The Kolektivo Framework

Decentralized Exchange Trading Systems

Curve Labs & Kolektivo Labs

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I. Abstract

New crypto-institutional forms are now possible due to the maturation of modular blockchain components in monetary management, governance, user and data management. When these components are combined as an institutional assemblage, they can maintain and enforce self-sovereignty for a socioeconomic interior vis-à-vis foreign speculation and control. With Kolektivo, we introduce a crypto-institutional framework that combines a native token, an elastic-supply complementary currency, decentralized governance, and geographic natural capital currencies. This framework aims to drive transformative localization per the tenets of the UN Sustainable Development Goals. We use the Celo blockchain, given its interoperability with Ethereum and specialized tooling for the last mile of users. While the framework focuses on the first pilot to be launched in Curaçao, it may be generalized to any comparable initiative.

II. Acronyms

AMM	Automated Market Maker
CC	Complementary Currency
CDT	Composable Data Token
CP-DOTO	Constant-Product Decentralized One-to-One Mechanism
CTF	Gnosis Conditional Token Framework
DAO	Decentralized Autonomous Organization
DeFi	Decentralized Finance
DETS	Decentralized Exchange Trading System
DID	Geographic Decentralized Identifier
EA	Ecosystem Assets
ES	Ecosystem Services
EVM	Ethereum Virtual Machine
HQLA	High Quality Liquid Assets
IMF	International Monetary Fund
JV	Joint Venture
LETS	Local Exchange Trading System
LBP	Liquidity Bootstrapping Pool
LP	Liquidity Provider
MCM	Multi-Collateral Mento
NCC	Natural Capital Currency
NFT	Non-Fungible Token
PES	Payments for Ecosystem Services
TNC	Transnational Corporation
SDG	United Nations Sustainable Development Goal
SE	Solidarity Economy

1. Introduction

> *"[B]lockchain-based coordination may enable new types of economic activity that were previously not able to be governed by firms, markets, or governments... bringing economic coordination and governance institutions to spaces that are currently either poorly served or not served at all by extant coordination mechanisms... **it is an institutional technology**."*
>
> *- Davidson, Filippi, and Potts* [1]

The world's institutional terrain consists of a rhizomatic blend of transnational corporations (TNCs), nation-states, foreign exchange reserves and their corresponding monetary authorities, and both private and sovereign investment funds.[2-4] Although nation-states overall are the largest economic actors, when evaluating the world's top 100 entities by revenue, the strong majority are TNCs. TNCs, though, are functionally integrated with other institutional actors: the global TNC control network consists of millions of ownership relations, with mixtures of state, public, and private ownership.[5-6]

The corresponding institutional order is primarily defined by open markets, transnational corporate governance, and hyperfinancialization. Its economic paradigm is referred to as neoliberal capitalism or neoliberalism in short.[7] The dominant neoliberal development pattern — export-led growth — tends to follow a general sequence where local institutions are instrumentalized in support of global capital.

First, foreign direct investment or trade deals are negotiated with institutional elites in the Global South. These negotiations include prerequisites that open up commons for extraction and financial markets for free capital movement. Northern TNCs then enter Southern markets, which finance the investment by borrowing foreign fiat — typically USD. Over time, a lopsided balance of payments emerges with increasingly unpayable dollar-denominated debts. While on paper export-led growth appears economically efficient, in practice, it leads to increased rural displacement, unsustainable land management, high levels of foreign ownership, and diminished self-sovereignty.[8-10] Through dual overarching processes of displacement and extraction, effective commons management and environmental degradation increase, diminishing local resilience and increasing the frequency and volatility of economic shocks.

