purposes. The challenge is to build awereness on what is blockchain and what problems can solve if rightly implemented. UNIDO shares the view that Blockchain technology is a tool to optimize transparency, trade, trust, tracking, tranfers and transactions, it works better if prior conditions are met in the ground before uploading data to the blockchain network. There are many startups trying to sell off the shelf solutions to govenrments without a sound assessment of wheather the physical system is ready to be put into a blockchain and without an adequate returns of investment assessment.

Blockchain regulations will require concerted efforts for both establishing and enforcing rules. Blockchain-based systems that are part of a global network further increase the complexity. In systems that are powered by the combined computational power of nodes with different geographical locations, under various legislations, and where there is no central party governing and operating the system; who should be held responsible and accountable for misbehaviour or failure? Alternatively, how liability can be apportioned? The challenge for developing countries is two-fold: First, to increase their engagement with global digital governance. Second, simultaneously develop national capabilities to develop and enforce regulations for Blockchain.

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[2] UNIDO 2019. SIIP: Enabling private financing of SMEs to facilitate more circular business models https://www.unido.org/siip Accessed on Apr 8, 2020.

[3] It is worth noting that within the context of Blockchain, some developing countries like India and China, in particular, have increasingly played a major role in their development.

Similarly, Blockchain is still in incipient stages of standardization and continuously surrounded by highly contested terminology. Standardization will be an essential step towards more comprehensive regulatory frameworks. Currently, the problem is twofold. On the one hand, the lack of regulation limits the capacity of governments to cope with fraud, local regulatory compliance and tax evasion. On the other, it hinders technology adoption and innovation, primarily affecting entrepreneurs and start-ups, which are often confronted with the uncertainty of being incurring a legal problem.

The lack of standardization among Blockchain can be the source of additional problems related to interoperability. For example, the costs of integrating blockchains into financial infrastructures like payment and settlement systems require not only industry-wide coordination and collaboration but also demands significant expenses.[4] Systems integration problems related to legacy systems are not an exclusive challenge of developed countries. Although, to a different extent, governments in developing countries are also confronted with the challenge of ensuring that blockchain systems can be integrated with the existing infrastructure, yet often incompatible systems.

3. What are the actions that the international community, including the CSTD, can take to contribute to harnessing Blockchain for sustainable development?

The CSTD can play an essential role in promoting international best practices, international guidelines and legal frameworks governing the engagement with science and technology for advancing socio-economic development. The impact could be maximized by building and strengthening collaboration ties with existent initiatives such as the UN Innovation Network, as highlighted in the Secretary-General's Strategy on New Technologies. Similarly, the international community could support governments with decision making tools to invest or not to invest into new technologies and increase the preparednes countries to adopt and adapt new technologies.

UNIDO shares the perception that Blockchain has become a buzz word. Thus, the CSTD could coordinate the international community's efforts to raise awareness as a tool to counteract the technology's pitfalls related to its incipient standardization and general scarcity of regulatory and policy frameworks. Similarly, the international community could contribute to developing content-specific training programmes for countries and institutions planning to implement a blockchain-related solution to provide them with relevant information about the technologies' capabilities and limitations.

4. Could you suggest some contact persons in your agency responsible for projects/policies and international collaboration in this context as well as any experts (from academia, private sector, civil society or government) dealing with projects in this area? We might contact them directly for further inputs or invite some of them as speakers for the CSTD inter-sessional panel and annual session.

Juan Pablo Davila, Industrial Development Officer at the Quality Infrastructure & Smart Prod.Div.
Email: J.Davila@unido.org

5. Do you have any documentation, references, technological assessments, future studies or reports on the priority theme?

- UNIDO Methodology for Assessing the Readiness of Adopting Blockchain within a Commodity Value Chain (not published yet)

Please send your responses and any further inputs on the theme to the CSTD secretariat (stdev@unctad.org) by 7 October 2020. We look forward to receiving your valuable inputs.

Sincere Regards,

CSTD secretariat

[4] Natarajan, Harish, Solvej Karla Krause, and Helen Luskin Gradstein. 2017. "Distributed Ledger Technology (DLT) and Blockchain: Fintech Note No. 1." 122075. The World Bank.

Feedback Form

PRIORITY THEME 1: Harnessing blockchain for sustainable development: prospects and challenges		
Question/Area	Inputs	
1. Could you share specific examples, projects or initiatives that have used or plan to use blockchain technology for the SDGs? What are the main challenges confronted while trying to implement these projects/initiatives? (Examples may include blockchain solutions for financial inclusion, trade facilitation, supply chains, health, energy, e-Government, etc.)	UNIDO's SDG Impact Investment Platform (SIIP): Understanding that Small and Medium Enterprises (SMEs) are key drivers of economic development and thus key stakeholders in the achievement of the SDGs, UNIDO's Sustainable Development Goal Impact Investment Platform (SIIP) aims at lowering the transaction costs associated with investing in SMEs. With the assistance of its Member States, the SIIP will unlock the potential of SMEs in developing and emerging countries to deliver SDG-aligned impact. SIIP is a user-friendly highly interactive platform enabling the identification of SMEs for possible investments. It will act as repository of information, and it will be critical for the first steps towards an investment. The market need for the impact investment platform is established. Specifically, the SIIP will ensure that SMEs receive technical and financial assistance toward circular business models and that they are able to strengthen their business models for SDG-aligned impacts, with impact investors benefitting from being connected to a steady stream of investment-ready SMEs. The SIIP will be established using advanced technologies such as blockchain and artificial intelligence to improve transparency and efficiency in assessing the investment-readiness of SMEs.	Blockchain technology will be introduced to track, trace and report on the impact of the products/value chains at the level of environment and socioeconomic Project related to Agribusiness (amazon products) but project document is still under finalisation (CEO endorsement)
2. What are the challenges that governments have faced or may face for promoting innovation and competence building in blockchain, to contribute to their national development priorities and accelerate the progress towards the SDGs?	The novelty of blockchain technology may pose certain challenges. Blockchain technology can offer new opportunities for governments not only to improve transparency, prevent fraud, and establish trust in the public sector, but also to contribute to their national development priorities and accelerate the progress towards the SDGs as seen in the example above. However, blockchain adoption and use in this context is rather unexplored. The main challenges faced in blockchain adoption are probably presented as technological aspects such as security, scalability and flexibility. From an organizational point of view, the issues of acceptability and the need of new governance models might be the main barriers to adoption. Moreover, the lack of legal and regulatory support could be one of the main environmental barriers of adoption.	
3. What are the actions that the international community, including the CSTD, can take to contribute to harnessing	Awareness raising Best practice examples Technical training Preparation of toolkits	

blockchain for sustainable development?	Provide technical guidelines Development and deployment strategies Legal and policy recommendations	
4. Could you suggest some contact persons in your agency responsible for projects/policies and international collaboration in this context as well as any experts (from academia, private sector, civil society or government) dealing with projects in this area? We might contact them directly for further inputs or invite some of them as speakers for the CSTD inter-sessional panel and annual session.	UNIDO: Fukuya Iino. F.lino@unido.org	
5. Do you have any documentation, references, technological assessments, future studies or reports on the priority theme?	http://www.siip.online/ http://www3.weforum.org/docs/WEF_Blockchain_Government_Transparency_Report.pdf	

In addition to answers to your questionnaires, please consider:

1. Mr. Rikiya Abe, who is one of the pioneers in this field in Japan, as an expert to include in your pool of international experts. His work includes, among others, utilization of digital technology in energy systems.

Mr. Rikiya Abe (Ph.D.)
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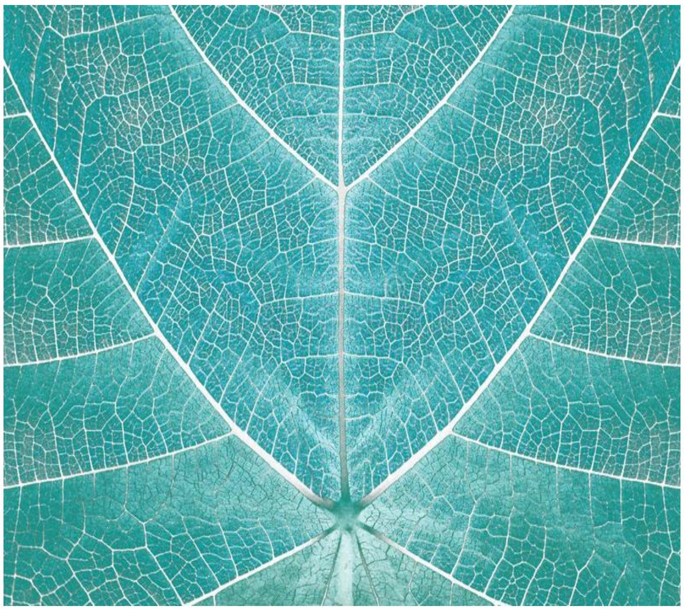
PERÚ Ministerio del Ambiente



Climate Responsible Value Chains

Transparency, Traceability and True Cost Accounting in value chains for equitable biodiversity conservation and reduced GHG emissions

This document provides the insights to block chain lead transformation through value chains enabled for transparency, traceability and true cost accounting to support regenerative approaches in harvest and conservation of biodiversity, enhance carbon capture, and ensure long term equitable, inclusive and regenerative socio-economic development.

Dr. Neeraja Havaligi
Sr. Biodiversity Specialist
UNIDO, May 2020

Contents

SUMMARY

Amongst all anthropogenic activities, the agricultural sector contributes most significantly to climate change.

Therefore, it seems to be the most significant tool to bring transformational change and curb global movement of climate change.

Agricultural sector depends on natural capital - clean water, healthy soil, biodiversity, and on the knowledge of cultivation, seed saving, and post-harvest processing and storage held in communities to establish and to thrive.

Stable economic gains through agriculture depends on reasonably steady climate and biodiverse ecosystems that enable ecosystem functions critical for all bio-physical processes upon which all life-systems, including agricultural systems depend.

Loss of natural capital, specifically biodiversity, and accelerating climate change are abetted by conventional agricultural practices and linear economics.

Linear agricultural and economic approach erode natural capital, the foundation of life systems, and the impacts reverberate across agriculture systems, through value chains that link stakeholders in local,

regional and global production and consumption economies.

Yet, the very value chains causing large environmental impacts, hold the potential for transformative change if infused with transparency, traceability and true cost accounting to products traversing the value chain, linking local, regional and global economies.

Agricultural value chains connect stakeholders across the borders and are quintessential invisible links connecting the global economy. They respond to the market requirements and policy guidelines, determine the types of produce and products to move across time zones and landscapes, and value chains dictates their cost and availability and influence lives of all stakeholders across the value chains.

These conventional value chains are dominated by the following:

- presence of intermediaries (involvement of intermediaries makes it impossible for the customer to interact with the producer directly, delays the processes);
- lack of transparency (a layer between what is happening at the source and across the value

chain, and the information accessible to the consumers);

- centralization (of all the information, any damage to this can result in loss of data and information),
- poor tracking (current system doesn't offer a quick system of monitoring and tracing, resulting in wastage of time and investment) are persistent and pervasive problems that render them environmentally, socially, and economically unsustainable.

Hence, value chains provide a great opportunity to usher new ways to shift from business as usual approach.

Value chains can be transformational, when they are enabled with the right technology to be transparent and engage stakeholders across the change with traceability and true cost accounting. Doing so will allow agribusiness value chains to be a conduit for reliable science-based information shared with stakeholders to make informed decisions based on data, and usher intentional and informed change.

Blockchain technology enables transparency, traceability and true cost accounting practices along value chains. This technology can usher potential transformatory changes in agricultural systems, if interventions designed with through science, and an in-depth, realistic knowledge of local needs, capacities and desire for change.

Blockchain is a digital distributed ledger where all the information is present in chronological order, or simply, it is time-stamped. It means that people in the system can easily trace or track any information.

Blockchain offers a series of benefits when it comes to storage of information such as decentralization of information and easy tracking of data, which are key features of the blockchain. This feature makes it easy for the people in the network to track the order and know details of its production.

Blockchain is versatile and useful for stakeholders in the agricultural value chains to create ways to value agroecological practices that conserve biodiversity and decelerate climate change, thus transforming business as usual through engaged and informed actors across the food systems.

INTRODUCTION

1.1 Background

Our day to day activities are predominantly dependent on the seamless movement of produce and products chugging their way on multifaceted agricultural value chains.

Agriculture based business or agri-business, is reliant on value chains (VC) at local, regional levels, and as Global Value Chains (GVC) crossing boundaries and connecting economies.

Agriculture or agribusiness value chains are a set of linked activities that enable access to consumption of diverse products from the morning breakfast cereal to our dinners, and other products such as clothes, shoes and even pillows and beds that support our sleep, rejuvenating us for the next day.

These value chains consist of stakeholders and activities that enable production, processing, marketing and improvement of products, linking the producers to processors of diverse outputs or commodities to markets and consumers around national, regional and global hubs based on the produce, products, sale price and market demand.

Like other economic activities, value chains depend on the flow of natural and social capital from produce to products, which reaches consumers through the markets.

Agricultural value chains depend on growing, harvesting, packing, processing, transforming, marketing, consuming and disposing of food and other products[1]. Agriculture relies on natural capital held in crop diversity, healthy soils, water and moderately stable growing conditions enabled by local weather and the overarching climate systems.

> Clearly, the primary source of products in the value chain is the natural capital, a finite, non-renewable resource.

