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ZMT LEIBNIZ CENTRE for Tropical Marine Research

POLICY BRIEF 2023/2

Implementing blockchain technologies in PES schemes: tools and opportunities

Summary

This policy brief shares the results of investigations carried out at the ZMT on how blockchains can contribute to improve the environmental and social outcomes of Payments for Environmental Services (PES) schemes.

Blockchains are a type of distributed ledger technology (DLT). They are a system of electronic records to establish a consensus around a shared digital ledger of transactions. Transactional information is recorded in blocks of digital information and chained together using cryptographic means.

Payments for Environmental Services (PES) are widely used incentive-altering economic mechanisms for influencing human activities to achieve environmental goals. Payments are provided as economic incentives for carrying out environmentally friendly activities or for avoiding environmentally detrimental practices.

Blockchain technology can provide various tools that contribute to the creation and management of PES schemes that promise to be more effective, efficient and aligned with social co-objectives.

For the benefits of blockchain implementation to materialize, practitioners must understand the social, economic and technical framework upon which the schemes rely. Based on this the blockchain architecture can be designed in accordance with the specific needs of the PES project.

RESULTS

- Blockchain implementation can substantially reduce transaction costs associated to the establishment and management of PES schemes.
- The immutability of information coded in a distributed ledger, along with the deterministic nature of smart contracts increases predictability and confidence in the outcomes of contractual arrangements, and promotes trust between PES participants, thus contributing to PES project success.
- Blockchains, as a technology for disintermediation, can help align the incentives of environmental service (ES) providers and the ES buyers, and can facilitate the appearance of direct PES schemes where buyers and providers transact environmental services directly.
- Blockchains can assist PES conditionality arrangements by reducing monitoring cost, facilitating sanctioning mechanisms and automatizing conditional payments.
- Blockchains can facilitate institutional innovation in PES schemes.

RECOMMENDATIONS

- Consider the digital endowment of participants and their acceptance towards technological adoption prior to blockchain implementation.
- Ensure the availability of reliable oracle systems to translate real-life information on environmental resources and on ES provision to the digital realm of blockchains.
- Consider the economic implications of blockchain implementation relating to costs, willingness to pay (WTP) for ES and willingness to accept (WTA) payments.
- Design the blockchain architecture according to the specific needs of the project.
- Ensure the redeemability of tokens.

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CONTEXT

Many ecosystem services are public goods or common pool resources. They are not transacted in markets, it does not pay to help provide them and nobody can be excluded from using them. Those characteristics often lead to overuse and to gradual degradation, particularly when degradation is associated to profitable activities that bring private gains.

One instrument to correct this market failure are payments for environmental service (PES)[1] mechanisms to internalize the cost of providing environmental services and outweighing the opportunity costs associated to their provision. Engel (2016; 133) defines PES as "positive economic incentives where environmental service providers can voluntarily apply for a payment that is conditional either on ES provision or on an activity clearly linked to ES provision".

Although PES are not a silver bullet to address all environmental problems (Engel, Pagiola, & Wunder, 2008), they are important tools for changing incentive structures in favour of providing ES. They help distribute the economic burden of environmental service provision between those who perceive their benefits. Wunder et al. (2020) argue that despite obvious shortcomings of PES schemes, the available scientific studies still show higher positive environmental impact rates for PES schemes than for most other environmental management instruments.

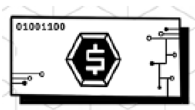
With the aim of designing innovative financial mechanisms for the provision of environmental services, the MIMAC project of the German Cooperation Agency (GIZ) commissioned the Leibniz Center for Tropical Marine Research (ZMT) to investigate novel alternatives for designing PES schemes. In this sense, the ZMT investigated whether blockchains could facilitate the successful implementation of PES schemes.

Blockchains are a subset of DLTs that bundles transaction-information in blocks. Rauchs et al. (2018; 24) describe DLTs as "a system of electronic records that enables a network of independent participants to establish a consensus around the authoritative ordering of cryptographically validated ('signed') transactions. These records are made persistent by replicating the data across multiple nodes and tamper-evident by linking them by cryptographic hashes".

Blockchain technologies favoured the propagation of applications that can be used to improve the outcomes of PES schemes such as cryptographic *tokens* and such as programmatically executed transactions, also referred to as *smart contracts*.

