PwC's Blockchain Sustainability Framework

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Stellar Development Foundation

Purpose of the Framework

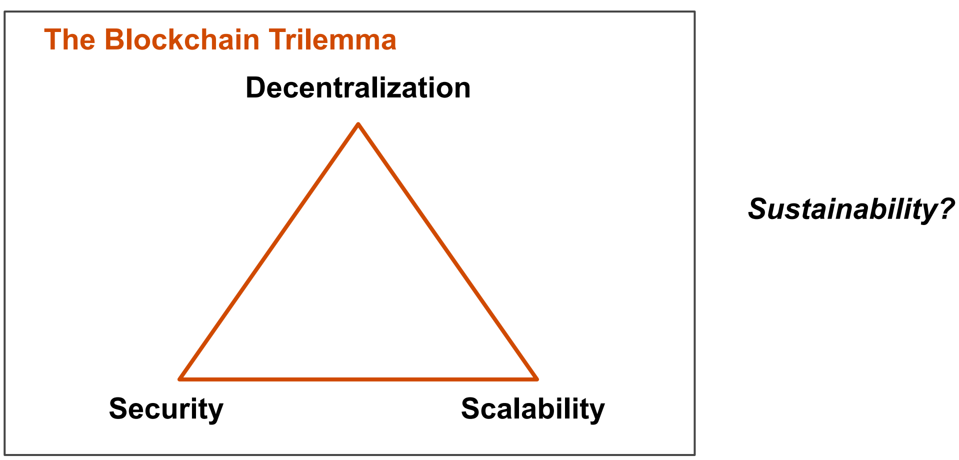
PwC's Blockchain Sustainability Framework (the Framework) provides a methodology to quantify the environmental impacts of a blockchain protocol. Although existing studies on the sustainability of blockchain exist, these often focus on a single blockchain and define bespoke methodologies and assumptions, making meaningful comparisons of results challenging. By defining a consistent and widely applicable methodology, as well as a common set of assumptions and data sources, the Framework can theoretically be applied to a wide range of blockchain protocols while providing comparable and trusted results.

The methodology described in this document can be repeated regularly to follow the changing impacts of blockchain networks as they evolve. As such, reporting cadences can be established to maintain transparency and track growth of the protocols, whether it be general scalability or specific impacts from governance changes. Other participants within the blockchain community and environmental groups at large are encouraged to leverage and build upon the Framework.

Challenges of comparing blockchain protocols

The consensus mechanism of a blockchain protocol is the critical component for achieving agreement on network state. Consensus mechanisms have been adapted over time as benefits and drawbacks have been identified within each approach, and thus serve as a leading differentiator between protocols. This leads to a focal point of discussion for blockchain networks: The Blockchain Trilemma.

Well known in the industry, the Blockchain Trilemma proposes a set of three main issues - decentralization, security, and scalability - and postulates that a blockchain network can only reliably provide two of the three, sacrificing one as a trade-off. It is important to note that the Trilemma is a conceptual model for a challenging problem within the blockchain space, but does not suggest that it is impossible to solve. As emergent protocols seek solutions to address the Trilemma, creators should also consider a fourth axis of sustainability, or how the protocol impacts the environment.



Due to the decentralized nature of blockchain systems and the vast number of anonymous participants, it is not feasible to retrieve energy usage data for each participant in a given protocol. However, attempts can be made to estimate the environmental impact of blockchains through a variety of approaches, which are covered in the remainder of the Framework.

Designing the Framework

The Framework aims to quantify material environmental impacts of a blockchain protocol, building on existing research in the market.