While it relies on natural capital of which climate is a part, agriculture is the major contributor to global greenhouse gas emissions (GHG) and shifting planetary boundaries (Campbell et. al. 2017)[2]. Agriculture is a major driver for land use change (LUC) covering nearly 40% of the planet's land surface[3]. It accounts for nearly 70% of global freshwater withdrawals[4], is a key sector in energy consumption[5]

[1] http://www.fao.org/cfs/home/blog/blog-articles/article/en/c/448182/
[2] https://www.ecologyandsociety.org/vol22/iss4/art8/
[3] Foley, J. A., et al. (2005), Global consequences of land use, Science, 309, 570–574.
[4] http://unesdoc.unesco.org/images/0021/002154/215492e.pdf
[5] http://www.wri.org/blog/2014/05/everything-you-need-know-about-agricultural-emissions

and contributes nearly one third of GHG emissions[6]. Agriculture is also one of the worst polluting industries on the planet by use of fertilizers and insecticides[7].

The business as usual accounting and liner business models in agriculture do not account for the natural capital upon which agriculture is dependent, nor do they account for the environmental degradation, and the depletion of the very resources that the agribusiness value chains depend on.

Thus, unsustainable agricultural practices continue, leaving trails of eroded and depleted lands, polluted waters and disappearing biodiversity.

This is abetted by increasing globalization and demand for agricultural commodities across geographical boarders, inequitable trade protection and distorted agricultural support policies and subsidies, resulting in unaccounted loss of non-renewable natural capital (healthy soil, biodiversity, water etc.).

Clearly, conventional linear agricultural practices and market systems designed for monocultures and fossil fuels have a negative impact on agricultural biodiversity and biodiversity in general.

[6] Gilbert, N, 2012. One-third of our greenhouse gas emissions come from agriculture. https://www.nature.com/news/one-third-of-our-greenhouse-gas-emissions-come-from-agriculture-1.11708

[7] http://www.earth.columbia.edu/articles/view/3281

Dominant markets and value chains favor linear monocultural systems specializing in few crops with high-yielding varieties that are more uniform in terms of quality and form (Prescott-Allen and Prescott-Allen, 1990; Gruère et al., 2006).

Such linear production systems are the major cause for decline in crop and varietal diversity. It narrows the genetic pool which critical for continued evolution and adaptation (Pimbert, 1999; Lenzen et al., 2012; Rao et al., 2005; Van Dusen and Taylor, 2005), especially as our crops continue to adapt to climate change.

> "Like the impact of the recession, there is simply no sector that will be immune to biodiversity and ecosystem loss. Business needs to begin to draw the dots between natural resources, their supply chain, consumer demand and the future value of their business." Malcolm Preston, Pricewaterhouse Coopers partner for sustainability and climate change.

Linear development models have other critical implications.

Although in the short term they led to stronger employment, trade and economic benefits across the value chains, they are not equitable to all stakeholders, particularly the environment and other unaccounted stakeholders in the chain.

In context of humanity's pursuit of the 2030 agenda for sustainable development, the call for 'Zero Hunger', 'Good health and wellbeing' and 'Decent work and economic growth' is clearly in conundrum with the linear practices in agriculture and linear economic approaches in business as usual economic and development models.

> The climate summit (2014) saw commitments to more sustainable value chains catalyzing action with Countries, 53 multinational companies, 20 provincial government, 16 indigenous peoples, and 63 NGOs.

There is hope. Increased awareness of human activities contributing to climate change among businesses, governments and consumers is beginning to challenge the *status quo* of the agricultural system *per se* and linear economic development models.

For example, in 2019 the UN Climate Summit proposed nature-based solutions[8]to address drivers of climate change. Among others, these solutions include,

(i) Improving afforestation and forest sustainable management (conserving primary forests, increasing forest coverage and sustainably managing forest for carbon sequestration, biodiversity conservation, food and water security, and livelihoods);

ii). incorporate nature-based solutions in urbanization and ecosystem management

iii) integrating the concept of NBS into sustainable urban design and green infrastructure and enhancing conservation and sustainable use of biodiversity given its role for both mitigation and adaptation, and to support an ambitious and achievable post-2020 global biodiversity framework;

iv) to use agriculture and food systems to transform food production systems to sustainable ones by promoting healthy green supply chains, transition to greener, more productive and sustainable farming, promoting more productive, and sustainable food systems producing high quality and nutritious food.

[8] https://www.un.org/sustainabledevelopment/wp-content/uploads/2019/05/WP-Nature-Based-Solutions.pdf

There is also a growing interest among high and middle-income consumers to be part of change they wish to see to decelerate climate change. For example, this is reflected in the desire for labels such as ‘local’, ‘organic’ ‘non-GMO’ etc. Consumers are seeking to understand their local food source and culture, and related information, raising legit concerns on food quality, authenticity and long-term sustainability (Gruère et al., 2006).

These concerns challenge the prevailing paradigm of linear practices in the overall economic systems, and specifically in agricultural systems and agricultural value chains.

These concerns call for a shift from linear approaches in resource use and management to nature-based solutions that are agroecologically aligned to regenerative and responsible use of natural resources.

This shift will *transform how we value the provisions of the global commons*[9], the bedrock of raw materials for food, shelter and all other basic life supporting needs and engage everyone to be change agents.

Agricultural systems can be repositioned, from feeding and providing diverse needs to people to

[9] http://globalcommons.earth/opportunity

nourishing both the people and the planet. Agriculture based solutions that are regenerative, restorative and circular can be conduits to achieve transformation we need now.

1.2 Purpose of White Paper

Since agriculture a key contributor for land use change, GHG emissions, shifting planetary boundaries and climate change with the right tools[10], it can also be the solution for transformative change.

Agribusiness value chains provide opportunities for these transforming solutions. Ensuring transparency, traceability and accounting for externalities - energy, water, nutrients and other inputs through production, processing, transport and post-consumer lifecycle of agricultural products can enable to transformational change in agricultural systems.

Each link in an agricultural value chain is an opportunity to bring solutions through the food systems-to address challenges to biodiversity loss, climate change and changes in planetary boundaries.

[10] http://www.fao.org/cfs/home/blog/blog-articles/article/en/c/448182/

The purpose of this white paper is twofold. First, the paper will inform and propose the methodology to use blockchain technology to design nature-based solutions enabled by transparency, traceability and true cost accounting for agricultural products in value chains, and to reposition conventional value chains as biodiversity friendly, climate responsible, resilient value chains.

Accountable Transformations in Agriculture

Transformational change will require us to expand the definition of agricultural productivity measured typically by yield per hectare - to include the environmental and socio-cultural costs of agriculture, while ensuring equitable access and culturally appropriate nutritional security to all, within the planetary boundaries.

Secondly, the paper *will present potential solutions using blockchain technology in the* GEF project "Building human well-being and resilience in Amazonian forests by enhancing the value of biodiversity for food security and bio-businesses, in a context of climate change" *for transparency,* *traceability and true cost accounting in agribusiness value chains in Peru*.

This GEF project will be implemented in the regions of Loreto, Ucayali and Junin in Peru, and aims to

i) advance the conservation of healthy and functional forests and wetlands resilient to climate change
ii) maintain carbon stocks, prevent GHG emissions and generate sustainable and resilient livelihoods
iii) deploy field interventions in and around the protected areas (PA) and indigenous territories (IT); supported by regional and international actions.

This paper will present potential solutions to address the third component in the project focusing on '*sustainable productive practices, eco-businesses and bio-trade',* introducing sustainable eco-business models to enhancing the value of timber and non-timber from the Amazon forest.

The project proposes to carry this by strengthening technical capacities of stakeholders in bio-trade and bio-businesses and promoting the diversification and value addition of biodiversity products, developing partnerships, supporting green incentives and improving emerging partnerships and innovations.

1.3 Terminologies

Transparency, traceability and true cost accounting, henceforth referred as **3T**, are foundational to develop value chains that harmonize, integrate and augment accountability for use of natural resource across value chains.

Transparency, Traceability and True Cost Accounting are the terms that will transform conventional value chains to responsible value chains through nature based, technology enabled, innovative solutions.

The climate responsible value chains are enabled and accountable to value biodiversity and regenerative processes that reduce GHG emissions and protect biodiversity while being equitable, and inclusive in its approach. Thus, responsible value chains are climate resilient and regenerative by intentional design.

Blockchain technology will align the mechanisms and strategies that generate, manage, and deploy the 3T's, transparency, traceability and true cost accounting in agribusiness value chains transforming them to *climate resilient, regenerative* and responsible value chains.

1.3.1 Transparency

Transparency is the quality of being easily 'seen through', providing accountability and predictability in knowing the input or resources in a product.

Transparency is akin to honesty and openness, considered the main pillars of good governance, equitable management and business ethics. This is true of businesses, markets and supply chain in general.

In the case of value chains, transparency calls for disclosure of information to all stakeholders-along the chain, from producers, to those involved in processing, packaging, transport and marketing, stakeholders in regulatory bodies and product customers/ consumers.

Transparency is a critical element in risk communication, since it is directly linked to trust building among stakeholders (Hofstede, 2004; Renn, 2008).

In a value chain or supply chain transparency enables shared understanding of the product-related information, and ensures the stakeholders have access to product related information without loss, noise, delay, or distortion (Hofstede, 2004).

What does Transparency do?

Transparency provides the stakeholders across the value chain the confidence that their suppliers, materials, and products are genuine, acquired honestly, and comply with the socio-economic-environmental standards set by the players involved.

Transparency enables building trust and helps achieve better visibility to all parts of the supply chain to ***drive improvements and react faster and more effectively when problems occur.*** These characteristics are critical as ***value chains increasingly endure changing limits thrust by climate change on agriculture production systems***.

1.3.2 Traceability

Traceability is defined as the "ability to trace the history, application, or location of that which is under consideration" (according to ISO 9000:2000).

Olsen et. al, 2019 define traceability as the 'ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications'.

Traceability is critical to facilitate investigation problems in the value chain for example with raw materials, ingredients, transformations, processes, and products in the value chain. This requires record keeping systems designed to track the flow of products or product attributes through the production process or value chain (Golan et al.2016).

Traceability relies on unbroken chain of comparative data between measurement devices set for local, national and international standards ensuring the test standards are routinely calibrated by “higher level” reference standards.

A traceability system aligns with the book-keeping approach used in blockchain and can provide a coherent overview of all the processes in a value chain.

A good traceability system can provide product-related information to stakeholders (for example on of all the raw materials, ingredients, transformations, processes, and products in the value chain) with little loss, noise or delay.

What does Traceability do?

Traceability helps understand the requirements of the product standards and requirements or aspirations set by the end user of the product.

A reliable traceability system will verify requirements, ensure their fulfilment and set a standard and process for accountability in the value chain.

1.3.3. Deconstructing Traceability and Transparency

Transparency and traceability are mutually dependent, and are not the same thing (EgelsZandén et al., 2014).

The differences between traceability and transparency are illustrated in Figure 1.

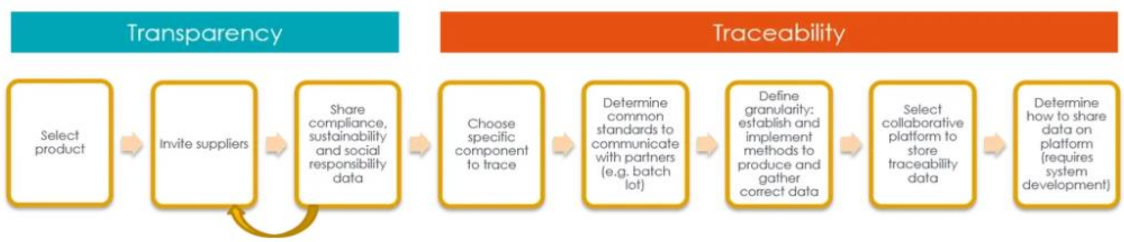


Figure 1: Transparency and Traceability

Source: [Transparency-One]

Defining characteristics include the following.

- Traceability is broad and can be summarized as - keeping a record of what one is doing in the value chain. Traceability systems 'allow industry partners to have access to reliable, comprehensive data of their business activities as well as their related environmental and social impact'(Papu Carrone, 2020) [11].

- When the traced information is available to others, transparency will enable all stakeholders to have access to the relevant information needed to make informed decisions, including but not limited to customers and business partners.'
- Hence, transparency has a specific application and target audience in focus (e.g. general public vs. decision-makers).

1.3.4 True Cost Accounting

True Cost Accounting is a "practice that accounts for all external costs—including environmental, social and economic-generated by the creation of a product." (Gayeton, 2020[12]).

In business as usual scenario, the social costs, health costs, and environmental costs of our food system are not accounted for in the final price paid at supermarket or restaurant etc.

True cost accounting will rely on life cycle analysis of inputs, outputs, and the potential hidden

[11] - Papu Carrone, Natalia. January 2020. Chapter 'Traceability and Transparency: A Way Forward for SDG 12 in the Textile and Clothing Industry'. In book: The UN Sustainable Development Goals for the Textile and Fashion Industry, pp.1-19.

[12] https://www.pbs.org/food/features/lexicon-of-sustainability-true-cost-accounting-the-real-cost-of-cheap-food/

(i.e., conventionally unaccounted) social and environmental impacts/costs of producing a product.

For example, some of the hidden costs in a linear agricultural system are effects of fossil fuel energy use in the agricultural system (transportation, harvest, sowing etc.) and effect of fossil fuel based fertilizer and pesticide use on soil (degradation), water (pollution), human health (obesity/nutrient deficiency), loss of biodiversity (gene pool for adaptation and nutritional diversity), land use change (e.g. GHG emissions).