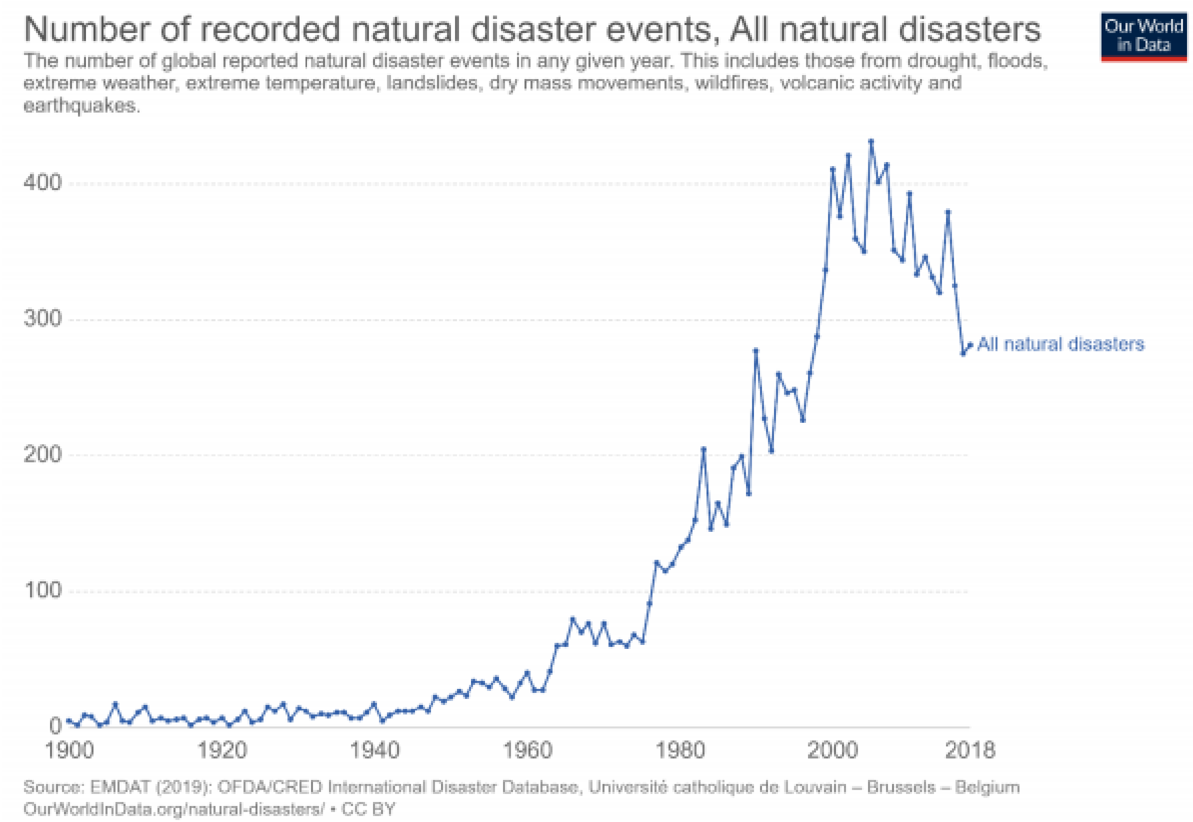

Figure 1: "Number of recorded natural disaster events, All natural disasters," Our World in Data.[11]

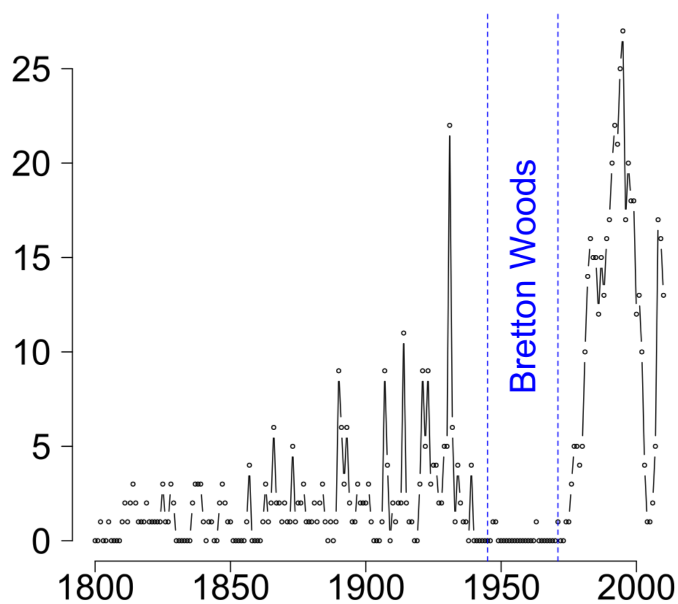

Figure 2: "List of Banking Crises," Wikipedia.[12] These two figures are co-dependent phenomena — banking crises are integrated with the biosphere. Demarcating socioeconomic and ecological systems both at and across scales is analytically incorrect.

The International Monetary Fund (IMF) and other global institutions such as the United Nations (UN) have acknowledged these issues and the corresponding need to revisit bottom-up development, capital controls, and other protectionist mechanisms framed by an import substitution development paradigm. Their concerns are exacerbated by climate change and the increasingly volatile biosphere.[13] To support this strategic shift, new locally biased institutional frameworks and designs are needed.

