Application of blockchain technology in the blue growth strategy and environmental sustainability

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Abstract
Blue Growth is a cohesive approach for environmentally compatible, integrated and socioeconomically sensitive management of aquatic resources.
Healthy ocean ecosystem ensured by sustainable farming and fishing operations is a prerequisite for a blue growth. Many of the challenges for how we manage natural resources and maintain ecosystem services arise because of a lack of trust and confidence in the rules governing exchange and possession.
In the last decade, one of IT technologies that emerged ten years ago is the blockchain technology. blockchain might support environmental sustainability through three key underlying mechanisms relating to resource rights, product origins and behavioral incentives by decentralising and digitising the adjudication of what is trustworthy.
A digital coupon or cryptocurrency can be introduced to trade the wastes, energy and by-products (e.g. fertilizers or feedstock) among the stakeholders and the model can contribute to environmental sustainability from a small county to a larger region.

Introduction
The roots of the blue growth concept can be traced back to the conceptualization of sustainable development. Sustainable development - or the challenge of a sustainable use of natural resources. [1]
In the United Nations Food and Agriculture Organization report (FAO 2014), the FAO promotes "Blue Growth" as a cohesive approach for environmentally compatible, integrated and socioeconomically sensitive management of aquatic resources including marine, freshwater, and brackish water environments. The report is divided into four parts: (1) world statistics of capture and aquaculture systems and sectors, (2) selected issues in fisheries and aquaculture, (3) highlights of special studies that help to interpret the statistics, and (4) the outlook for the future goals of meeting fish demand. [2]
At the Rio+20 conference, the Food and Agricultural Organization (FAO) sent a very strong message to the international community that a healthy ocean ecosystem ensured by sustainable farming and fishing operations was a prerequisite for a blue growth. [1]
In the last decade, the steadily growing volumes of industrial production, growing population in the world and growing traffic exhaust lead to the contamination of environment. These issues concern policy-makers, scholars and practitioners around the globe. The IT sector cannot stay apart of the global trends and concerns and has much to offer in order to reduce the volume of pollution and thus save the environment. One of such radical IT technologies that emerged ten years ago is the blockchain technology. [3]

What is blockchain technology?
The blockchain technology is defined as "a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties". The system is secure—the records are verified by public ledgers and can never be erased

in the future. The main benefits of the blockchain technology are transparency and cost-efficiency. [3]
In the past decade, blockchain technology has gone mainstream. It has rapidly evolved from a few bitcoin software nodes in January 2009 to a multibillion dollar industry backed by Wall Street, Silicon Valley, and major banks. Blockchain software, which permits the maintenance of a public ledger secured by cryptography, can be used to increase the speed and lower the cost of consumer and business transactions. The blockchain technology that is currently being developed by both new startups and established software companies (such as IBM) may prove to have a significant economic impact in the next decade. Small businesses will be able to purchase software to issue their shares of stock as digital tokens, rather than as paper certificates. State and local governments will be able to purchase software to permit real estate transactions to be instantly recorded through "smart contract" software that utilizes electronic signatures and metadata, rather than physical filings. Banks will be able to permit their customers to utilize blockchain-based software that will enable instantaneous and irrevocable transfers of funds between bank accounts (rather than on a delayed basis using wire or Automated Clearing House (ACH) transfers). In the next decade, it is likely that attorneys shall find themselves called on to assist clients with matters related to digital assets and blockchain technology.
At its core, blockchain technology is an enhanced method of maintaining a ledger. Blockchain software creates a transaction ledger database that is secured by cryptography and shared by a distributed network of computers. The blockchain software records and stores every transaction that occurs on the computer network. All of the computers on the network can view all of the blockchain records, and to the extent any change to the distributed ledger is made, it is visible to everyone. [4]

Why could blockchain matter for environmental sustainability?

The potential of blockchain to support environmental sustainability comes down to one key feature: its ability to provide a verifiable record of who exchanges what with whom – and therefore, who has what at a given time. Many of the challenges for how we manage natural resources and maintain ecosystem services arise because of a lack of trust and confidence in the rules governing exchange and possession: will governments and other users respect entitlements to use a natural resource? Can companies' claim of reduced environmental impact be verified and trusted? Can environmentally sustainable actions be effectively incentivised?
Blockchain's ability to provide a verifiable and transparent record may make it well placed to help answer such questions. By decentralising and digitising the adjudication of what is trustworthy, blockchain also has the potential to empower broader communities of stakeholders and improve the slow, costly intermediation associated with our current models of environmental governance. But for this potential to be fulfilled, a number of conditions will have to be met. And, in this context, it should be noted that not all blockchains are public. 'Permissioned' blockchains – in contrast to public, permissionless networks – are designed to restrict access to only verified parties. This characteristic has important implications for the

Smart contract: A smart contract is a collection of code and data that is deployed using cryptographically signed transactions on the blockchain network.

extent to which blockchains can disrupt existing power dynamics and potentially dis-intermediate powerful central entities, such as governments or dominant firms. [5]

opportunities

Blockchain technology can address a range of environmental sustainability challenges. Building on Chapron's review (2017), we suggest that blockchain might support environmental sustainability through three key underlying mechanisms relating to **resource rights**, **product origins** and **behavioural incentives** These mechanisms reflect three underlying challenges in relationships between people that have consequences for sustainable management of natural resources and the environment.