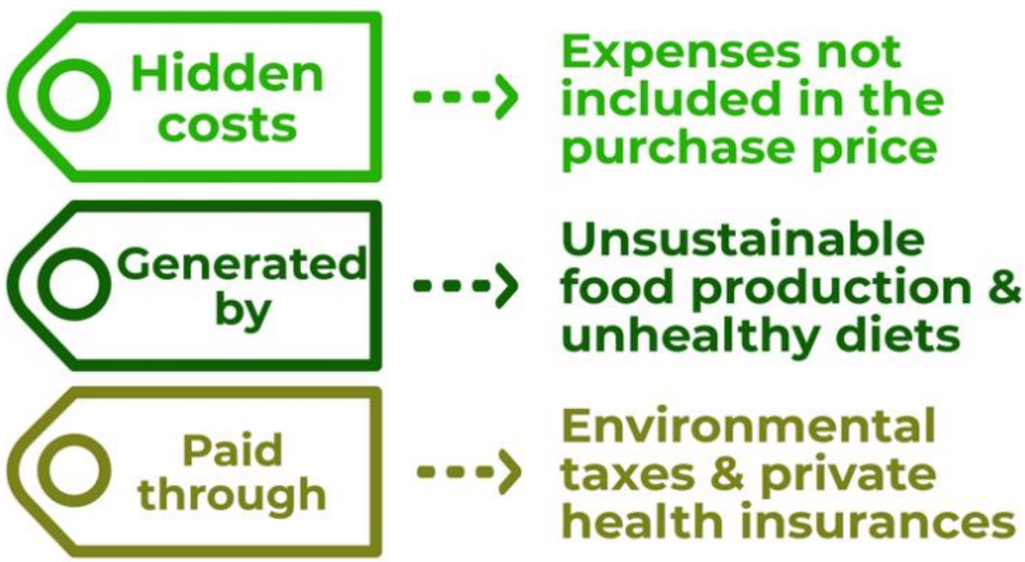


Figure 2: True Cost Accounting

Source: Sustainable Food Trust

This also includes the contributions of fossil fuel use on climate change (crop loss, decreased yield, new/more intense disease and pest infestation, to list a few).

True cost accounting will require *location and community specific* identification and internalization of social and environmental costs and compensation for ecosystem services and/or other public goods. This will rely heavily on equitable and inclusive stakeholder engagement, technical capacity to identify and quantify the costs, and extensive and extremely detailed regulations to ensure the holistic cost is internalized and reflected in the business as usual system.

True cost accounting with economic valuation and compensation mechanisms is not be a one size fits all panacea for the current unstainable practices in use of biodiversity-based products and GHG emissions in agriculture.

It is, however, a worthwhile market-based measure, which can up the ante for informed behavior change, to tackle loss of biodiversity and climate change. Internalizing and accounting the costs of ecosystem services, local knowledge associated with farming are the first steps to that direction while ensuring equitable and inclusive sustainable development.

What does True Cost Accounting do?

True cost accounting calculates the impacts of economic activities on natural and social capital (or, on the natural and social environment) in which the business operates.

It includes factors such as equity, inclusion and access, to ensure a more holistic economic value for the processes, people and systems responsible for production and distribution of products.

Historically, the interconnectedness of economics and ecology has been recognized by economists in the fields of agriculture and forestry (Gregory 1972[13], Bowes and Krutilla 1989[14]) and by resource economists in general (Kahn 1995[15]).

Dynamic linkages between economic and ecological systems and the links of society to ecosystems has been shown by research (e.g. Daly 1968 and Odum 1971).

Business as usual linear economics does not acknowledge the dynamic relationship of this paradigm. This has led to current day depletion of

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[13] Gregory, G.R. 1972. Forest resource economics. Ronald Press, New York, New York, USA.
[14] Bowes, M.D., and J.V. Krutilla. 1989. Multiple‒use management: the economics of public forestlands. Resources for the Future, Washington, D.C., USA.
[15] Kahn, J.R. 1995. The economic approach to environmental and natural resources. Harcourt Brace, Orlando, Florida, USA

natural resources, climate change and strained planetary boundaries.

Unfortunately, economic research focused on this often align remedies through taxes and incentives, conventionally sought out to correct for market failure (Tietenberg 1988[16]).

Agribusiness value chains are optimal tools to gather greater recognition of the interconnection between humans and nature, and the integration of natural systems into collective climate action.

Clearly, the answer to the problem does not lie in conventional economics and accounting. There is a growing acknowledgement of interrelations between development and economic activities which is changing that outlook.

Conservation of ecological services is identified as the key determinant of sustainable economic development (Kahn, 1995). Increase in the scale of development, reveals deeper connections between economies and environmental dynamics (O'Neill et al 1998).

[16] Tietenberg, T. 1988. Environmental and natural resource economics. Scott, Foresman and Company. Glenview, Illinois, USA

The intimate relationship between economic activity and the ecosystem is particularly clear in the management of renewable resources (Hamilton 1948[17], Watt 1968[18]). One of the best examples is provided by the fishery industry (e.g., Paulik and Greenough 1966[19]). As the rate of harvest approaches the reproductive potential of a population, the catch per unit effort decreases. Fisheries management has learned to build the population dynamics into the economic model and to explicitly include the feedbacks. Similarly, forestry and whaling have also recognized the need to integrate population dynamics into the economic models (Walters 1986[20]).

Along those lines which recognize the intricate dependency of economic activities on the natural capital, true cost accounting is a step toward internalizing economic costs within an accounting system.

[17] Hamilton, J.E. 1948. Effect of present−day whaling on the stock of whales. Nature 161: 913−914
[18] Watt, K.E.F. 1968. Ecology and resource management. McGraw−Hill, New York, New York, USA
[19] Paulik, G.J., and J.W. Greenough. 1966. Management analysis for a salmon resource system. Pages 215−252 in K.E.F. Watt, editor. Systems analysis in ecology. Academic Press, New York, New York, USA
[20] Walters, C. 1986. Adaptive management of renewable resources. Macmillan, New York, New York, USA.

True cost accounting acknowledges human societies collective urge to develop and maintain a quality of life is dependent on the ecosystem; we are part of a single, integrated system, a cog in the wheel of planetary systems (McDonnell and Pickett 1993[21]).

> Nature based solutions help advance climate change mitigation and adaptation. They reinforce the value of ecosystems services and encourage investments in nature that benefit people's livelihoods and wellbeing, as well as improve ecosystem health, protect biodiversity and address food and water security.

True cost accounting allows us to identify mechanisms underlying production systems, even one as complex as agricultural system to be investigated by systematically isolating individual parts to understand how they function in isolation and identify their interdependencies.

The three T's have the potential to change how value chain commodities are understood and valued.

[21] McDonnell, M.J., and S.T.A. Pickett, editors. 1993. Humans as components of ecosystems. Springer–Verlag, New York, New York, USA

This could be defined as a 3T based **Regenerative Value Addition** in agricultural value chains.

> This progressive accounting system aims to shift the isolation of economic activities and ecological processes, viewed and valued in silos, identifying pieces of their interactions, to then reassembled into an understanding of the complex, connected systems.

The 3T's in the production consumption processes in value chains become **information and education tools** to all stakeholders along the value chain[22]. Particularly to the consumers who can drive significant change through informed consumption, thus result in consumer lead change in production practices, consumption behavior and post consumption management of remaining resources.

In summary, the 3T approach in our production systems starting with the food systems, has the potential to lead the change through sustainable production systems and markets that respond to

[22] https://hbr.org/2011/10/the-sustainable-economy

choices made by informed end users and other stakeholders in the value chain.

The 3T approach can bring significant changes to production and consumption economies through value chains, depending on the efficiency of technology, the capacity and proclivity of companies, their shareholders and governance to respond to science, data and climate challenges with the appropriate changes in policy.

1.4 The Case for Biodiversity Friendly Climate Responsible Value Chains

The planets natural systems enable life processes that support all the economic systems. Agriculture has a profound and planet wide impact on these processes and systems.

This section argues for the essential changes required in the agricultural practices and agribusiness value chains, particularly in the context of biodiversity conservation and carbon emissions to set the course for transformations in the economic systems and address biodiversity loss, and climate change.

Agriculture is a board all-encompassing sector that impacts food systems, land use, biodiversity, and the climate systems.

Agriculture has close ties with urban systems or cities, where it finds the largest market for its produce and products. It is also an energy intensive sector, relying heavily on non-renewable fossil fuel-based energy inputs from production to processing, packaging, storage, transport and post-consumer cycles.

Agriculture systems, energy systems, urban systems and the production and consumption systems are closely interconnected in pushing planetary boundaries and accelerating climate change. As allies, they could provide solutions for the impacts of climate change across interconnected economies and planetary boundaries.

Agriculture promises to be a game changer for climate change by creating opportunities to

(1) Promote sustainable food systems to meet growing global demand,

(2) Promote deforestation-free agricultural commodity supply chains to slow loss of tropical forests, and

(3) Promote restoration of degraded landscapes for sustainable production and to maintain ecosystem services[23].

Agriculture provides opportunities to address accelerating climate change by restoration of degraded lands, diversifying value chain with biodiversity, decarbonization of economic footprints and reduce pollution and waste and make progress toward circular economies[24].

Biodiversity, soil health, stable climate systems and access to water are the foundational assets to agribusiness to meet nutrient requirements of growing population, to ensure ecosystem services, socio-economic development, and to secure human and planet health.

Biodiversity is a fundamental provider of natural capital or the global environmental benefits (GEB), such as regulation of carbon, nutrients, water cycles and climate and the raw material for evolutionary natural capital necessary for climate adaptation and mitigation[25].

[23] https://www.thegef.org/sites/default/files/council-meeting-documents/GEF-7%20Programming%20Directions%20-%20GEF_R.7_19.pdf
[24] Focus on hotspots in Asia (Viet Nam, Indonesia, India, China)
[25] https://www.cbd.int/doc/publications/ahteg-brochure-en.pdf; Addressing Climate Change: Why biodiversity matters https://www.unep-wcmc.org/system/dataset_file_fields/files/000/000/221/original/IKI_report_2_accessible_version_20140530.pdf?1401884844

Biodiversity plays a crucial role in human nutrition through its role in global food production as it ensures the productivity of soils and provides the genetic resources for crops, non-crop terrestrial species, livestock and marine species harvested for food. *Nutritious varieties of foods accessed with biodiversity (preferably local/ small footprint) is a fundamental determinant of health.* Emerging research on changes in plant nutrient content (in leaves, pollen, seeds/produce) in response to increasing CO_2 levels in the atmosphere re-emphasize importance of biodiversity and the efforts to conserve it[26].

Conservation of biodiversity and healthy soil and water systems are critical issues both for the global environment, socio-economic security and human well-being particularly as we try to adapt ourselves and our agricultural systems to climate change[27].

However, worldwide, 75 billion tons of soil is lost every year, costing approximately US$400 billion per year, or about US$70 per person, per year, according to the U.N. Food and Agriculture Organization (FAO).

Further, conventional agriculture has an enormous water footprint[28]. These are external costs

[26] https://e360.yale.edu/features/bee_collapse_co2_climate_change_agriculture
[27] https://phys.org/news/2020-03-crop-diversity-buffer-effects-climate.html
[28] https://waterfootprint.org/en/

that are not reflected in the cost of food at the market. For example, in U.K. alone Pretty et al (2005) estimated that the external cost of UK agriculture to be £1.51 bn per yr. The study found that switching to organic production could lead to avoided costs of £1.13 bn per year.

Another study, also from the U. K[29] (2017) found the real costs of conventionally produced food were 100 percent higher than its market prices. This food sale came with hidden costs to society, through environmental pollution, excessive use of fossil fuel-based chemicals, and unsustainable use of water and energy resources.

Clearly, neither biodiversity, nor soil health nor water used are considered while valuing food in conventional value chains.

Other externalized costs include ill health related to production and diet-related diseases and social repercussions such as lack of fair wage payment to laborers, farmers and others in food production and access to culturally appropriate nutritional security for all.

[29] Source: The hidden cost of UK food. November 2017 http://sustainablefoodtrust.org/wp-content/uploads/2013/04/HCOF-Report-online-version.pdf

The current linear valuation of food and other products in value chains does not reflect the unaccounted externalities- social costs, health costs, and environmental costs imposed by the food system. These externalities may be quantified indirectly by assigning dollar values through a process called valuation (Pretty et al 2005 for example, and numerous other studies from FAO, TEEB and other).

> Formal market trading does not take place for ecosystem functions and its health attributes that are the foundational natural capital supporting all four economic systems (food, urban, energy and production and consumption systems) many consequences are borne involuntarily by all.

Beyond externalizing costs as mentioned above, agriculture is also the largest greenhouse gas (GHG) emitting sector, and the largest contributor to changes in the planetary boundaries.

Business as usual linear agriculture is dependent on non-renewable unsustainable use of freshwater, energy and fossil fuel-based inputs that leaves long unaccounted footprints on ecosystem and human health and does not account for these externalities.

A circular/ regenerative agriculture with holistic land management practice accounts for all inputs to agriculture, leverages the power of photosynthesis and its intricate relationship to other organisms such as microbes in the soil biome to close the carbon cycle, and build soil health, crop resilience and nutrient density.

> Transformational change in agriculture will require an intentional shift from linear agriculture to a regenerative and responsible agriculture which internalizes the cost of natural capital. This transformation is dependent on agriculture becoming transparent, traceable and accountable to its true cost of production for all products on its value chains and finding nature-based solutions for regerative agricultural practices.