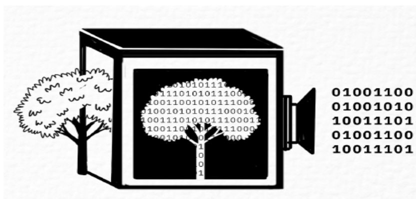
Smart contracts are computer scripts that when triggered by a given input, execute a predefined output. The execution of each contract statement is recorded as an immutable transaction stored on the blockchain. When the code operates accordingly to the intentions of all parties, "the deterministic nature of the execution reduces the level of trust required for individual participants to interact with each other" (Rauchs, Glidden et al. 2018; 37). Their usage reduces the risk of error, manipulation and non-compliance. In doing so, they can reduce enforcement- and monitoring-related transaction costs. The likelihood of legal disputes over contract compliance are largely reduced.

Cryptographic *tokens* are digital representations of assets or access rights that are managed by a smart contract in a DLT supported ecosystem (Voshmgir, 2020). *Tokens* serve various purposes in blockchains depending on their characteristics and their role in the system. *Tokens* can be harnessed to create programmable money which can be "programmed to be spent only when certain conditions are met… Once programmed, programmable money can know who it can be spent by, what it can be spent on, when it can be spent, how much of it can be spent" (Royal et al., 2018;5-6). Programmable money respects conditions that limit its liquidity and increase the control that can be exercised over its use. Policies for programmable money can be linked directly to the money itself.



A prerequisite for the integration of exogenous real-life information into a blockchain ledger is the effective development and implementation of so-called oracles. Oracles are gateways that bridge the gap between the blockchain system and external systems by serving as sources of information (Rauchs, Glidden et al. 2018). Oracles provide gateways through which real world information on assets, facts, events, problems, etc. can find its way into the blockchain. They request, verify, and authenticate external information before communicating it to the blockchain.

PES schemes require trustable oracles for translating information on the managed natural resources and on the provided environmental services on bits and bytes. Developing a reliable oracle system is key to ensure the quality of information upon which the schemes´ decisions are taken.



[1] The concept of environmental services (ES) underlines the idea that the provision of many services provided by nature often depend on human contributions.

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RESULTS

Blockchain utilization can reduce transaction costs associated to the establishment and management of PES schemes. All costs associated to the scheme that are not part of the direct compensation for ES provision represent transaction costs (Wunder et al., 2008). High transaction costs consume resources otherwise available to finance additional ES provision and reducing the positive impacts of PES schemes. Transaction costs can be reduced through creating institutions that minimize transactional friction (Williamson, 1981). Blockchains offer various tools for reducing PES transaction costs such as reducing financial intermediary costs, reducing monitoring costs through harnessing a wide variety of digital oracles, increasing confidence in contract fulfilment through smart contracts and incrementing trust.

The transparency and nonrepudiation of transactions, along with the immutability of data and the deterministic nature of smart contracts, can foster trust between PES participants and reduce the costs associated to securing PES transactions, thus contributing to PES project success.

Blockchains can facilitate the appearance of direct PES schemes. Direct PES schemes are those where ES buyers and sellers transact directly without resorting to intermediaries. Engel et al. (2008: 666) affirm that such direct PES approaches are more ''likely to be efficient, as the actors with the most information about the value of the service are directly involved, have a clear incentive to ensure that the mechanism is functioning well, can observe directly whether the service is being delivered, and have the ability to re-negotiate (or terminate) the agreement if needed''. Nevertheless, there are few examples of direct PES schemes. The digital infrastructure offered by blockchains reduces the need for classic intermediation. By taking advantage of blockchain infrastructures, individuals around the world can more easily organize themselves in networks to pursue common objectives, like promoting the provision of an ES. A collective management tool based on a collectively edited and reviewed distributed ledger facilitates accounting. The safety and transparency of a common ledger promotes trust between participants and confidence in the scheme´s arrangements. It allows transacting parties to visualize and scrutinize the flows of money and services without necessarily relying on an external witness. Economic transactions occur at low cost through the usage of payment tokens and tokenised assets. Conflicting situations, in which the intervention of an arbitrator is required for solving contract discrepancies, are reduced by automating agreements with smart contracts and relevant real-life information about the environmental resource are added directly to the accounting ledger through oracle systems, possibly circumventing the need for third party monitoring. Blockchains can assist PES conditionality arrangements by facilitating sanctioning mechanisms and automatizing conditional payments. Payments for ES should only be granted if the expected environmental services are provided. If payments are conditional on ES delivery, then the consequences of non-compliance to the PES contract should be the discontinuation of payments. Yet, many schemes do not sanction noncompliance of contractual agreements. Sanctioning non-compliance is often costly in political and social terms, for it implies taking unpopular measures such as discontinuing payments and applying penalties. The authorities, politicians or stakeholders in charge of implementing sanctions must often bear the social cost of implementation. They lose acceptance or popularity. Smart contracts and programmable money can help solve such difficulties by automatizing sanctioning mechanisms.

