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Tokenizing Behavior Change: A Pathway for the Sustainable Development Goals

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To be successful and sustainable, social impact programs require individuals and groups to change aspects of their behavior. As blockchain-based tokens are increasingly adopted to target social outcomes, it is important to properly define these activities as "behavior change interventions" and assess their design and management as such—otherwise, there is significant risk of possible unintended consequences. Designing tokens as behavior change interventions requires new constructs beyond those currently in use to model the interdependence of digital and social ecosystems, and integration of token engineering, cryptoeconomics, and behavioral skill sets to test token designs within various ecosystems. New token design and testing protocols that integrate behavior measures around the targeted social outcomes are needed, to fill a critical gap in current practice. Hence, new standards, operational frameworks, and ethics are needed to guide the use of tokens at scale, as tools to achieve social impacts such as attaining the United Nations' Sustainable Development Goals. Meeting these needs requires a collaborative approach between token design actors (computer scientists, cryptoeconomists, token engineers, etc.) and social impact practitioners who will be increasingly called upon to use tokens as behavior change tools. This paper begins to identify common ground and address areas to further develop research and practice of tokens being used for social impact.

Keywords: blockchain, tokenization, behavior change, social impact, sustainability, sdg

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INTRODUCTION

The potential of blockchain technology to provide value in achieving various social impacts has been widely discussed. Based on current usage, alleged benefits range from assisting vulnerable populations (World Bank Group, 2019), improving supply chain management (World Bank Group, 2020), local currencies (World Bank Office of the Chief Economist, 2018), and more. Blockchains support the digitization of assets and values in the real-world through digital cryptographic tokens (cryptotokens). This process is known as "tokenization." Programmable computer code known as "smart contracts" allows cryptotokens to be generated, exchanged between parties, and destroyed, while maintaining a tamper-proof record of balances and transactions between participants in decentralized environments (Lee, 2019). Blockchain consensus mechanisms ensure that this ledger record cannot be subsequently revised or changed by any party, even when the participants in the ecosystem do not have equal standing. As a result,

blockchains can be used to bring transparency into an ecosystem. Blockchain technology's greatest potential for social impact may rest in the ability to use tokenization to motivate the behaviors necessary for social impact (Thomason, 2018), while providing greater transparency.

Given that "all development interventions presume behavior change" (Flanagan and Tanner, 2016), the ability to achieve behavior change effectively and efficiently is critical. Even programs that do not explicitly target human behavior change, such as policy development and implementation, organizational strengthening, or infrastructure development programs, indirectly require individuals and groups of humans to change some sort of behavior to be successful and sustainable. Tokens have long been used as behavior change tools (Hackenberg, 2009). The emergence of blockchain technology and its cryptotoken capabilities has amplified the capacity to use these tools at scale (Lee, 2019). The potential opportunities from using cryptotokens as behavior change tools to attain the Sustainable Development Goals (SDGs) (UN General Assembly, 2015) must be explored fully (Wuropulos and Hager, 2016). Many current blockchain projects critically lack usage of existing social impact evidence in design and management, posing a threat to inflict significant harm. This paper begins to address gaps already identified by research in the emerging field of cryptoeconomics (Voshmgir and Zargham, 2020). These gaps highlight the need for greater consideration of behavioral science in the interaction of ledger, tokenized, and digital ecosystem, with cryptotokens as the technological bridge between the two (Tan, 2021). If cryptotokens are to be adopted as tools that can contribute to achieving the SDGs, they must leverage desired behaviors in an ethical, efficient, and sustainable manner. This paper discusses integration of new interdisciplinary behavioral skill sets, functions, perspectives, and evidence into protocols beyond those currently present in the blockchain and social impact communities. This paper is written for researchers and practitioners who want to use cryptotokens for positive social impact. We fully appreciate that consensus is lacking on specific definitions. Our contributionis a sincere attempt to capture the latest thinking and an open invite for collaboration, with recognition that this field is evolving quickly. Differences in terminology and culture between fields can create confusion and contention. While the social impact sector has extensive practices and tools to create more inclusive and bottom-up-driven solutions to social problems, those unfamiliar with their design can see these interventions as being mandated from the top down. Similarly, to social impact practitioners, technology-driven solutions can appear to neglect human dimensions of social problems by assuming consistently rational and predictable behavior. Additionally, popular views of the wider cryptocurrency space bring skepticism that obscures and weakens research unrelated to financial speculation. Bridging these cultural divides is as important as bridging the technical gaps.