Circular / regerative agriculture can be a transformational tool to address growing GHG emissions and accelerating climate change.

Such transformation will require concerted effort from all stakeholders in the Earth Systems -

producers, consumers, policymakers, scientists, educators and others to make a *deliberate and collective shift and engage with the true cost of processes in the food chain from growing, processing, packaging, consuming and addressing post-consumption remains of food.*

There is a willingness to change, for example, 94% of consumers are willing to change their daily behavior to tackle climate change[30].

> Natural Capital is the foundational investment and provides a compass of indicators to measure progress towards the SDGs.

Further, to realistically achieve the Sustainable Development Goals it is critical that externalities in the economic systems be accounted for, inter-dependencies, synergies between the systems identified and trade-offs across different sectors are made with full awareness of environmental and societal implications.

On a global scale, the call for nature-based solutions for climate change and biodiversity conservation are gaining momentum. As mentioned

[30] Sir David Attenborough at COP24 https://unfccc.int/news/sir-david-attenborough-launches-un-campaign-to-promote-climate-action-by-the-people

earlier, the UN climate summits in 2014 and 2019 have called for nature-based solutions to climate change

Several companies such as the ones listed under the Science Based Targets Initiative, businesses working with the World Business Council for Sustainable Development (WBCSD) and 87 companies with a combined market capitalization of over US$2.3 trillion and annual direct emissions equivalent to 73 coal-fired power plants — are taking action to align their businesses to lead the way towards a 1.5°C future could harness nature based solutions from food systems to address climate challenges and protect biodiversity.

It is here that 3T approach can elucidate linkages between natural capital and business as usual economic development and the need to shift to regerative and responsible ways nature-based solutions. The 3T approach can guide better understanding of inter-dependencies in agriculture, harvest the power of new technologies to address the issues of externalities, and empower communities through entrepreneurship to solve local and global challenges through value chains.

For such transformations to create lasting impact through technology adoption, policy and behavior change, it is critical that it is inclusive, equitable and accessible to all stakeholders.

Responsible value chains could build resilience in food systems by supporting agroecological approaches that enhance dietary diversity, create market opportunities across value chains for organized promotion of biodiversity across the value chains. Valuation of biodiversity using 3T approach (traceability, transparency and true cost accounting) is key to transforming economies by creating informed consumers and responsible producers.

> Responsible value chains can address the critical weaknesses of lack of markets for diverse crops which provide nutritional security through diversified diets, create innovations and knowledge generation in harvest, processing, packing and carbon retention and capture; provide raw materials for sustainable food, cosmetics and health care products.

Using blockchain with 3T approach we can harness the capacity of value chains to bring biodiversity into agribusiness, enhancing dietary diversity[31] and capture the 'true value' to stakeholders and end-users across the value chain.

Block chains enabled value chains with true cost accounting, transparency and traceability for community lead inclusive and equitable biodiversity conservation and climate adaptation could lead to long term positive outcomes for climate change through informed behavior change of stakeholders across the value chains.

This approach can be potentially applied to value chains for all products ranging from informal or traditional, and the other formal or modern. It can encourage small producers to markets characterized by low-quality products, and low prices and low returns for them — hence a frequent concern is to find ways to integrate small producers into both domestic and export-oriented value chains and markets.

[31] Advancing equity, equality and non-discrimination in food systems: Pathways to reform', https://www.unscn.org/uploads/web/news/UNSCN-News43.pdf

METHODOLOGY

2.1 What is blockchain?

Blockchain is a distributed database, a decentralized public ledger. It is an Internet of Things (IOT) based technology that has existed since 2008 and growing in its applications since.

A 'block' is the foundational element of blockchain data structure, and a blockchain is literally a chain of blocks made up of digital pieces of information.

This is a key advantage of a blockchain since transactions/digital pieces of information can be traced back all the way to the start of the blockchain.

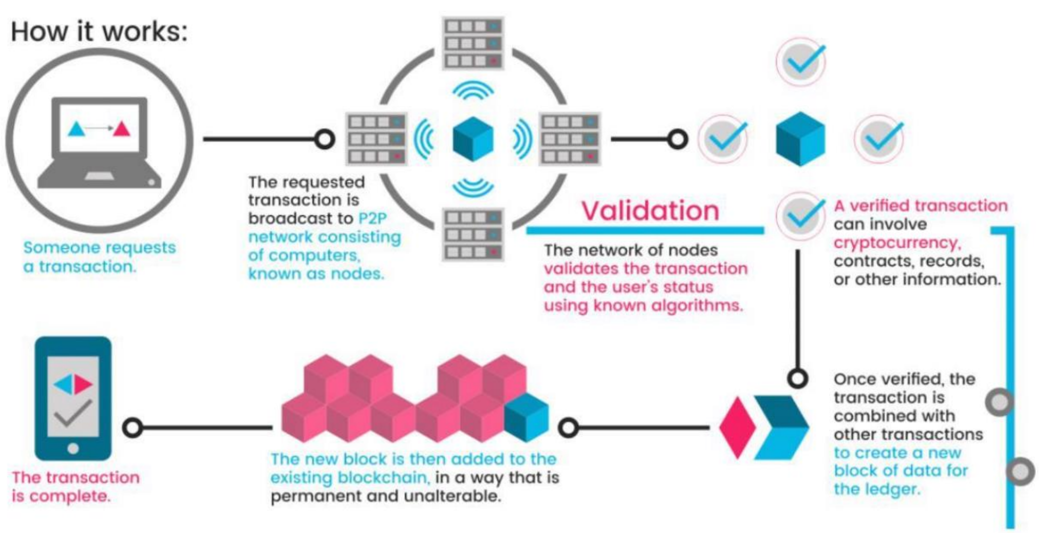

Figure 3: How does Blockchain work?
(from Olsen et al, 2019)

The above figure (3) explains how a blockchain system can work. Steps include creating a transaction, to validating that transaction, to finally appending the transaction to the blockchain.

Over time, transaction history gets locked in blocks of data that are then cryptographically linked together and secured. This creates an immutable, unforgeable record of all the transactions across that network. This record is replicated on every computer that uses the network[32].

> Blockchains can reveal where an asset is at any point of time, who is handling it at that at any point in time as well as its state. Blockchain can link both sides of the supply chain with information, as well as help in efficient inventory management, cost reductions, waste management and maintain a standard quality.

[32] How the blockchain will radically transform the economy, Bettina Warburg. https://www.ted.com/talks/bettina_warburg_how_the_blockchain_will_radically_transform_the_economy/transcript#t-202950

As a distributed database or distributed ledger with a set of immutable instructions blockchain ensures *all transactions are recorded, stored, and unaltered since the first entry*.

Hence *blockchain is a reliable technology conduit to integrate data for transparency, traceability and true cost accounting embedded with socio-economic parameters such as equity and inclusion* to enable value chains become transmission lines (Figure 4) of sustainability efforts across the value chains.

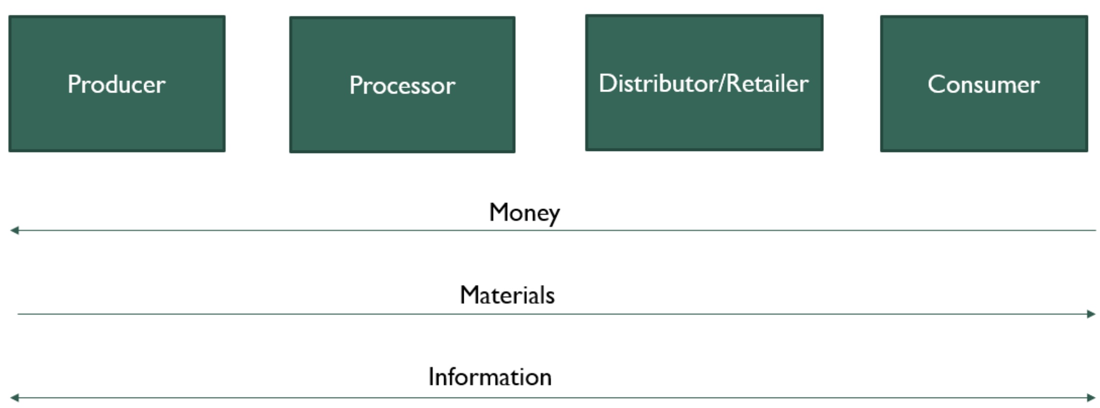

Figure 4: Information flow in Blockchains

The Scientific and Technical Advisory Panel (STAP) which provides advice to the GEF on strategies, policies and projects calls for –

integration, innovation, and learning as essential elements for a successful GEF-7[33].

Blockchain technology is one such innovation that allows for integration and learning while supporting equitable transformation to climate resilient economies in Peru and elsewhere as needed.

2.2 Principle of Blockchain Operation

A typical public blockchain implementation is based on five basic principles that underly its technology (Lansiti & Lakhani, 2017 and Olsen et al., 2019).

The following list of principles of blockchain operation is an excerpt from Olsen et al., 2019.

1. Distributed database

a. Each user in the network has access to the full database and all its transactions.

b. No single user controls the database.

c. Every user can verify the transactions directly.

2. Peer-to-peer transmission

a. Communications between users in the blockchain happens directly without the use of an intermediary.

b. Each user stores and broadcasts information to the full network.

[33] http://www.stapgef.org/sites/default/files/FINAL%20---Rosina%20-%20assembly%20closing%20remarks%20to%20Assembly_July%202018.pdf

3. Transparency with pseudo-anonymity

a. Every transaction on the blockchain is visible to anyone who has access to the blockchain.

b. Each user has a unique address (typically a public-key) that identifies them.

c. Users can be anonymous or can choose to reveal their identity.

d. Transactions occur between user addresses.

4. Irreversibility of records

a. Once a transaction is stored into the blockchain it cannot be altered.

b. Transactions within blocks are linked to other blocks.

c. Algorithms are used to make sure transactions are recorded permanently, are chronologically ordered, and are available to all users on the network.

5. Computational logic

a. Blockchain transactions can be tied to computational logic and therefore programmed.

b. Users can set up algorithms to generate transactions between nodes.

There are different types of blockchains as shown in table 1. The Peru project would most likely adopt the Federated blockchain or the Private blockchain.

	Public	Consortium/Federated	Private
Consensus determination	everyone	selected (few)	single authority
Read permission	public	public, partly public, restricted	public, partly public, restricted
Immutability	nearly impossible	possible with majority of validators	possible
Efficiency	low	high	high
Centralised	no	partially	yes
Consensus process	permissionless	permissioned	permissioned

Table 1: Types of Blockchain (Olsen et al., 2019)

That decision would be driven by resources, governance capacity, and findings that reflect the expectations of the stakeholders involved in the project.

Blockchain provides a reliable technological way to usher practical, nature-based solutions that embed the natural and social capital value, the value of infrastructure, economic processes and informed trust built between diverse stakeholders across the value chain.

2.3 Requirements and Costs for Blockchain Solutions

The initial investment in developing blockchain technology solution will be in identifying and assessing needs, capacities and expectations with *deep ethnographic research*, and developing a culturally sensitive blockchain system solutions through *human-centered design and design thinking.*

This will also be based on a thorough analysis to get insights to

1. to identify the major commodities produced in these landscapes as well as important minor products (e.g. Biodiversity based NTFPs used by poorer households or biodiversity-based handicrafts as in the case of Peru).
2. Identify major land uses and trends, natural resource endowments (water, forests, minerals), major public and private (commercial) stakeholders in these supply chains, characteristics of the labor force (e.g. permanent versus migrant labor)
3. key production inputs, volume and value of major outputs, commercial relationships and major end use markets

4) project structure and participation of key stakeholders and organizations (primary producers, input suppliers, processors, distributors and final market retailers), as well as access to existing traceability systems & data.

5) insights to social and environmental context associated with the production of the main products

6) location, size and distribution of human settlements and infrastructure, governance and other social structures, dominant majorities and vulnerable

minorities, the major local drivers of environmental change

7) existing initiatives like certification or agricultural extension services, etc.

Other investments or costs to the project include additional hardware investments to make that would enable information to be stored onto the blockchain.

For example, where would one store the information in a digital database, ledger, or supply chain system, one can now store their information directly (e.g. application programming interfaces) or indirectly (e.g. web interface) on the blockchain.

The project will also need support to manual entering data into the system, scanners or other electronic reading devices. Data connector application programming interfaces (APIs) that allow companies to efficiently upload supply chain data from existing data stores (such as SAP) to their blockchain system could be required based on the plan developed for the pilot site. This will enable seamless integration of data from enterprise systems to blockchain solutions. Data can also be entered through web interfaces.

Blockchain for Peru could be a combination of Ethereum-based public blockchain solutions as well as Hyperledger for the permissioned blockchain. The exact user interfaces and associated identity management tools will be designed during the early stages of the project, taking into consideration cultural and local contexts.

Apart from all that is already mentioned, four key inputs will impact the costs[34] for a blockchain intervention. These include:

1. transaction volume (amount of activity performed on the network per day),
2. transaction size (storage requirement for one unit of value transacted on the network),
3. node hosting methods (chosen method of storing blockchain platform) and all its ancillary technical requirements), and
4. consensus protocol (methods of verifying legitimacy of blocks for transactions)[35] identified for the blockchain in the chosen pilot areas(s).