Origins. Where it is used to encode verifiable information about a product's origins, blockchain could give greater confidence to consumers and intermediary companies in supply chains about the environmental impacts of their purchasing decisions. An early example in this area was the work of provenance, a UK-based start-up, to pilot a tuna-tracing system on a public blockchain. Similar initiatives have emerged in the timber trade – for example BVRio's system in Brazil makes use of blockchain technology to support the traceability of wood products from source to final buyer (Herweijer et al., 2018).

Incentives. Blockchain could offer greater certainty to people that they will be rewarded for environmentally sustainable behavior. For example, GainForest has developed a concept to incentivise farmers in the Amazon to preserve rainforest, offering potential climate change mitigation and biodiversity benefits. Remote sensing satellites verify the preservation of a patch of forest and blockchain facilities the payment of internationally crowdfunded financial rewards to farmers (Greene, 2018).

Rights. Using blockchain to encode rights to use natural resources could increase a right-holder's confidence that their share can be defended against expropriation, and that overuse by others, or themselves, will be identifiable. In turn, this could discourage each right-holder from overusing the resource for short-term gain. Existing examples for this mechanism are rarer. The majority of pilots explore private property rights to land, and focus on the economic, rather than environmental, benefits – though some of these are in middle-income countries such as Ghana, Georgia and Brazil (Graglia and Mellon, 2018).Common-pool resources – that is, natural resources that are owned and managed collectively by a community or society rather than by individuals – are potentially more complex, featuring rights for different types of use and nested levels of rules (Ostrom and Hess, 2007). However, blockchain is intuitively suited to decentralised or collective management of common pool resources, given the technology itself functions through distributed consensus rather than central control. A rare, though unsuccessful, example is an attempt to use blockchain to encode water rights in Australia. It should be noted that markets for water rights are rare, globally, and require a high degree of institutional and technical capacity, even without introduction of technologies like blockchain.

Initiatives may work through more than one mechanism. figure 1 select examples of how blockchain is currently being applied to environmental sustainability challenges.