CONTEXT

Cryptoeconomics

The emerging field of cryptoeconomics researches the economic potential of decentralized and cryptographically secured ecosystems. While predominantly developed from computer science communities, it is intended to be interdisciplinary and to incorporate methods from various economic disciplines (Voshmgir, 2019). Token engineering is a methodology with a lifecycle consisting of ideation, design, modeling, simulation, testing, deployment, and maintenance of ecosystems created by a cryptotoken[1]. This lifecycle is similar to those established in behavioral sciences and social impact practices. While there is a lack of consensus around these definitions, we propose them as working definitions for our purposes here.

Current outcomes in cryptoeconomics facilitate iteratively improved system designs, yet they are mostly centered around creating infrastructural stability and security for tokenized ecosystems. Social and behavioral sciences could contribute to further optimizing these systems in accordance with societal goals. Token engineering attempts to incorporate values from engineering disciplines into the building of decentralized ecosystems, such as Civil Engineering ethics and standards. Cryptotoken designs already affect the behavior of users in many ways, even if unintended. Ethical, sustainable, and effective tools that are implemented by communities in their own interest and that further collective and societal goals could strengthen communal values.

However, current public blockchain technology acts under technological and regulatory constraints. Many public blockchains, such as Bitcoin and Ethereum, currently find consensus on state updates through "Proof-of-Work". This results in substantial energy consumption (de Vries, 2021) and limits transaction throughput (Schäffer et al., 2019). Regulatory uncertainties (i.e. immutability of recorded data and complexity of global ecosystems) hinder implementations (Yeoh, 2017). Attempts to mitigate these limitations are actively researched.

Behavior Change

Behavior change interventions (BCIs) are understood as "Coordinated sets of activities designed to change specified behavior patterns" (Michie et al., 2011). Numerous cryptotokens fit this definition with some already being used as behavior change tools. This potentially results in significant opportunity cost and risk due to a lack of behavioral insight in current design and management practices.

Cryptotokens are often designed assuming that intended social behavior will emerge from a well-designed application (or "dAPP"). This assumption is well known to social impact practitioners and rarely proves true—and when false, it can create more harm than good (World Bank, 2014). Cryptotokens, as part of an intervention, are manifested as computer code that can be easily modified. This lowers barriers for experimentation and creates higher potential for learning. Therefore, cryptotoken constructs should be designed, tested, and adapted as BCIs.

This is not to say that the social impact sector has mastered these standards. While evidence and best practices are largely

[1]https://www.usaid.gov/sites/default/files/documents/Digital_Strategy_Digital_Ecosystem_Final.pdf

conceptually accepted, there is no widely shared understanding of basic constructs such as "Mechanisms of Action" through which individual behavior change techniques (BCT) operate (Carey et al., 2019). This could prove to be troublesome, as the potential of tokenized systems to achieve any social impact is dependent on evidence-driven standards. Their misuse (i.e., use outside of evidence-driven standards) has high potential for harm (Sylvester et al., 2019). The ease of experimentation could pose significant damage if not properly informed, thus violating a fundamental tenet of social impact to "Do No Harm" (Anderson et al., 1999).

Ecosystems of Interest

Emerging research and practice places emphasis on ledger design (maintaining transparency, security and immutability). More is needed to link this layer with the behavioral relationships they seek to modify (spanning real-world social contexts) and the ecosystems they are embedded in, namely:

- *Digital Ecosystem:* Comprised of 1) Digital society, rights, and governance; 2) Digital economy; 3) Digital infrastructure.
- *Tokenized Ecosystem:* Those actors who influence the desired social outcome and are in turn influenced by the design of the token to achieve desired behavior, mitigate undesired behavior and align incentives.
- *Ledger Ecosystem:* The blockchain ledger as a substrate for the token provides the immutable, transparent, and secure accounting of the interactions (i.e., transactions) of actors in the tokenized ecosystem.