2.3.1. Potential partners for Collaboration

There is a significant potential to build parentships regionally and globally for a blockchain based 3T intervention to develop responsible value

[34] https://cloud.ibm.com/docs/services/blockchain?topic=blockchain-ibp-saas-pricing
[35] https://www.ey.com/Publication/vwLUAssets/ey-total-cost-of-ownership-for-blockchain-solutions/$File/ey-total-cost-of-ownership-for-blockchain-solutions.pdf

chains using nature-based solutions. Companies such as the ones listed under the Science Based Targets Initiative, businesses working with the World Business Council for Sustainable Development (WBCSD) and the 87 companies with a combined market capitalization of over US$2.3 trillion who committed to reduce emissions (in the 2019 UN climate summit) are worthy of exploration for potential financial and technical partnerships and building networks to further the 3T blockchain approach for expanding nature based regenerative solutions in value chains. These links were mentioned earlier (page 33, section 1.4).

Apart from these, organizations listed below could be explored for collaborative purposes in the Peru project.

1. The consumer goods forum[36]
2. The sustainability consortium[37]
3. Tropical Forest Alliance TFA 2020[38]
4. CDP- Driving Sustainable Economies[39]

[36] https://www.theconsumergoodsforum.com/offices/
[37] https://www.sustainabilityconsortium.org/
[38] https://www.weforum.org/projects/tfa-2020/
[39] https://www.cdp.net/en/

5. Solidaridad[40]
6. Banking environment initiative[41]
7. The Sustainable Trade Initiative[42]
8. CBD's Business Engagement Program[43]
9. BIOFIN- Biodiversity Finance[44]
10. EU Business @ Biodiversity Platform[45]

In the context of the Peru bio-trade project, it is recommended that the search be initially directed toward strengthening regional partnerships and selectively aligning with established food systems leaders such as the partners in One Planet Business for Biodiversity (OP2B)[46].

2.3.2 Potential technology companies for 3T

Research conducted for the purposes of applying blockchain technology in Peru yielded insights not only to the technology, but also to the potential of the companies interviewed for this work.

The following paragraphs present a summary of these interviews and follow-up communications.

Waryer:

[40] https://www.solidaridadnetwork.org/
[41] https://www.cisl.cam.ac.uk/business-action/sustainable-finance/banking-environment-initiative
[42]https://op2b.org/ https://www.idhsustainabletrade.com/about-idh/
[43] https://www.cbd.int/business/
[44] https://biodiversityfinance.net/about-biofin/what-biodiversity-finance
[45] https://ec.europa.eu/environment/biodiversity/business/index_en.htm
[46] https://op2b.org/

Waryer's online platform allows its clients the transparency on the way funds are administered in projects by implementing agencies, such as NGOs and others. Waryer achieves this by Blockchain (Cryptography) technology which secures transaction by tracking and showing accountability. All cash flow reports are verified by Waryer, using a combination of digital and analog tools. Waryer guarantees a transparent process from donation to distribution.

Waryer's ongoing project in Puerto Rico shows the movement of donor funds to residents at-risk and undeserved communities throughout Puerto Rico with roofing and other construction-related services.

This gives an idea of the company's intentional design to work with local people, identifying local needs, finding solutions that work for their situations while factoring future climate crisis, and ensuring the process of building communities is transparent across the path from donors to receivers.

Waryer Pros:

Based on the information received from Waryers' project experience, Waryers' strengths include, their ability to complete the project in the designated time, Quantify goals and report social impact; technical competence to create Blockchain design to include provision made for donor to rate receiver after completion, and for receiver to reviews donors after disbursement, ensure Waryer Blockchain stamping records every transaction (which can be useful in certification process), Ethereum smart contracts safeguard all data, Crypto-ledger provides stable data trail. Waryer and its partners are transparently audited (authenticates their work in the context of their values).

Waryer has a dedicated and diverse technical team, with fluency in languages to work in any region of the world including South America. Waryers' methodology to onboard local people is called 'Positive Deviance', a method created Waryers' advisor Prof. Sternin of Tufts University.

The concept of positive deviance is the act of creating change within a specific area of a social norm. The positive deviance approach will work well for the Peru project, since the project involves work with very diverse stakeholders, some of who are minorities in the region and the project has diverse stakeholders including women and youth.

Positive deviance method could work in favor of engagement with user community who will benefit from the blockchain intervention. This method may also help project evaluation at a later phase of the project.

On the technical side, Waryer team show case competence and experience. Waryers' sensor expert is Kim Chanug, whose sensors can collect temperature and vibration data by attaching the stickers to freight trucks and other transportation means. This tech is already in use in Taiwan-Airport Metro System.

Waryer can enable International codes for produce. Waryer's team includes experts in artificial intelligence (AI), Deep Learning Drones and Satellite imagery, Cybersecurity, UX Design, Web/APP, Business Development, and includes Crisitan Oliveres Co-founder of Solubag (a bag that dissolves in water) on their board. This is of interest in context of achieving reduced carbon emissions in packing and quantifying regerative approaches in the responsible value chains.

Waryer Cons:

Relatively smaller company in comparison to others interviewed for this work. Waryers' experience in agricultural work is with a food security project initiated in Puerto Rico.

In summary, Waryers' approach of positive deviance, its technical competency and diverse team members with international work proficiency, and the potential to onboard sustainable packaging solution into this project are points that work in their favor.

OpenSc

OpenSc is a company based out of Australia, co-founded by WWF (the World Wide Fund for Nature) and BCG Digital Ventures aimed at proving solutions to challenges in food systems through technology-based transparency and traceability solutions.

OpenSC is a supply chain transparency and traceability platform that enables more responsible production and consumption.

Opensc enables companies and consumers to *verify* claims about sustainable and ethical production at source using data science and machine learning, *trace* products throughout supply chains using iot and blockchain and *share* that information with consumers across digital channels to promote purchasing of more responsible products.

OpenSc Pros:

OpenSc case study with Austral fisheries and its experience in certifications speak for the company's dedicated work pursing sustainability in food systems. Zoom interviews introduced the core team members and the WWF expert who advises OpenSc. OpenSc has also raised 4million in seed funding to further develop its technology platform for driving sustainable and ethical supply chains. OpenSC uses ethnocentric approaches to work with communities, which has its advantages particularly when working with indigenous communities. Project team has language competency to work in Peru, and international experience, and can harness the connections with WWF as needed for this project.

OpenSc Cons:

Larger company, and therefore might be more expansive to engage in the project. Also, the company is in Australia. This might add a larger travel cost during next phase. Might be led/influenced by their previous work in other regions, which may not translate to the needs in Peru

Ripe.io

This is a company based in California, USA, consisting of a 'team of supply chain engineers, food scientists, blockchain developers, technology executives, farmers, sustainability specialists and entrepreneurs united by a passion for transparency and truth in food system'.

Their press releases illustrate the breadth of their work and ongoing efforts in partnership development. They use blockchain technology to 'power real time data in one concise dashboard'. Interviews indicate Ripe has a strong technical team and are gaining wider application experience with fruit/farm produce, dairy and meat industry.

Ripe.io Pros:

Their work most closely fits to the work the Peru project is envisioning to do. As mentioned, their work shows their capacity to deliver.

During the interview for this research, the founder of Ripe mentioned they do not use a public style blockchain and have spent the past two years creating both a track and trace application along with food quality management application. This ensured that the end users or entities don't have to code or adopt anything. This could make a difference in the cost for implementation, and influence post project upkeep, although at this time there is not clarity on these issues.

The company is geographically closer, and has work experience in the US, and other regions of the world, including South America.

Ripe.io Cons:

For the reasons mentioned above, the intervention *might* cost more. Invitational bidding might provide better insights to the projected cost, to develop the track and trace application for Peru and successful technology transfer.

Other companies reached out for review include Deloitte, Provenance and itpeoplecorp.

In summary, the companies interviewed have the potential to play key technology delivery role for the project.

Here are some recommendations for potential next steps.

i) evaluate the company's responses to TOR, which also asks for provisional cost for intervention
ii) Initiate intervention in a pilot area with a crop such as Aguaje that has a higher volume.
iii) allocate realistic timeline based on capacity in stakeholders, project personnel and technical company that is hired for the job.
iv) make provisions for engagement of local blockchain startup such as qiru solutions, based

in Peru. Qiru has worked on wood tracking protocol, and do not have ongoing projects in Peru (based on their website).

v) Based on lessons from pilot area, identify project sites, communities and products to engage for 3T in other parts of project area, beyond the pilot.

vi) transfer technology to these selected project areas, ensuring local capacity is built for this intervention to continue after project lifetime.

2.4 Purpose and Role of Blockchain for 3 T.

Trade in agricultural products has changed over time, with the food we eat, the clothing we wear and other products including nature-based medicines and personal care products are increasingly being delivered by global production systems that cross several borders.

Growing environmental concerns and desire in the consumer and producers to shift to sustainability by locating sources and ethics of productions is formidable challenge to make changes to these vast value chains.

However, traditional electronic traceability systems do not support interoperability thus preventing system-wide food product traceability, transparency and its true cost. It is here that blockchain based food traceability system which are more homogenous (than traditional electronic traceability systems) and has better interoperability (between different blockchain-based systems) will be better option to implement, ensuring responsible use of resources across food systems.

A smart contract is a computer code that can be built into the blockchain to facilitate, verify, or negotiate a contract agreement between the stakeholders.

Blockchain's 'smart contracts' can be used in agricultural value chains to record the origins of materials and authenticity of products, along with indicators of environmental, socio-economic parameters for health and ethics giving greater insights to labels across the value chains.

Since smart contracts can be intentional by design, it allows for standards to go beyond ones set for labels such as organic, local and fair trade, allowing verification for circular and regenerative aspects and ethical standards rooted in equity and inclusion. With blockchain technology value chains will be able to expand tracking and response to the food safety challenges throughout the producer-to-user journey.

Blockchain enables the following actions through a series of action assigning value to socio-economic and environmental measurements set against indicators that are collectively agreed upon.

Blockchain design to capture the economic and environmental costs of land use change, chemical use, packaging and transportation (see figure 5) with measurable science based indicators that are equitable to all stakeholders could change the business as normal platform into one that accounts for socio-economic and environmental values of stakeholders across the value chain.

> Smart contracts can be intentional by design, to operate under a set of conditions that users agree to uphold the socio-economic and environmental values, hence allows for novel standards, beyond Organic and Non-GMO, etc.

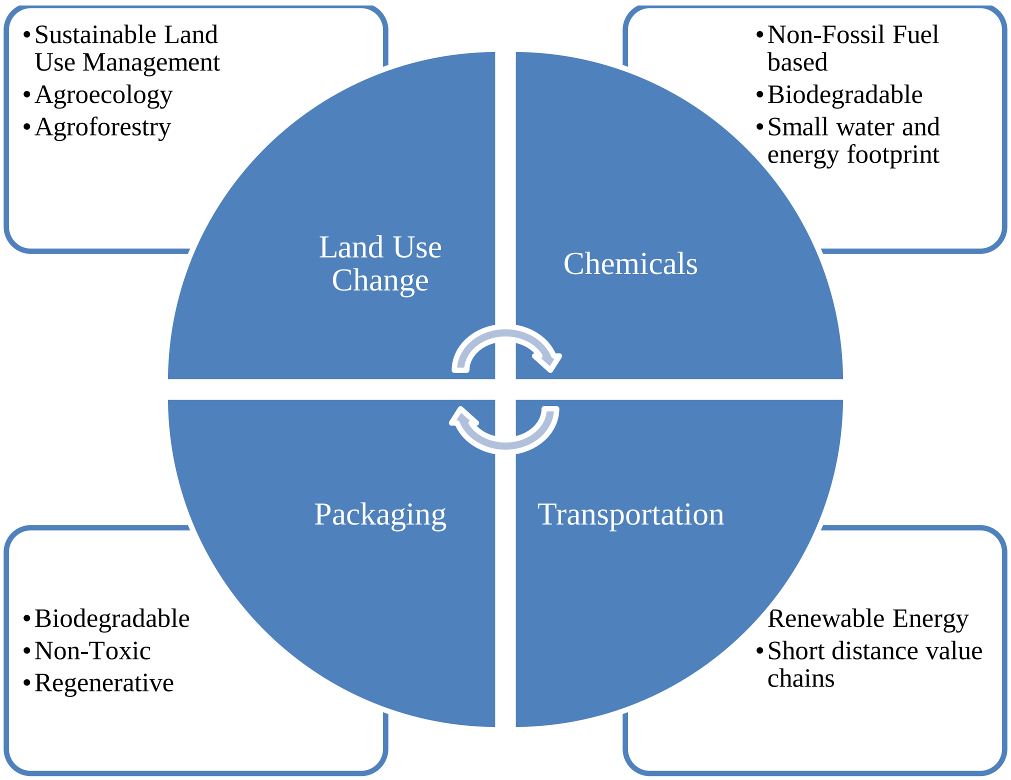

Figure 5: Measurable parameters in a responsible value chain.

Agricultural value chains are a complex network of people, processes, and technologies that are interlinked, engineered and managed to deliver value to customers and producers, through flow of material, money and information.

Keeping these flows smooth with minimal disruptions and turbulence is critical to manage these chains. This can be challenging due to challenges imposed on food, infrastructure and economic systems due to climate change.

One response to this is observed in the growing demand to shift to nature-based solutions such as agroecological methods which are sustainable and regenerative.

> Nature based solutions through 3T methodology supports lean production times, just in time deliveries for smaller and infrequent harvests and to allow time for resources to recover from vagaries of climate change.

In this scenario, deigning value chains with a combination of shorter value chains that branch off the longer ones, to increase local resilience and contribute to larger resiliency might be one approach to consider along with deploying the 3T methodology across the value chains.

This also supports lean production times, just in time deliveries for smaller and infrequent harvests and to allow time for resources to recover from vagaries of climate change.