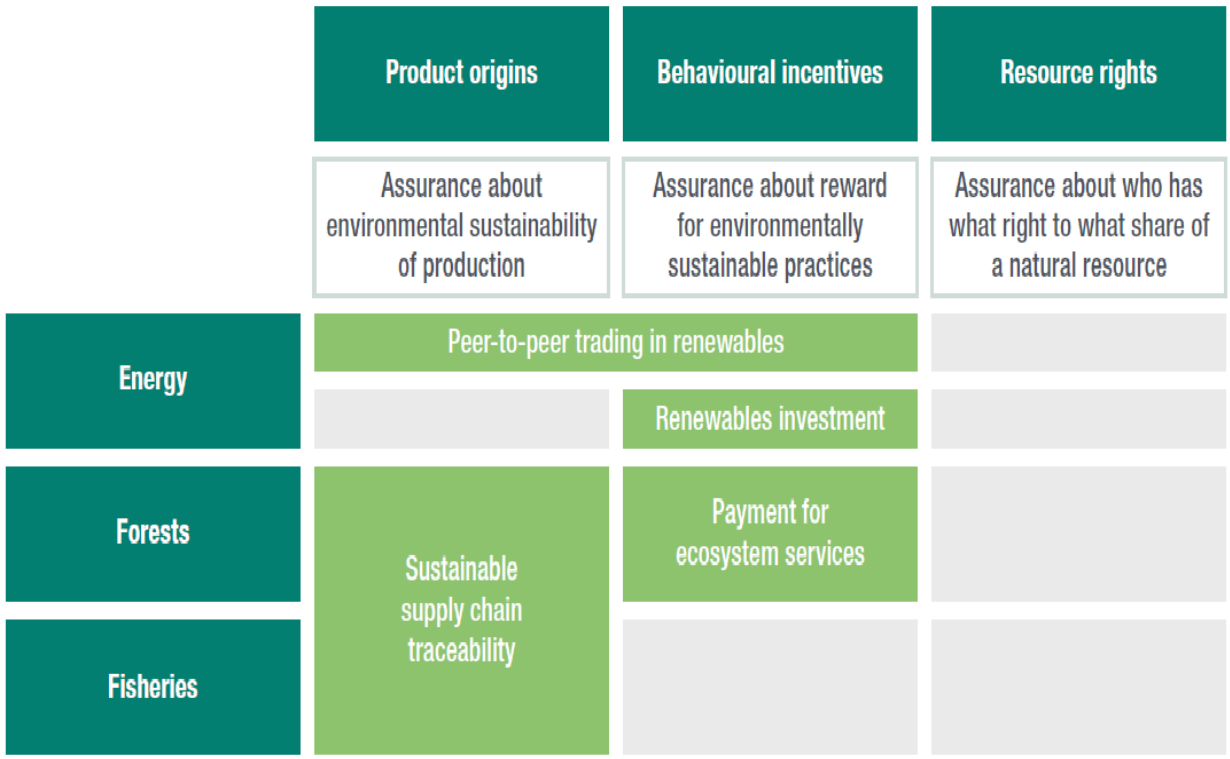

Figure 1: examples of how blockchain is currently being applied to environmental sustainability challenges

challenges

For blockchain technologies to fulfil their potential and deliver their promised benefits for environmental sustainability, a number of challenges will need to be addressed. It is easy to draw parallels with the internet, another decentralising digital technology that has transformed human society in many ways but which, in the words of the inventor of the World Wide Web, has 'failed to deliver the positive, constructive society many of us had hoped for' (Siegele, 2018). For blockchain, the challenges are both technical and political, and though significant, are not necessarily insurmountable. They are especially relevant to questions of environmental sustainability in low- and middle-income countries but are also relevant to attempts to use blockchain for socially valuable outcomes more generally. [5]

Waste management and blockchain technology in small Islands

Small islands are extremely valuable in terms of environment and culture, but at the same time they present fragile ecosystem structures. In this context, waste management policies play an important role. In fact, the economy of the islands mainly lives on tourism, a phenomenon that generates an "accordion effect" on the population of the islands: in the high season months the number of inhabitants triples, with higher peaks during the central weeks of August. Out of 34 municipalities present in the small Italian islands, 9 have exceeded 50% of separation, reaching peaks of 73% in the municipality of Sant'Antioco and 69% in La Maddalena (Sardinia), 66% in Procida (Campania). However, despite the growth trend, the level of separate collection still remains low.in fact, 20 municipalities do not exceed 40%, 11 of which do not reach 20%. Surely, an increase percentage in separate waste collection would allow significant economic savings.[6]

Nowadays, Waste-to-energy facilities (WTE) are becoming a common alternative for waste management [7]. Today, around 2,450 WTE plants are active worldwide. They have a disposal capacity of around 368 million tons of waste per year. [8]

A study presents how a digital coupon or cryptocurrency can be introduced to trade the wastes, energy and by-products (e.g. fertilizers or feedstock) among the farmers and entrepreneurs. This system could maximize the use of agriculture wastes by incentivizing farmers and enterprises to work together. Figure 2 shows the macro level of operations. First, the farmers will produce agricultural waste like crop straw and animal residue as well as non-putrescible waste like plastics. They will store their agricultural wastes and non-biodegradable wastes (plastics) separately in Smart Bins (SB) provided by the WTE plant. Through calculations at time of collection, the waste received will translate into a certain amount of energy and agricultural products (i.e. briquettes and fertilizer) that the WTE plant owes each farm. As a result of this transaction, there will be an "atomic swap" of resources; farmers instantly receive digital coupons/cryptocurrency of energy and agricultural products when the WTE collects the segregated waste. In the proposed model, several incentives and responsibilities can be predicted for the stakeholders (Table 1).

Meanwhile, the waste is brought to the WTE plant, where through furnaces and condensers, energy and agricultural products are produced. Farmers can then decide to a) cash in their digital coupons (Energy and Fertilizer Coupons [E/F]) for respective goods or b) trade with others on the integrated blockchain system for money. [9]