1. Identifying a list of ESG impacts

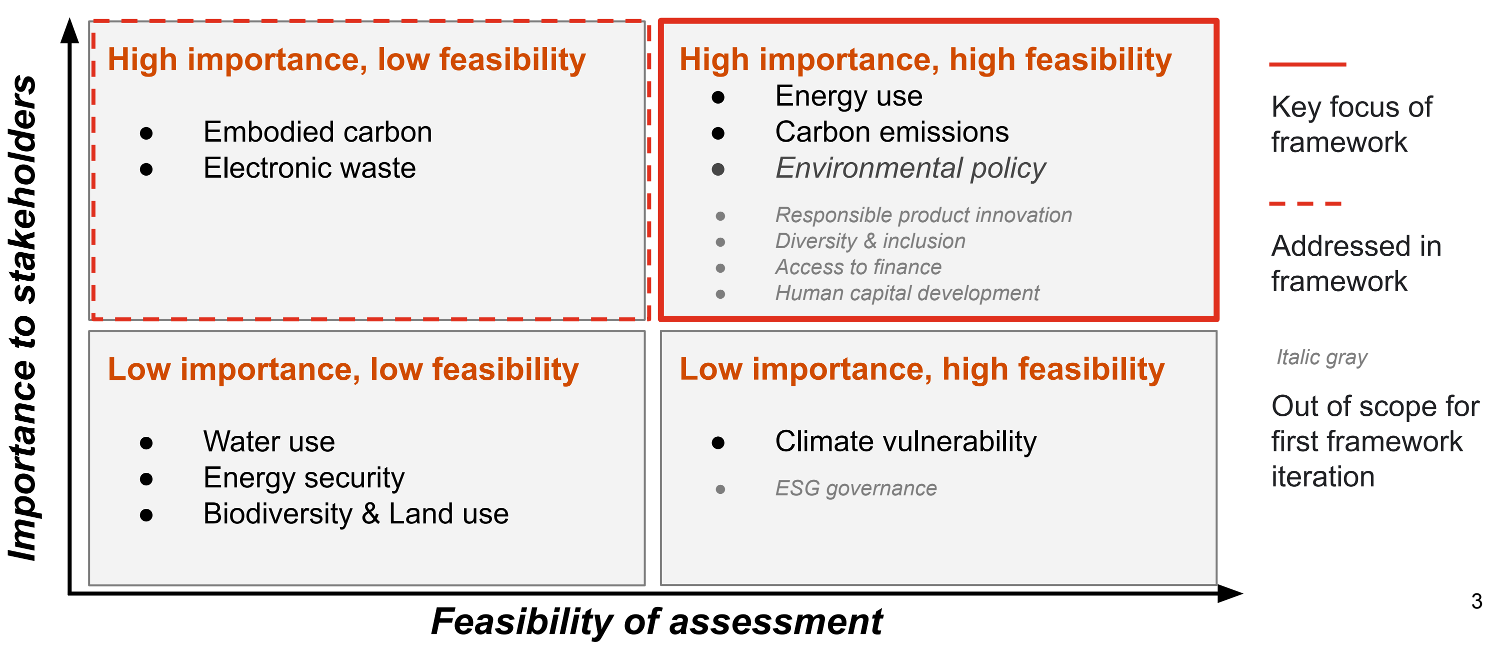
The first step in the development of the Framework was to identify the material sustainability impacts that are relevant to blockchain protocols. An impact is material to blockchain protocols if it (1) is important to stakeholders (including investors, society, customers and developers) and (2) creates a significant impact on the environment, economy, and society.

Materiality impacts for ESG topics were drawn from PwC's proprietary ESG issues framework, and were supplemented by industry leading practices [1]. This list was used as a guidance for discussion and initial identification of priorities and is not comprehensive. Note that social and governance considerations, such as the access to finance, responsible product innovation, etc., are not included in the Framework.

Environment		Social	Governance
Energy use	Climate vulnerability	Access to finance	Responsible product innovation
Carbon emissions	Water use	Security and privacy	Risk management
Embodied carbon	Biodiversity & Land Use	Community	Business ethics
Electronic waste	Energy security	Diversity, equality, and inclusion	
Environmental policy			

2. Prioritizing material and quantifiable ESG impacts

Following a review of different blockchain protocols, current and emerging trends in the industry, and current or potential impacts blockchain protocols have on the environment, economy, and society, key ESG components were mapped according to their importance as determined by industry knowledge and experience and their feasibility of assessment.



3. Selecting environmental impacts to include in the Blockchain Sustainability Framework

To balance the importance to stakeholders and feasibility, the Framework covers a prioritized subset of three impact areas: energy use, carbon emissions, and e-waste/embodied carbon.

It is desired that future research considers the quantification of ESG impacts not included in the Framework to continue to build on the wider body of research already conducted.

Framework Overview

The Framework was designed to provide a holistic view of environmental impacts, and has the potential to develop further in the future to include wider environmental and social impacts.

A detailed analysis of several previous environmental impact assessments of blockchain protocols found that existing assessments focus largely on energy use and its associated carbon emissions. Some studies also evaluated the embodied carbon and e-waste associated with the hardware used to participate in the consensus mechanism of a blockchain. Existing studies differ in approach, each focusing on different impact areas.

Building on the previous studies analyzed, the Framework entails four material impact areas, with between 1-2 metrics defined for each impact area.

Approach type	Impact area	Description	Metric
Quantitative approaches	**Energy use**	Energy use of the system (including the hardware running the consensus mechanism)	• Electricity use per transaction
	Greenhouse gas (GHG) emissions	Associated GHG emissions from electricity use	• GHG emissions per transaction
Qualitative approaches	**Marginal energy use**	Energy use conducting one additional transaction	• Marginal electricity use for one additional transaction
	Embodied carbon / E-Waste	Embodied carbon and end-of-life modeling of hardware used to run the protocol	• E-Waste (kg) per transaction • Embodied carbon (kg) per transaction

Methodological Limitations

The Framework attempts to further existing research and create a holistic assessment methodology; however, noting the Framework's limitations and acknowledging the difficulties of capturing and measuring mutually agreed upon potential impacts should be balanced with the perspectives presented herein. A few key limitations include:

- Accuracy of final results: it may be impossible or impractical to collect information to conduct an analysis to estimate the impacts of a protocol implementation, and therefore we have exercised a level of pragmatism to judge the balance of obtaining reasonable and robust results and aspiring to develop a future-proof impact Framework.
- Availability of input data: The results of applying the Framework will depend on data available through the sources accessed, some of which might not be primary data and may therefore have a level of uncertainty.
- Scope may be limited: Not all ESG components were considered, and not all aspects of blockchain energy consumption were considered.

Citation

[1] World Economic Forum, and PwC, Deloitte, KPMG, and EY. "Measuring Stakeholder Capitalism Towards Common Metrics and Consistent Reporting of Sustainable Value Creation." 22 September 2020, https://www3.weforum.org/docs/WEF_IBC_Measuring_Stakeholder_Capitalism_Report_2020.pdf. Accessed 20 March 2022.