RESPONSIBLE VALUE CHAINS

3.1 Human centered design thinking with biomimicry for Responsible Value Chains

Innovations in food systems are tagged with solutions for challenges in food systems issues like agricultural waste, packaging, pest management, fertilizers for soil nutrient content and plant growth, food distribution, and water and energy use in the production systems.

Agriculture is a nature-based human activity. Mimicking natures tools - circularity and regenerative processes could provide nature-based solutions for ongoing systemic challenges in agriculture.

Be it the challenges in efficient use of energy, water, land or other resources across, nature-based design solutions nested in concepts of regeneration and circularity provide solutions that can be applied across all steps in a value chains - processing, packaging and transport of produce or products and post-consumer timeline for the product.

While considering actions to transform value chains it is critical to bear a visual of these chains (Figure 4) and remember the measurable parameters of these chains (Figure 5).

Value Chains are a complex network made up of people, processes, and technologies that are engineered to manage the flow of money, material, and information, and deliver value to their end-users/customers/consumers. Ideally, these flows should be smooth and timely to minimize disruptions, turbulence and risks of loss to stakeholders across the chains.

A step toward change would start with information-based change in decision and policy making, and consumer choice, broadly classified under informed behavior change. *Development organizations and public health officials 'give behavior change interventions as much credence as conventional legislative, economic, or infrastructural programs to achieve positive social change'*[47].

> To improve policy by drawing on behavioral economics and psychology, and marketers and managers are becoming increasingly sophisticated in their 'human centered' approach.

[47] https://www.bi.team/wp-content/uploads/2019/04/2019-BIT-Rare-Behavior-Change-for-Nature-digital.pdf

A recent research by *The Behavioral Insights team*[48]*suggests "a greater focus on how our cognitive biases, emotions, social networks, and decision-making environments all impact our behaviors and choices".* This finding has a historical precedence when we examine the marketing developed for organic and non-GMO labels for agricultural production, and other sustainability labels to reinforce messages to draw attention to climate change, biodiversity loss, and impeding water shortages.

Hence, designing interventions for systemic change in production-consumption cycles, needs a holistic approach, embedded with equity and inclusion at the foundation. Human centered design thinking provides that platform.

Human centered design thinking is an amalgamation of human centered design and design thinking. Human centered design calls for interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and applying human factors (based on observation and putting oneself in the situation of the end-user), usability knowledge and techniques.

[48] https://www.bi.team/

Design thinking on the other hand is a human centered approach to innovation. ***When these are placed in context of tools from biomimicry -such as nature-based solutions identified by regenerative processes and circular economic processes, we have a holistic approach to seek transformation in value chains.***

Responsible value chains are about nature-based solutions for strategic sourcing, with methods of harvest, processing and transport that incorporate measurable indicators for GHG emissions removed or added, and biodiversity conserved or lost, during the cycle of product development, consumption and post consumption period.

Regerative processes such as elaborate signaling in cells with molecules to change their own gene expression patterns to modulate cell repair, and regeneration of lost parts in animals are examples that display signaling (communication) and the reserve energy to recoup, grow and continue life processes.

Circular processes in nature that restore the natural cycle and ecological functions of soil, water and nutrients hold key take-aways to redesign linear value chains to responsible value chains that support biodiversity conservation and address factors contributing to climate change.

Responsible value chains i) Enable action-oriented business coalition on biodiversity with a specific focus on agriculture. ii) Capture information on protected biodiversity and cultivated biodiversity along with nutrition values for diverse diets through product portfolios; iii) Scale up regenerative agricultural practices and circular approaches to conducting business with equitable stakeholder engagement across the chains; iv) and provide data to reflect deflected deforestation, enhanced management and restoration and protection high-value natural ecosystems; v) are flexible in lean manufacturing and just in time deliveries, encouraging diverse smaller scale value chains for selected products; vi) are built to absorb risks associated with consistent procurement, a key determinant in value chain performance and supporting independent sellers who add value to larger value chains, through their biodiverse and seasonal products that is embedded into the social fabric of the Peruvian society.

As the first step to develop a blockchain intervention with 3T approach, it is important to get an overview of the potential players in the project, with figures 4 and 5 in context.

Next, it is critical for project personnel to meet with the stakeholders identified in the provinces of Atalaya (Ucayali), Loreto-Nauta (Loreto) and Satipo (Junín) to identify their challenges in business as usual scenario for the diverse produce they grow and use (from forests) in the project areas.

This will set the baseline to understand the *status quo* and factor in their requirements and expectations from this project, and project a realistic potential of 3T technology to provide solutions for the project area and communities therein.

> The first step in designing a human centered responsible value chain based on design thinking and biomimicry is to engage with stakeholders, to identify the human values and non-human intrinsic values from their perspective.

In the case of bio-business project for Peru, the first step of stakeholder engagement would be to recognize the diversity of landscapes and its peoples who will be impacted by this project.

This would include stakeholders from

a) Tiger-Cashew landscape is dominated by wetlands, especially palm swamps (Aguajales, Mauritia flexuosa), with the highest concentration of carbon known in the Amazon basin;

b) Alto Ucayali landscape is dominated by forests and deforestation fronts; and

c) landscapes that overlap with extensive indigenous territories, including peoples in isolation and initial contact (river Inuya, Ucayali, and Reserve Murunahua).

Initiating the development of 3 T model for this project will identify the human values and non-human intrinsic values (Figure 6) held in these stakeholder communities.

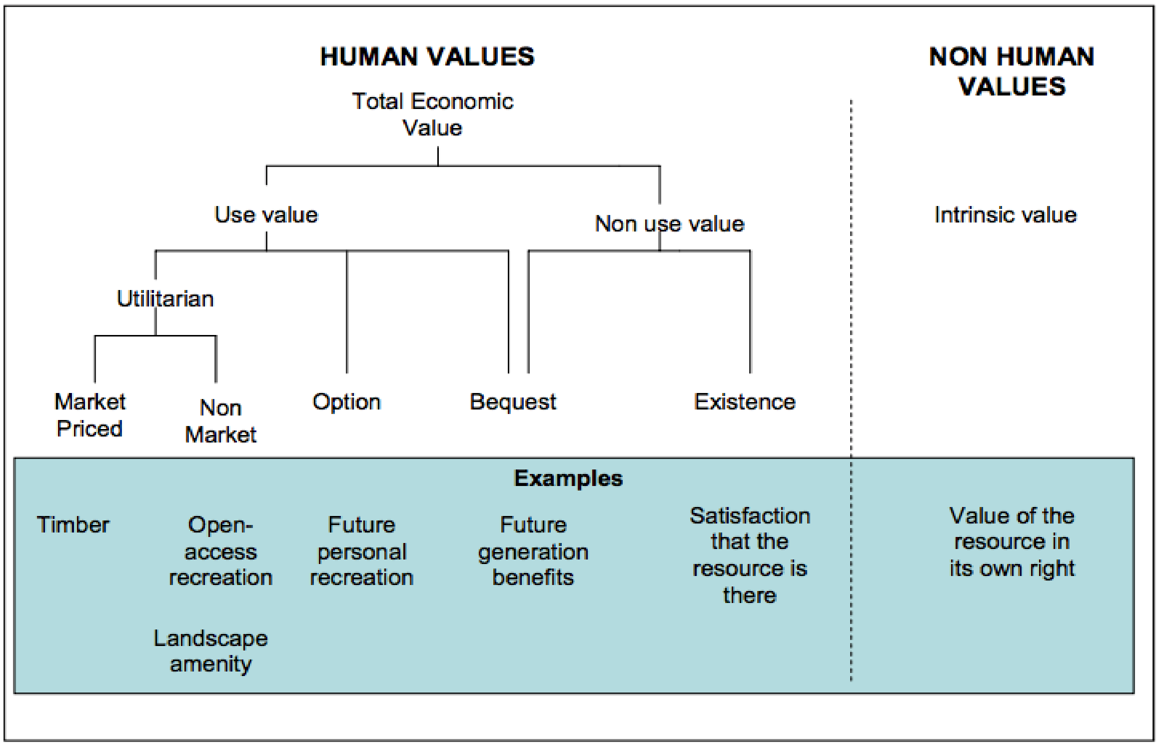

Figure 6: Environmental Value and Intrinsic Value
Source: Bateman et al. 2003[49]

Initiating the development of 3 T model for this project will identify the human values and non-human intrinsic values (Figure 6) held in these stakeholder communities.

This would mean, getting insights to community value for biodiversity, their historical/traditional/ sustainable methods of harvest of aguajales for example (prior to the current unsustainable methods), the agroecological alternatives for unsustainable land use and harvest, use of

49 Ian J. Bateman, Andrew A. Lovett, and Julii S. Brainard, Applied Environmental Economics, Cambridge University Press, Cambridge, 2003.

biodiversity for socio-cultural and nutritional values, and the presence of forests *per se* in the everyday lives of the people and communities.

In addition to known quantitative data, qualitative variables that are identified based on expert local knowledge and consideration of indirect cause-effect influences based on aggregation of diverse stakeholder points of view on the natural capital in question (biodiversity harvested, biodiversity preserved, undisturbed peat swamps etc.), will help in designing a blockchain protocol to reflect the values held in the community and weighed with scientific measurable parameters, such as measurable carbon emissions offset by sustainable harvest methods(s) of aguajales, for example or measure the value of biodiversity conserved due to sustainable harvesting procedures.

These will ensure the 3T blockchain method developed is responsive to the values, needs, ambitions and goals identified by the stakeholders.

The success of designing 3T blockchain intervention in pilot areas will rest on a thorough analysis of

1. Stakeholders, their roles and their buy-in for 3T methodology in value chain, their commitment to biodiversity conservation, and the effect of climate

change on their current economic activities, if continued business as usual (without the project intervention).

2. Details of contractual arrangements between stakeholders; barriers to enter the 3T value chain; and the level of competitiveness between enterprises in the value chain.
3. The current avenues of information exchange between stakeholders on solutions to improve their products and marketability for example, between the 11 markets in Iquitos, which caters to a popluation of over 231,648 people.
4. What are the bottlenecks to access technology to people involved in formal and informal (street side) markets, since Aguaje is then resold to another intermediary or directly to the consumer, usually a member of the family? Similarly, it is imperative to know the roles of and technical access that small companies have specialized in selling fruit, aguaje mass (pulp) or processed products such as ice cream?
5. What are opportunities available for development (modernization) of the value chain, for example to Loreto people in Kukama Kukamiria, Kichwa, Achuar, Jibaro and Urarina?

6. The current avenues of financial transactions and technical capacity for stakeholders in the chain?
7. Identify parameters -quantitative and qualitative, that the community identifies and agrees to measure as indicators. Examples include 1. Preserved and intact natural forests, 2. Avoided GHG emissions (through forest clearance, unsustainable use, biofuel production for fuel and plastics in packaging etc.); 3 Improved water quality and availability due to agroecosystem management practices, 4. Improve livelihoods due to 3T in the value chain. 5. Improve nutritional security across the value chain, ensuring biodiversity is used for food and nutritional security.

8. Current $ value added to the product by stakeholders at different stages of the chain, and the distribution of these costs between stakeholders.
9. Hierarchy and distribution of decision-making power between stakeholders, and how profits and economic risks among chain actors distributed? Harvesters for subsistence generally have weak bargaining power, particularly with small batches of products, uneven quality, limited infrastructure, and little knowledge of prices and quality requirements (Belcher and Kusters, 2004[50]). For bio-trade to be successful it is imperative that the community stakeholders and intermediaries, suppliers, and even companies are linked to the

> Biodiversity offsets are defined as "measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development" Business and Biodiversity Offsets Programme (BBOP, 2012)

[50] Belcher, B., & Kusters, K. (2004). Non-timber forest product commercialisation: development and conservation lessons. In: Kusters, K., Belcher, B. (Eds.) Forest products, livelihoods and conservation: case studies of non-timber forest

end consumer to ensure strengthened relationships based on knowledge and trade.

10. Limitations set by policies and institutions to develop 3T and build community capacity and ownership after project period.

The value for 3T approach is hence centered around its multidimensionality, with a vulnerability and abundance approach in the context of climate change.

The multidimensionality and vulnerability in the 3T framework can be measured in context of parameters referred to in figure 5 with the following matrices.

1. **Developing metrics**
    - Identifying complexity and interconnectedness of the species and systems in question.
    - Providing information and interpretation of values- intrinsic and extrinsic for decision making
    - Increasing scientific knowledge through vulnerability assessment and by incorporating socio-cultural, and local economic values.
    - Representing the opportunity to involve

regional stakeholders in a place-based analysis and collaborative assessment (geographic approach)

- Anticipating and predicting new hazards and changes

2. Analysis metrics

- Information analysis through dynamic, multiple factor analysis for an interdisciplinary understanding of species and systems vulnerability; including quantitative and qualitative data and novel methods.

The multidimensionality and vulnerability measures in the 3T framework can be enhanced by circular/regenerative development lens. This will result in a conceptual framework which is adaptive, which improves the design with information systems over time, incorporating values of interrelated environmental, economic, socio-cultural dynamics emanating from the natural capital of the project area and geographic region.

3.2 Unlocking behavior change for biodiversity

In order to step toward communication/ signaling mentioned earlier in context of regenerative processes, the project will use blockchain to create a feedback loop from producers in the field to the consumers at the table.

This creates opportunities for continued learning, improve sustainability practices and push for holistic design innovations for regenerative use of natural resources, such and biodiversity, and socio-economic factors such as equity, inclusion and policies nested in social justice for all.