The token at the center of any tokenized ecosystem must be designed to influence the drivers of behavior change in real-world ecosystems, while recognizing the limitations and costs of using the technology. There are challenges in connecting blockchains' digitally controlled and verifiable state to real-world ecosystem states—recognized as the "oracle problem" (Caldarelli, 2020). If cryptotokens are to be adopted as scalable and sustainable social impact tools, these points of integration and accompanying social measures should be a primary focus for research. If their social aims are to be achieved, any tokenization project should include an assessment of the desired behavior change in every ecosystem of interest. This includes measures of the social effects to improve its design and management.

The ledger and tokenized ecosystem, in the case of blockchains, clearly defines the rules governing the system (i.e., read and write permissions, validity of transactions, incentives for behaviors involved in upkeep of the ledger, such as mining, etc.). The Ethereum blockchain, for example, can be considered a ledger ecosystem. When applications are built on Ethereum, using a token designed for a specific purpose (e.g., carbon sequestration), then this creates a tokenized ecosystem that operates within the digital infrastructure - comprised of the digital society, economy and infrastructure. Social outcomes are dependent on behaviors within all three ecosystems and the interaction between them as managed by the token, illustrated in **Figure 1** below.

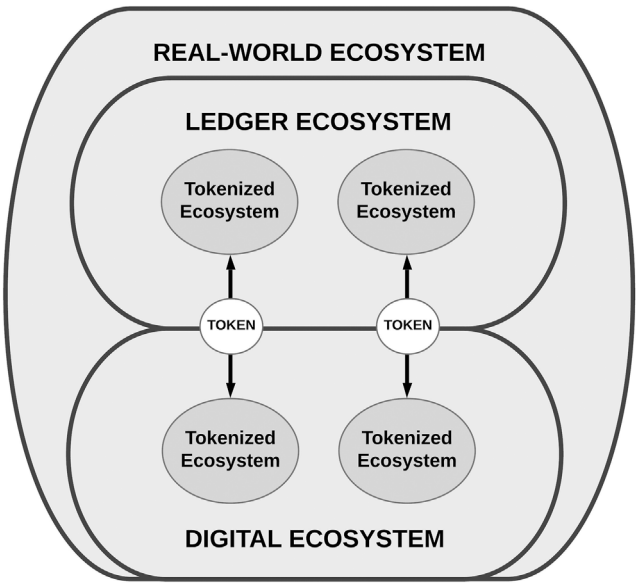

FIGURE 1 | Tokens bridging ecosystems of interest.

The Rebalance Earth[2] initiative, for example, is developing a cryptotoken that incentivizes maintenance of priority species critical in capturing carbon and restoring ecological resilience through biodiversity targets. Voshmgir (2021) describes how a decentralized application can use sensors, AI, and tokenization to track carbon capture and sequestration that results from maintaining biodiversity. Sensors installed within the forest measure biodiversity data, which is analyzed by algorithms, with smart contracts triggering on predetermined conditions to release cryptotokens worth US$80 per elephant per day. This provides payment for the forest rangers and other community biodiversity services.

In this scenario, a blockchain platform establishes a tokenized digital ecosystem, bootstrapped by the biodiversity cryptotoken. Critically, the objective is not to incentivize behaviors to maintain the digital ledger and the cryptotoken itself, but for forest rangers and community members from the existing real-world ecosystem to act within the new tokenized ecosystem. The voluntary "opt-in" of these actors into the proposed tokenized solution cannot be assumed, it must be designed accounting for interest, incentives, and capabilities of these actors. When community members perform activities to ensure preservation of the elephant herd, they are acting within the tokenized ecosystem. When they eat dinner that evening, they are acting within the social ecosystem, and outside the tokenized ecosystem. However, the cryptotoken must be designed with effective BCTs to induce people to not only adopt the performance of monitoring activities, but all behaviors required for the tokenized ecosystem (e.g., forest rangers enforcing poaching