Self-executing smart contracts and programmable money can be coded to ensure that payments are only released after a valid certification of service provision is uploaded. Additionally, smart contracts can make sanctioning mechanisms less costly in political and relational terms, for sanctions are automatically triggered by automatized, self-executing smart contracts instead of human representatives. Such automatized mechanisms are based on a transparent and fully accessible code. This transparency could make conditionality agreements more foreseeable and acceptable.

Blockchains can also facilitate institutional innovation in PES schemes. The underlying code of a blockchain dictates the institutional framework that governs the relationships and transactions between the participants of the distributed network. Articulating institutions and implementing rules can be less costly when using a DLT. Networks can test, amend and improve institutional arrangements by simply altering the source code. They can copy-paste positive elements of existing institutional structures and adapt them to their own social reality without incurring high costs. Blockchains thus allow for low-cost institutional innovation and implementation (Berg, Davidson, & Potts, 2018). The relative simplicity with which institutional frameworks can be created, copied and evolved will facilitate the emergence of networks that engage on different projects, including the provision of ES. Such networks will be able to build upon existing digital infrastructures for formulating their own favourable institutional frameworks. Bottom-up initiatives can be crafted from within the local social-institutional framework and bring the essence of innate institutions within themselves, thus promoting the utilization of native institutional alternatives.

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POLICY RECOMENDATIONS

Recommendation 1

Consider the digital endowment of participants and their acceptance towards technological adoption prior to blockchain implementation.

Ensure that the participants of the scheme have a knowledge of digital technologies that allows them to participate in a distributed network and take advantage of the benefits this offers. The technology used should be adapted to the needs and wishes of participants.

Also understand whether stakeholders welcome the adoption of a distributed technology. The introduction of a new distributed digital technology has repercussions on a scheme´s governance and can affect the perception of communities towards the PES scheme. If stakeholders are reluctant to the usage of the technology, its usage is less desirable. Blockchains are thus desirable when they not only offer solutions to technical or economic PES needs, but when they are also an accepted alternative to do so.

Recommendation 2

Ensure the availability of reliable oracle systems to translate real-life information on environmental resources and on ES provision to the digital realm of blockchains.

In order to use PES-related information in DLTSs, it is necessary to be able to translate real-life events and real-life information into the digital realm of blockchains in a secure and reliable manner. The oracle system must have the capacity to deliver high quality information safely, reliably and at affordable cost. For those schemes where a reliable oracle system cannot easily be implemented, digitalizing external real-life information will result improbable and the benefits of utilizing blockchains for PES schemes are questionable.

Recommendation 3

Consider the economic implications of blockchain implementation relating to costs, willingness to pay (WTP) for ES and willingness to accept (WTA) payments.

Initial blockchain development can at present be significantly more expensive than alternative non-distributed options. The expected economic benefits of implementation should not exceed the costs.

Blockchains can also potentially transform the transaction costs (TC) associated to ES exchanges and the values corresponding to WTP and WTA. Blockchain implementation should be considered only for situations where the WTP-TC>WTA.

Recommendation 4

Design the blockchain architecture according to the specific needs of the project.

The architectural design has stark institutional implications for the PES scheme. The appropriate architectural choice depends on multiple factors, including the relationships between participants, the accessibility preferences, the socio-economic characteristics of stakeholders, the availability of oracle systems, costs, technical knowledge and others.

Recommendation 5

Ensure the redeemability of tokens.

When employing tokens in a PES scheme, it is important for stakeholders to be able to exchange their tokens for other currencies, for goods, or for services that allow them to enjoy the fruits of their work. Crypto tokens are not always accepted as payment methods. Since the *tokens do not have an* inherent market value, the redeemability of the tokens is essential for the correct operation of the network and for maintaining the incentives of the PES scheme and of the blockchain network.

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ABOUT THIS POLICY BRIEF
This Policy Brief is part of a series aiming to inform policy-makers on the key results of the ZMT research projects and provide recommendations to policymakers based on research results. The series of ZMT Policy Briefs can be found at https://www.leibniz-zmt.de/en/research/publications/policy-briefs.html.

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