The challenge here is to arrive at an agreed value for biodiversity where products in the value chain could be a result of the exploitation of biodiversity may be embedded in a nexus of environmental, economic, and social weaknesses (Silva et al. 2014[51]).

Promoting products such as Aguaje as a conservation strategy requires an understanding of how their value chains arise, are established, and operate. Work carried out by Silva et al (2017)[52] in Brazil with non-timber forest products (NTFP) For pequi (C. coriaceum Wittm) and fava d'anta (D. gardneriana Tul) shows that "conservation of these species should be seen not only as a way to ensure the supply of raw materials to industry, or to protect

[51] Silva, R. R. V., Gomes, L. J., & Albuquerque, U. P. (2014). Methods and techniques for research on the supply chains of biodiversity products. In U. P. Albuquerque, L. V. F. C. Cunha, R. F. P. Lucena, & R. R. N. Alves (Eds.), Methods and techniques in ethnobiology and ethnoecology (pp. 335– 347). New York: Springer Protocols Handbooks

[52] What are the socioeconomic implications of the value chain of biodiversity products? A case study in Northeastern Brazil. Rafael Ricardo Vasconcelos da Silva & Laura Jane Gomes & Ulysses Paulino Albuquerque Environ Monit Assess (2017) 189: 64

the communities sources of income, but also as a strategy that builds and perpetuates the communities' knowledge and lifestyle connected to the forest".

There multiple challenges to valuation of biodiversity in the context of value chains.

> Community based agreement on the roles of targeted biodiversity in ecosystem and socio-cultural services is the first step to accounting its value into the block chain.

Biodiversity loss in an area is an outcome of aggregate human impacts. These include (and not restricted to) unsustainable harvest of the species in question, land conversion, land use changes, habitat fragmentation, climate change and pollution driven by increasing human presence and pressure on resources.

Disentangling the impacts of these diverse factors, is challenging, but not impossible. This will require clear understanding of relationship between species at an ecosystem level, understanding of economic dependence of communities on biodiversity, and the ability to begin to draw the dots between natural resources, their supply chain, consumer demand and the current and future value of the business.

Estimating biodiversity value will be more complex than measuring carbon offsets from preserved forests for example, since biodiversity is argued to have no intrinsic value (Ghilarov, 2000[53]), and to have it, based on the ecosystem services it provides (Alho, 2008[54]).

Accounting for biodiversity will require first to have an agreement with the stakeholders on the values they want to see incorporated into measurable indicators in the blockchain. This will require an assessment of intrinsic and environmental values (Figure 6) and weighing in diverse perspectives stakeholders, experts and practitioners (Hungate and Cardinale, 2017[55]).

Unlike carbon, accounting for biodiversity could include direct socio-cultural benefits, ecosystem service benefits, economic and climate benefits. It can have reputational benefits for business, which can share the message of advantages of preserving biodiversity to propel consumer led conservation in value chains (Figure 7).

[53] https://www.jstor.org/stable/3547152?seq=1#metadata_info_tab_contents
[54] https://www.scielo.br/scielo.php?script=sci_arttext&pid=S1519-69842008000500018
[55] https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1002/fee.1511

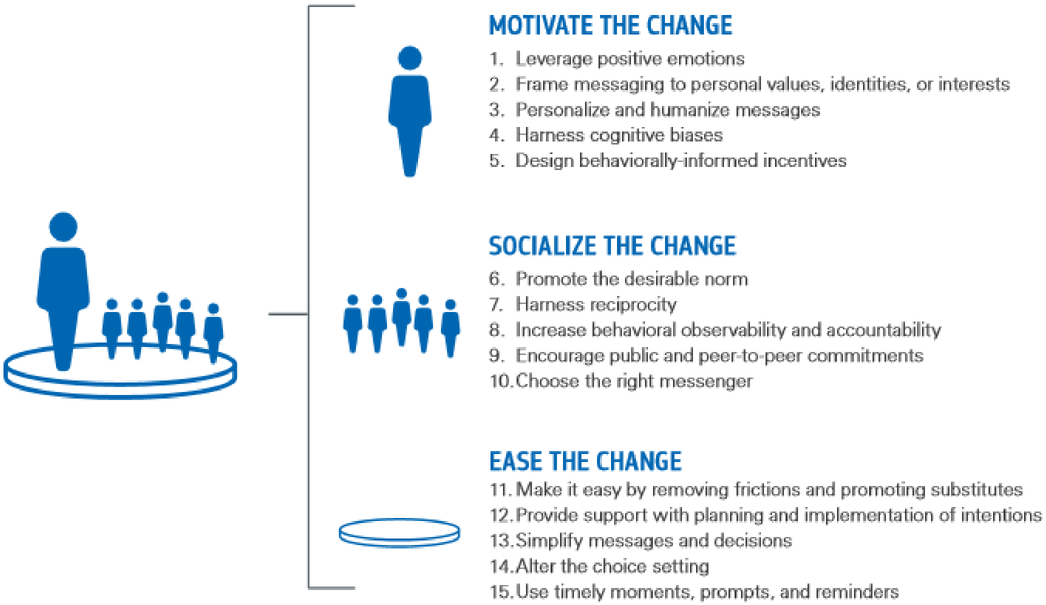

Figure 7. Applying behavioral science for conservation through value chains
Source: www.bi.team[56]

In valuing biodiversity, economic value goes hand-in-hand with socio-cultural and ethical values. Argument for biodiversity conservation along the lines of its intrinsic value (the intrinsic value of species other than humans), because it contributes to the economy and because its presence contributes to ecosystem services upon which our well-being depends. This includes the robustness and the

[56] Rare and The Behavioural Insights Team. (2019). Behavior Change For Nature: A Behavioral Science Toolkit for Practitioners. Arlington, VA: Rare.

capacity of biodiversity to support our adaption to climate change.

In summary, for Peru, we are most receptive to an admixture of positive reasons for protecting biodiversity, emphasizing on all the above and other parameter(s) identified by the stakeholders.

The success of 3T block chain method will depend on the effective feedback loop system set up in the value chain between all the stakeholders, from producers to consumers.

Success will also depend on adaptive management along the chain. This is because, insights to why people make the choices that they do, might prove critical for decisions along the value chain, and may be helpful for long term health of the value chains and natural capital.

3.3 Blockchain and GHG emissions

Agriculture based solutions should be regenerative, restorative and circular, accounting the natural capital and accounting for externalities to achieve transformation.

Research from the U.K. has found that farm externalities such as domestic road transport to retail outlets, domestic shopping transport and subsidies are the main contributors to the estimated hidden costs (Pretty et. al. 2005).

This will of course vary depending on the area and the value chains selected for the study. Based on other research reviewed for this work, accounting for externalities, and supporting shift in consumers' decisions can have a substantial impact on environmental outcomes (Pretty et al 2005). Agribusiness value chains provide opportunities along the chain for these transforming solutions.

Figure 8: Shared value creation through biodiversity and ecosystem services (from Lähtinen et al 2016)

Figure 8 provides a rough overview of the potential ways in which value for biodiversity and ecosystem services such as carbon offsets can be quantified along the value chain. Note though that this is a formative idea which must be consolidated in the field, based on the stakeholder engagement process, and available tools to quantify these ecosystem and socio-economic service values.

Framework for the economic aspect of full cost accounting of environmental externalities through the different types of use and non-use values such as one presented by Bateman et al. (2003) could be used in conjunction with others. This is one of the many works, which need to be considered to arrive at the kinds of environmental 'uses' and 'offsets' that project interventions will seek in the 3T approach.

Using lessons from research and real-life tools already in use such as Eosta[57] and comprehensive research on GHG emissions from the swamps of Peruvian Amazon, the 3T approach can incorporate the value of protected forests, swamps and sustainable harvest through curtailed emissions and conserved biodiversity in the project areas.

3.4. Blockchain and Gender

Transparency tools in block chain (through QR code related story telling) will be a tool for consumers

[57] https://www.eosta.com/en/news/true-cost-of-food-now-in-stores-all-over-europe

to connect with the contributions of women and men in the value chain, showing the project led ‘affirmative actions to promote the exercise of women's rights more egalitarian relationships in Amazonian society’.

Transparency tools in block chain will bring the stories of social enterprise highlighting the ‘diverse demographic, sociocultural, and ethnolinguistic characteristics of the native communities and the role of the extended family in the production and generation of income located in the intervention landscapes’ while recognizing ‘the social, economic and cultural differences between women and men, the differences in the way they organize and participate and have access to and manage the natural resources’.

Enabling this process empowers the consumers to be informed of the processes, people and planetary systems- land, water, forests - that enabled the development of the produce and product as part of the value chains.

In a feedback loop the transparency tools will provide data and inform institutional framework of public and private environmental management to reduce barriers to develop appropriate gender equality policies and institutionalize their application and management through the articulation of indigenous reserve protection plans and community territory plans, community development plans with concerted development plans (PDLC and PDRC), and regional gender equality plans (PRIG).

Transparency tools will speak for the efforts in reducing gender based income inequality (especially indigenous people in rural areas) shine light on the equitable access, use and control of the natural resources used in these value chains and highlight efforts to ensure equitable decision-making, benefits and processes related to governance, biodiversity management, restoration practices, and bio-business value chains.

To ensure this, blockchain system will depend on reliable data on

(1) gender statistics and indicators that measure baseline inequality and discrimination gaps against women

(2) systematization and dissemination of experiences and lessons learned related to interventions to mainstream the gender approach in the project implementation framework and

(3) awareness and communication campaigns in the construction and transmission of the importance of

equality of gender for the sustainable development of the Amazon.

Block chain will measure the value of indigenous arts and crafts value chain within the framework of the domestic economy as a complement to agricultural activity to promote the transmission and maintenance of their cultural roots and ethnic identity and at the same time to favor the sustainable management and use of the forest, from where they obtain their inputs.

As a result of feed-back-loop this could lead to the development of an inclusive and gender-responsive budget to guarantee that the measures and actions from this project will be in place for the future.

This can have a long term transformatory impact on the provinces of Atalaya, Loreto and Satipo particularly because they are predominantly young populations (under 15 years of age).

3.5 Implementing True Cost:

This will require a thorough understanding and validation of the scale and nature of these 'externalities' of costs.

Externalities[58] could be defined as market failures that arise when there is a 'divergence between social costs and private costs' (Eidelwein et al 2018[59]) and do not account for environmental cost (Ding et al., 2014; Larkin, 2013).

Environmental externalities, also known as external costs, include 'environmental impacts of production and consumption activities generate benefits (positive externalities) or costs (negative externalities) not compensated for by other parties' (Eidelwein et al 2018[60]).

These environmental costs are directed to society without impacting the economic results of their generating agent or the company that produces the product in question (Azar and Holmberg, 1995; Becker et al., 2011; Ding et al., 2014; Larkin, 2013).

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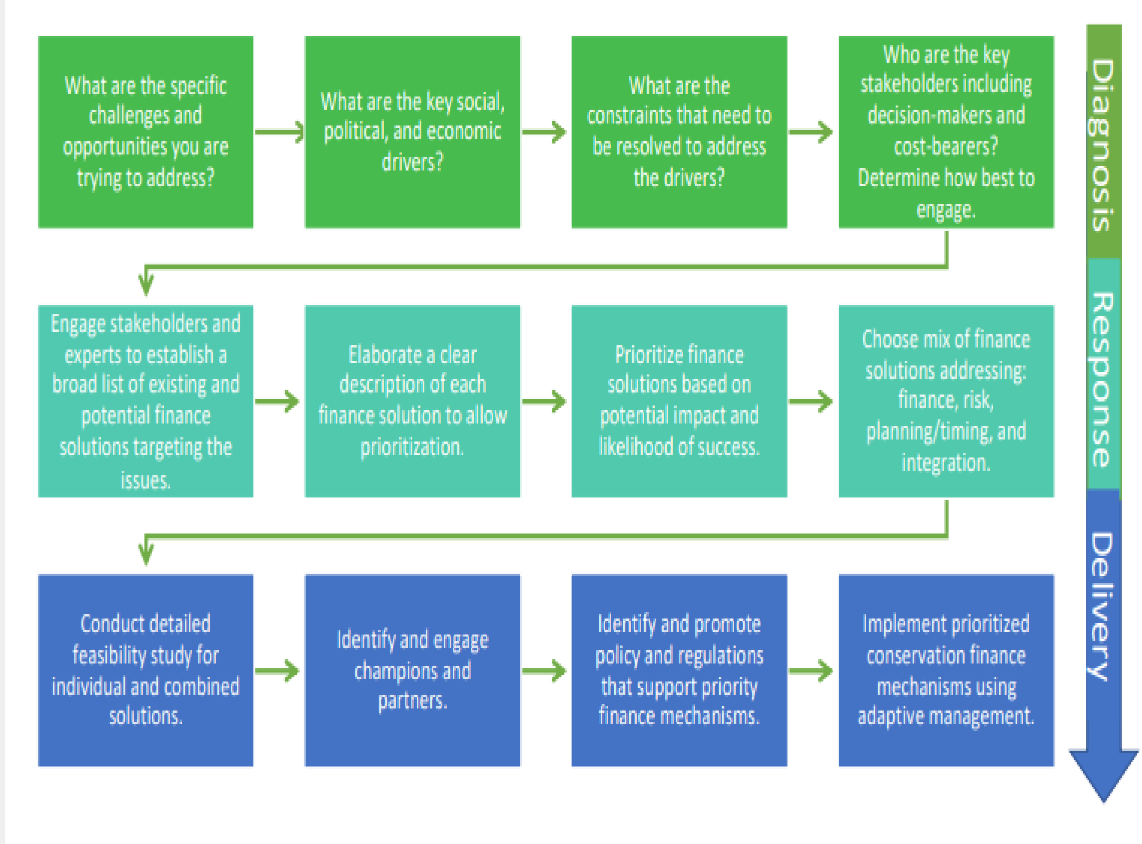
[58] Threshold Externalities in Economic Development Author(s): Costas Azariadis and Allan Drazen Source: The Quarterly Journal of Economics, Vol. 105, No. 2 (May, 1990), pp. 501-526

[59] Internalization of environmental externalities: Development of a method for elaborating the statement of economic and environmental results. Fabrício Eidelwein, Dalila Cisco Collatto, Luis Henrique Rodrigues, Daniel Pacheco Lacerda, Fabio Sartori Piran. Journal of Cleaner Production Volume 170, 1 January 2018, Pages 1316-1327

[60] Internalization of environmental externalities: Development of a method for elaborating the statement of economic and environmental results. Fabrício Eidelwein, Dalila Cisco Collatto, Luis Henrique Rodrigues, Daniel Pacheco Lacerda, Fabio Sartori Piran. Journal of Cleaner Production Volume 170, 1 January 2018, Pages 1316-1327



Adapted from GIZ 2018, BIOFIN 2018.