[2]https://outlierventures.io/wp-content/uploads/2019/05/Token-Ecosystem-Creation-Outlier-Ventures-PDF.pdf

laws). The token design should integrate BCI design principles and performance measures from the tokenized ecosystem for adaptive management purposes. Cryptotokens that seek to achieve goals like those targeted by the Rebalance Earth token require complex social behavior change in decisions from actors at different levels of social hierarchy, variability and difficulty of those decisions, etc. Assessing the complexity involved not only requires behavioral skill sets and methods; it also underscores the necessity of bringing these skill sets into token design sandboxes. Token design and management is a collaborative product that belongs to interdisciplinary teams not solely within the realm of any specific discipline.

DISCUSSION: UNDERSTANDING THE ECOSYSTEMS OF INTEREST

Design Criteria for Cryptotokens

The social impact sector has accumulated decades of evidence on the necessity of behavior change to achieve sustainable impacts. This evidence has resulted in strategic guidance (World Bank, 2014), community discussion (Dieye, 2018), toolkits (Heider and Flanagan, 2017), and advice on how to design, measure, and adapt interventions to achieve the behavior change required for sustainable impact (People in Need, 2017). While no absolute consensus exists, general standards for effective BCI design include the following:

- Defining the problem in behavioral terms for specific actors within the ecosystem of interest;
- Selecting the desired behavior correlated to specific actors;
- Identifying change needed between status quo and desired behavior for each actor in terms of Capacity, Opportunity, Motivation;
- Outlining options for intervention functions for each desired behavior change with supporting evidence and assessing options;
- Identifying specific BCTs with mode, method, timing, etc., of delivery;
- Formulating a time-bound hypothesis in a theory of change with measures for each link in the causal chain (inputs/outputs and outcomes such as knowledge/capacity, motivation, opportunity) including the fidelity of the BCT, assumptions, and residual effects in the ecosystem of interest (Michie et al., 2014).

These standards must be met by token designs to facilitate sustainable social outcomes, through creation of inclusive processes and guiding principles.

Behavior Change and the SDGs

If cryptotokens are to be effective in helping to address the SDGs, they will need to be optimized within BCIs according to documented, evidence-driven standards, maximizing learning potential. Learning comes from the ability to test the intervention through measurement, with resulting actionable evidence integrated back into improved design and management. However, testing the intervention through a series of measures is dependent upon the design of the intervention allowing for the right measures to be taken at the right time and in the right way. In many ways, we are still learning to design so that we can design to learn.

Defining Standards to Support Interoperability

Several efforts are underway to create standardized cryptotoken taxonomies[1] and design frameworks that allow for the selection and design of cryptotokens for particular needs (Toepffer and Thatmann, 2020). Generally, the starting point for taxonomy has been required general features and restrictions, with no clear linkage to how these considerations translate into and affect social behavior changes needed for the targeted social impact.

Evidence is needed to draw correlations between cryptotoken design, token behavior, and behavior of actors within the tokenized ecosystem (each with its own typology of classifications defined by priority attributes). If cryptotokens are to be used at scale for broader social outcomes, token taxonomies and behavior change taxonomies will need a functional level of interoperability. Without correlation between token design and desired behavior change targets, a systematic evidence base on the use of cryptotokens for specific social impact cannot be achieved.

Sustainability of the Ecosystems

The existing principles, protocols and practices need to be updated for sustaining impact in these new ecosystems, as well as sustaining the enabling environment to facilitate further impact. This goes beyond addressing the unsustainable cost of maintaining digital ledgers (primarily energy use in POW-consensus) and into the sustainability of the hard infrastructure (connectivity, security, etc.) and social factors (digital literacy, affordability, etc.) required for the desired impact. As tokenization and decentralized infrastructure are interdependent, using pre-existing guidance on sustainability for web-based digital ecosystems[1] and updating this for decentralized applications is a good start to begin building evidence on sustainability standards. Creating standards this way builds on recognition that sustainable impact stems from a variety of factors within the system, whether it is a village community, market system, supply chain, etc.