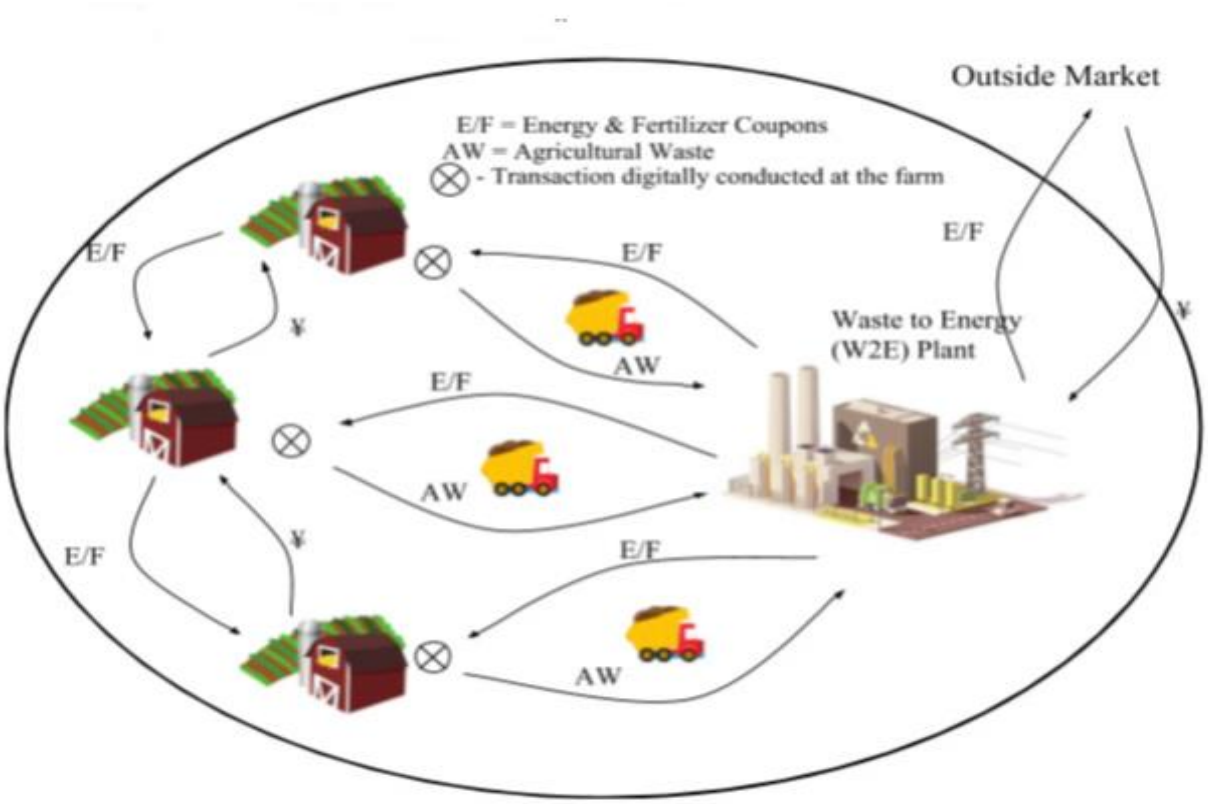

Figure 2: Diagram of waste to energy management on macro level

Stakeholders	Incentive	Responsibility
Farmers	- Essentially free fertilizer and energy - Reduction of hazardous waste - More Insurance = Energy Security	- Collection and Separation of Waste at Farms - Managing digital coupons
Entrepreneurs	- Low cost for attaining segregated waste - Profit from Surplus Energy or Fertilizer Produced - Potential for External Investment - High predictability and Accountability	- Collection of Waste from Farms - Purchase of Capital Equipment for Waste to Energy (W2E) facilities - Maintenance of Capital Equipment - Transportation Costs
Government Agency/ Blockchain Manager	- Ensuring that trust is established between farmers and entrepreneurs - Ensuring that quantity of waste delivered is accurate - Allow farmers in the region to trade and purchase "agricultural products" or "energy" - Providing regular payments to entrepreneurs for waste treatment	

Table 1: Incentives and Responsibilities of Stakeholders

Discussion

Small islands need to manage resources & waste in order to conserve a healthy and sustainable environment. Recently, blockchain technology brought new ideas to provide verifiable and transparent records. The main function of blockchain is to prevent the systems form garbage in garbage out. It means that blockchain is a tool to ensure that information on a chain is accurate and truthful. Thus, blockchain role is to control the incoming information.

In order to set up systems for waste & resource management based on blockchain technology, systems may need to be either government-owned or subsidized to cover startup costs before it approaches economies of scale. Furthermore, governments should supervise and control the systems to ensure the quantity and the quality of the waste or resources, payments and transactions, and the trust between stakeholders.

Small islands can use blockchain for resource & waste management. The islands can use the technology to conserve the resources by ensuring traceability along the supply chain. In addition, Establishing waste to energy plants and using a blockchain-based system can encourage the inhabitants of small islands to cooperate with the stakeholders to establish more efficient systems for waste management in order to save the environment.

Conclusion

Blockchain software, which permits the maintenance of a public ledger secured by cryptography, can be used to increase the speed and lower the cost of consumer and business transactions and it is able to provide a verifiable and transparent record. blockchain might support environmental sustainability through three key underlying mechanisms relating to resource rights, product origins, and behavioral incentives. digital coupon or cryptocurrency can be introduced to trade the wastes, energy, and by-products (e.g. fertilizers or feedstock) among the stakeholders and the model can contribute to environmental sustainability and applied in the blue growth strategy.

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