The challenge in true cost accounting is in identifying, categorizing and quantifying, and where possible pricing all the different costs and benefits involved in a production process, across the complete value chain and its numerous actors/stakeholders.

Another challenge after setting into motion the true cost accounting process for a product(s) is to garner enough public support and political will, this information would allow policy and economic interventions to be adopted which favored the production and consumption of foods with the lowest true costs.

This could be achieved by taxing those who pollute and using agricultural subsidies to encourage or discourage farming methods according to their true cost

Valuation frameworks such as the 3T approach will provide data and insights from the field to highlight issues on complex intertwined environmental-economic-social challenges to mainstreaming transformation, improve public discussion on these matters, and provide impetus for policy makers with priorities for policy design and planning (e.g. urban/city/community/nation).

3.6 Blockchain costs and benefits

Traditionally, initial data capture is more problematic for wild crops and wild captured fish; a blockchain database is more useful if the integrity of the initially recorded data can be assured.

Most blockchain implementations are technologically more advanced than the traditional systems, and would require infrastructure, processing capacity, online connection, etc.; it might be difficult to support a blockchain application in these situations

Table 2 indicates costs and benefits of implementing and maintaining a blockchain.

Clearly the costs for all stakeholders (food businesses, governance authorities etc.) associated with blockchain-based systems (speed, efficiency, and confidentiality in particular) outweigh the benefits, especially if recording of transactions are tagged with data on biodiversity and GHG emissions and held in immutable database for every stakeholder to learn from.

Comparison criteria	Traditional electronic traceability system	Electronic traceability system based on blockchain technology
Suitability of database	Authorities can only access claims in relation to state of variables	Authorities can access the entire set of transformations that led to the current state, which makes it easier to see the origin of the stated claim
Data quality and veracity	Authorities need separate and external checks to test the data quality and veracity	Some degree of quality and veracity is provided by the blockchain-based system itself
Immutability, integrity and transparency	It is difficult for authorities to know if recorded data has been subsequently overwritten	The immutability of the database means that the authorities know that the data has not been overwritten
Confidentiality	Not an issue for authorities	
Trust	Not really an issue for authorities (except for trust in data quality and veracity, which is better in a blockchain-based system)	
Robustness	Not an issue for authorities	
Speed and efficiency	Not an issue for authorities	
Interoperability	Lack of interoperability makes it more difficult to identify discrepancies, and to do mass-balance accounting which is sometimes necessary to identify fraud	Better interoperability and better access to comparable data from different systems makes it easier to identify discrepancies, and to do mass-balance accounting

Table 2: Costs and benefits of implementing and maintaining blockchain based VC system.

Blockchain is a feature-dependent technology. Hence the final price will vary in accordance with the project requirements[61]. Research shows that blockchain project development could start at $5,000 and can go as high as $200,000.

Although blockchain was invented in 2008, it has gained publicity as a technology independent of Bitcoin only recently. Critically, we should be cognizant that the development cost may vary substantially due to the number of features that we want to implement in the project. The described prices are only the average market estimates.

Blockchain analytical support will seek balance between top-down (off the shelf, science-driven) and bottom-up (case-specific, stakeholder-driven) approaches ensuring perspectives on information flow and details of the enabling technology is available to all stakeholders.

Stakeholder confidence in modeling results is enhanced through frequent formal and informal communication with their experts. Direct two-way communication with local stakeholders is essential.

Therefore, the modeling team should work with local experts to ensure that they understand the needs, strengths and weaknesses of tools applied to their domain and are able to discern indicators to measure for 3T, specifically True Cost Accounting.

[61] https://azati.ai/how-much-does-it-cost-to-blockchain/

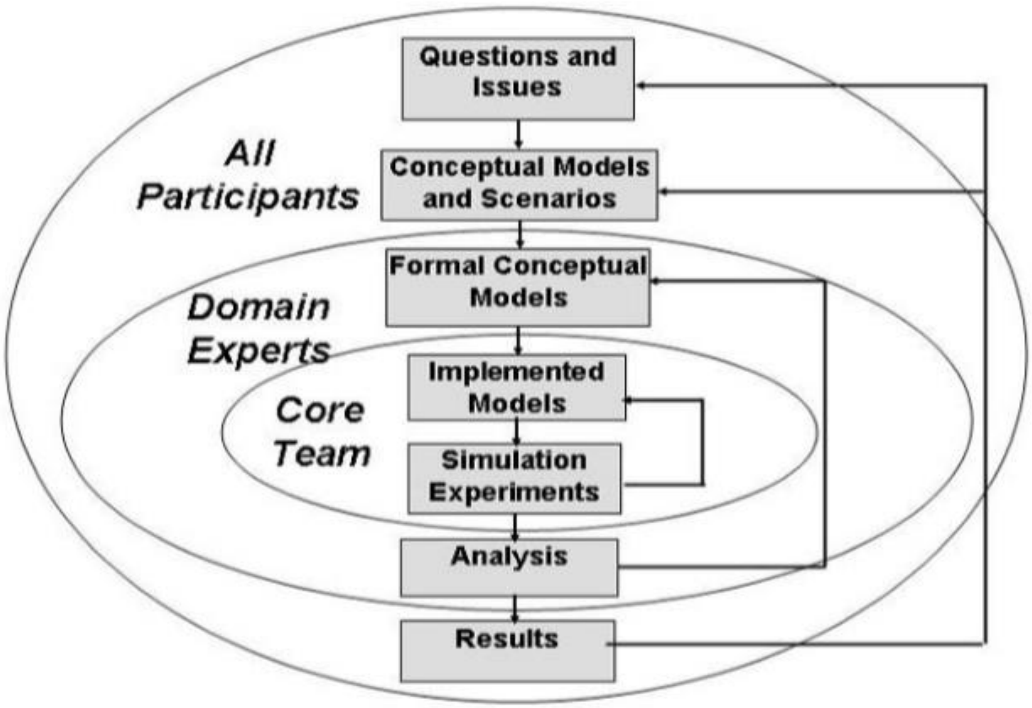
As domain experts often have their own tools, they may request model comparisons before they will begin to trust a new tool. Once satisfied that the implemented model is consistent with the formal conceptual model, local experts can work with the modeling team to develop output that is accessible and easily understood by stakeholders (Sturtevant et al, 2007)[62]

> ...for participatory modeling to be embraced at the local level, it must be configured in a form that is simple, transparent, and stripped of the typical complexity that often characterizes many models. The modeling paradigm must be such that stakeholders with little or no formal training in modeling can grasp the modeling process, feel comfortable in sharing their input and knowledge, and are able to contribute their expertise with relative ease.
> From Mendoza and Prabhu (2005, pages 146-147)

[62] Sturtevant, B. R., A. Fall, D. D. Kneeshaw, N. P. P. Simon, M. J. Papaik, K. Berninger, F. Doyon, D. G. Morgan, and C. Messier. 2007. A toolkit modeling approach for sustainable forest management planning: achieving balance between science and local needs. Ecology and Society 12(2): 7. [online] URL: http://www. ecologyandsociety.org/vol12/iss2/art7/).

The team leader or leaders must ensure that the right team is assembled to meet a local biodiversity need.

That is, to overcome the “chicken and egg” dilemma, where “until you define the problem, you cannot assemble a team; and until you have a team, you cannot really define the problem” (Nicholson et al. 2002, page 378), team leaders must go through a high-level iteration of the collaborative process and also have at least a cursory understanding of available modeling tools.



Iterative model development process
Fall et al. (2001)[63]

[63] Fall, A., D. Daust, and D. G. Morgan. 2001. A framework and software tool to support collaborative landscape analysis: fitting square pegs into square holes. Transactions in GIS 5:67–86

The conceptual model can then be refined by subsequent iterations with the newly assembled team. Including a local representative on the core modeling team vastly improved communications between the major groups (i.e., modelers, domain experts, planners, and stakeholders.

The mixture of local experts and stakeholders who understand how the tools work, identify measurable indicators, scientists who are willing and able to communicate their science and the science of indicators to stakeholders, and integrated analytical tools that can simulate complex spatial and temporal problems will provide powerful and efficient decision support for 3T.

> 3T based blockchain addresses three key approaches to usher change: awareness and education, incentives and market forces, and through legislation and regulation

Bi-directional information flow between local experts, stakeholders, scientists, and planners is essential for efficient, timely, reliable, and adequate 3T meta-model.

From Sturtevant et al., 2007. Groups participate in all circles that surround them. The initial interest and desire for strategic SFM planning comes from the stakeholders and decision makers. All participants (stakeholders, decision makers, domain experts, core team members) set objectives, select scenarios, develop conceptual models, and discuss model results.

Domain experts and the core team develop and verify the formal models. The core modeling team is responsible for organizing workshops and communication, gathering required information, implementing models, ensuring equivalence to formal conceptual models, running simulations, analyzing outputs, and documentation.

Examples of indicators could be such as the ones mentioned in the table below. These are ideally derived from local consultation sessions hosted by members of the modeling team in communities to identify measurable indicators and defining justification for the criteria on information used for indicators. These could be gleaned from the public consultations of the planning process and through surveys and interviews conducted by project personel, including social, economic, and ecological dimensions and alternative management scenarios

Indicator	Criteria			
	Biodiversity	Ecosystem Integrity	Traditional Activities	Community Well Being
Ecological Realm (Ecological Diversity, habitat loss and degradation, illegal wildlife consumption, human wildlife conflict Edge Contrast, Habitat patch size/core area, Insular habitat Connectivity, fruit bearing trees/shrubs,	Species at risk Indicator Species; forest succession, tree seed dispersal, fire/climate related disturbance for biodiversity	Ecosystem pattern/lan dscape pattern, interactions , landscape succession; tree establishme nt and succession as a function of soil water, nutrient dynamics, and climate (Post and Pastor 1996)	Harvesting fruits/other plant parts Hunting/trap ping	Revenue from harvest/trapp ing
Social realm (Number of forest-sector jobs/livelihoo ds, Landscape sensitivity, pollution)	Consequenc es of manageme nt scenarios on biodiversity using both coarse- and fine-filter approaches	. estimate changes in tree species compositio n and explore dynamics of partial harvesting regimes	Produce harvest schedules, and compare with scenario-based approaches	Local and regional markets; small businesses; food and nutrition security; Public health; Ecotourism
Economic Realm (overexploita	A set of indicator models for	Stand Dynamics Disturbance	Access to resource and intergenerati	Provincial revenue, Local profit,

tion, harvest flow, Road length/distan ce; processing, packaging, labelling, transportatio n modes,	assessing alternative manageme nt strategies in terms of biodiversity values (Doyon and Duinker 2003)	; numerical analysis approach used in economics to inform decisions with irreversible consequenc es that affect a real asset (Dixit and Pindyck 1994	onal gender specific knowledge	

Although the indicators are modeled in the ecological realm, their justification may come from the social realm and economic realm (Sturtevant et. al, 2007. Ibid)

3T based blockchain addresses three key approaches to usher change: awareness and education, incentives and market forces, and through legislation and regulation

3.7 Barriers for 3T

Being a relatively newer technology, the knowledge and awareness of blockchain is still growing. For example, a 2016 Deloitte survey of executives found only 40% of them are somewhat informed on block chains. In Peru, the government is already forging ahead with blockchain, using the technology to fight corruption[64].

The following are some of the challenges in general, some applicable to the Peru project areas.

- Technical obstacles such as transaction speed, verification, data management, security and privacy challenges.
- Integration- different ledgers talking to each other. ISO work is on the way to standardize rules for block chain
- Large energy required for transactions
- Block chain transactions are anonymous and irreversible
- Complex to develop and use – e.g. to program using Ethereum or Slock.it
- Cultural adoption regulatory acceptance and resistance to change.
- Change in laws, regulations, treaties, agreements.
- RISK-The stockout (not having enough in stock) effects short term revenues and affects perception of the brand and long-term loyalty to the product.
- Costing Method: finance operations remain challenged by the costing methodology that is chosen for costing and the business definition of the data collected (understanding that the data

[64] https://perureports.com/perus-government-looks-to-blockchain-to-fight-corruption/9045/

collected and used may have been collected for other purposes).

- Integration; source data often resides in disparate systems that can lack integration models to support an efficient and accurate compilation and extraction of data required for project costing

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