Table 1 is an initial attempt at providing a template for a Sustainability Matrix for the token design process. The matrix should be completed for any project under consideration, and can help ensure that relevant ecosystems are considered to facilitate sustainability. The matrix builds on Token Utility Canvas[2] tools common to token design practitioners, and Digital Ecosystem[1] guidance using social impact terminology and principles. Populating the matrix with considerations for each component should help link the proposed tokenized ecosystems to the real-world ecosystem in which impact is to be made. We intend that the initial table here is extended and improved by both communities, as experience in ecosystem design develops.

Facing Ethical Challenges

There is potential for cryptotokens to achieve social impact aims. There is also potential for significant harm. The technology itself is neutral in terms of outcomes and relies upon intelligent and ethical design and implementation. The social impact sector has gathered

TABLE 1 | Sustainability Matrix Template.

Design components	Digital ecosystem	Ledger ecosystem	Tokenized ecosystem
Points to consider	*What are the implications of the digital economy, regulatory environments and actors digital capacity?*	*How do we ensure that there is sustainable security for the ledger, maximize transparency, immutability and other desired characteristics?*	*How do we design the token in a way that ethically and sustainably leverages the desired behavior, mitigates undesired behavior and optimizes alignment of incentives?*
Participants			
Desired Behaviors			
Undesired Behaviors			
Mechanisms			
Assumptions			
Sustainability Impact			

evidence, developed guidelines[3], and learned lessons from unethical and negative unintended consequences within its efforts. This accumulated evidence base offers valuable insight into the use of cryptotokens as BCIs. Since tokenized ecosystems as a BCI are a novel innovation, this evidence base needs to be revisited and its principles modified to inform initial pilot studies. Projects need to enable testing of technical assumptions, known ethical considerations and facilitate discovery of unknown ethical consequences.

Developing New Operational Frameworks

An interoperable taxonomy, and the supply of evidence it would facilitate, is only possible through systematic collaboration among cryptoeconomists, token engineers, and social scientists. Collaboration could be structured around a common operational framework that builds on an agile lifecycle for designing cryptotokens as BCIs, and measuring their performance within tokenized ecosystems. This operational framework can be developed through a combination of cryptotoken design processes and established social impact due diligence processes, around needs assessments, intervention selection, intervention design monitoring and evaluation, learning agendas, etc.

Principles, protocols, and tools are needed to bring varied skill sets and cultures into operational sandboxes set on a common lifecycle. The approaches are similar, as early stages focus on problem identification, problem diagnostics, solution design, and later phases on iterative solution testing and adaptation (where solutions are cryptotokens for token engineers and programs for social impact practitioners).

CONCLUSION

This paper has identified challenges and risks for cryptotoken-based behavior change interventions. We have described approaches of the fields of social impact and token design, and identified similarities. We have raised concern on the interaction of different classes of ecosystems, and proposed potential ways to bridge them, through better integration of research fields and practitioners. This is a pressing need, as interventions of this type are already being conducted, often without notice of their complexity and potential outcomes. There is common ground to build upon, in regard to lifecycle phases and their functionality. Value will be created by developing the operational protocols—the rules of the sandbox—within each specific lifecycle phase that achieves the level of integration for the successful design, testing, and adaptation of cryptotokens as BCIs.

There are still many gaps left to be explored. The responsible use of tokens as social impact tools requires collaboration and accounting for relevant lessons across the disciplines. Practical implementations according to principles of design, management and learning need to be explored and shared. Technology is a tool, with consequences from misuse that require active caution and proper guidance. Through a growing group of social impact practitioners, token engineers, cryptoeconomists, and experts from related fields dedicated to collaborating, we seek to identify the principles, build protocols, and develop tools to ethically and efficiently use tokens as behavior change tools for the common good. We welcome additional partnerships to advance this work through research, collaboration events, and joint learning.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

IB and MC conceptualized the paper, IB, MC, and JH contributed equally to authoring the paper. PP provided expert peer review. All authors contributed to manuscript revision, read, and approved the submitted version.

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[3]https://tokenengineeringcommunity.github.io/website/docs/getting-started-welcome/

REFERENCES

Anderson, M. B. (1999). *Do No Harm: How Aid Can Support Peace–Or War*. Lynne Rienner Publishers.

Caldarelli, G. (2020). Understanding the Blockchain oracle Problem: A Call for Action. *Information* 11, 509. doi:10.3390/info11110509

Carey, R. N., Connell, L. E., Johnston, M., Rothman, A. J., De Bruin, M., Kelly, M. P., et al. (2019). Behavior Change Techniques and Their Mechanisms of Action: a Synthesis of Links Described in Published Intervention Literature. *Ann. Behav. Med.* 53, 693–707. doi:10.1093/abm/kay078

Dieye, A. M. (2018). *Experimentation and Behaviour Change for the Sdgs: Bringing Behavioural Insights to Scale*.

Flanagan, A. E., and Tanner, J. C. (2016). *Evaluating Behavior Change in International Development Operations*.

Hackenberg, T. D. (2009). Token Reinforcement: A Review and Analysis. *J. Exp. Anal. Behav.* 91, 257–286. doi:10.1901/jeab.2009.91-257

Heider, C., and Flanagan, A. E. (2017). *Putting Behavior Change at the center of Development and Evaluation Klaniecki*.

Lee, J. Y. (2019). A Decentralized Token Economy: How Blockchain and Cryptocurrency Can Revolutionize Business. *Business Horizons* 62, 773–784. doi:10.1016/j.bushor.2019.08.003

Michie, S., Van Stralen, M. M., and West, R. (2011). The Behaviour Change Wheel: a New Method for Characterising and Designing Behaviour Change Interventions. *Implement Sci.* 6, 42–12. doi:10.1186/1748-5908-6-42

Michie, S., Lou, A., and West, R. (2014). *The Behaviour Change Wheel: A Guide to Designing Interventions*. Silverback Publishing.

People in Need (2017). *Behavior Change Toolkit for International Development Practitioners Enabling People to Practice Positive Behaviors*.

Sylvester, G. (2019). *E-agriculture in Action: Blockchain for Agriculture, Opportunities and Challenges*. FAO.

Tan, L. J. (2021). *Economics and Math of Token Engineering and DeFi* (Singapore: Economics Design).

Thomason, J. (2018). *The New Frontier: Token Economies and Exponential Social Impact*.

Toepffer, P., and Thatmann, D. (2020). "Taxonomy and Universal success Parameters of Token Models in Distributed Ledger Systems," in 2020 2nd Conference on Blockchain Research & Applications for Innovative Networks and Services (BRAINS) (IEEE), 35–39. doi:10.1109/brains49436.2020.9223298

UN General Assembly (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development (UN)*.

Voshmgir, S. (2021). *Biodiversity Tokens: Rebalance Earth*.

Voshmgir, S. (2019). *Token Economy: How Blockchains and Smart Contracts Revolutionize the Economy*.

Voshmgir, S., and Zargham, M. (2020). *Foundations of Cryptoeconomic Systems*.

World Bank Group (2020). *Digital Ag Series: Blockchain-Powered Traceability Digital Platforms: Unlocking Supply Chain 20*.

World Bank Group (2019). *Inclusive and Trusted Digital Id Can Unlock Opportunities for the World's Most Vulnerable*.

World Bank Office of the Chief Economist (2018). *Blockchain and Cryptocurrencies*.

World Bank (2014). *World Development Report 2015: Mind, Society, and Behavior*.

Wuropulos, K., and Hager, C. P. (2016). "Behaviour Change for Sustainable Development," in *Encyclopedia of Sustainability in Higher Education*. Editor W. Leal Filho, 1–10.

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