We propose a new crypto-institutional framework that helps solve these critical problems by mediating local and global economic flows. Our *decentralized exchange trading system* (DETS) utilizes the state of the art of blockchain components[1] and borrows from key lessons learned from the Solidarity Economy to design an institutional assemblage that augments local self-sovereignty and resilience. Its ultimate aim is to support the UN Sustainable Development Goals (SDGs)[2] and other similar indices.

1.1 Decentralized Autonomous Organizations

Decentralized autonomous organizations (DAOs)[3] are blockchain-native digital organizations that strategically govern a given treasury or protocol. Similar to how cryptocurrencies are programmable assets, DAOs are crypto-institutions made up of programmable smart contracts. As such, DAOs can resemble traditional institutions such as central banks or TNCs, or experiment with new social choice algorithms. The DETS' system architecture will borrow from both old and new institutional patterns.

1.2.1 DAO Adoption Failures

Crypto-institutions, through radical transparency and automated smart contract execution, mitigate or outright eliminate institutional opportunism.[14] This suggests that DAOs are well suited to replace legacy institutions through more effective governance and coordination. However, DAOs have largely failed to achieve large-scale adoption since their 2016 inception, for several reasons:

➢ Blockchain is not yet widely conceived by the general public as a technology for institutional reform. Media coverage tends to exclusively focus on Bitcoin and cryptocurrency speculation, without considering its unique properties for social change. DAOs are more difficult to understand, therefore less viral.[15]

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[1] This paper assumes baseline understanding of blockchain technology and will not review basic concepts. For an introduction to blockchain framed in an institutional lens, see Davidson et. al. (2018).

[2] https://sustainabledevelopment.un.org/

[3] DAOs are alternatively referred to as cryptonetworks or digital organizations. For the purposes of this paper, we will use the term "DAO." For a layman's understanding of DAO taxonomy, see https://hackernoon.com/what-is-a-dao-c7e84aa1bd69

- The tooling available for DAOs is still young and fails to meet many important institutional use cases.[16] An example is a means for DAOs to negotiate: TNCs regularly undergo mergers and acquisitions, but no automated on-chain mechanism exists for this functionality today.

- The legal and regulatory uncertainty around DAOs concerns many users. Basic questions such as: “How does a user invoice a smart contract?” and “What legal form does an unincorporated DAO *de facto* have?” remain generally unresolved. Nonetheless, progress is being made in some jurisdictions towards greater regulatory clarity, such as Wyoming’s upcoming limited liability DAO option for legal incorporation.[17]

- DAO tooling is a credibly neutral good and as such, suffers from public good funding issues.[18] Historically, to circumnavigate this, DAO projects have raised funds through token sales to problematic results: biased usage tokens — a token required to use a given platform or protocol — create friction for users. Additionally, teams do not necessarily continue with the planned work due to misaligned incentives.

- The blockchain industry’s focus on decentralized finance (DeFi) tends to cause projects to prioritize a well-capitalized, technically-savvy milieu over the general public. In contrast, the last mile of users have digital access constraints, a lack of financial literacy, and user experience roadblocks. Improving DAO adoption requires tooling and interfaces that address these key issues, which the latest generation of blockchains like Celo are beginning to address. Nonetheless, key DeFi products such as stablecoins *are* improving financial access by meeting global demand for dollar instruments. Improvements in governance components — largely driven by DeFi project demand for DAOs — now offer strong starting points for crypto-institutional proofs-of-concept to be leanly assembled.

1.2 Local Exchange Trading Systems

Since the 1990s, the Solidarity Economy (SE) and its altermodern, ecological ethos has expanded with practical implementations in complementary currencies (CC),[4] worker-owned cooperatives and land trusts, and mutualist societies. SE proponents disregard the imperative pursuit of profit and logic of accumulation to instead emphasize communitarian paradigms in production, finance, distribution, exchange, consumption, and governance. This is realized through *transformative localization*, which embraces subsidiarity and aims to correct economic, social, and political issues at the local level through democratic and environmentally sustainable processes.[19]

[4] Also called social, alternative, or community currencies.

Wikipedia introduces the local exchange trading system (LETS) as "a locally initiated, democratic... community enterprise that... records transactions of members exchanging goods and services by using locally created currency."[20] As of a 2013 study, there were approximately 1,412 LETS implementations in 50 countries globally.[21] Unlike DAOs, LETS are physically embedded. As such, they deal with many key institutional issues that DAOs do not address today:

➢ LETS members tend to aggregate around a common set of values and narratives in philanthropy, bohemian living, environmental politics, and socially aware living.[22] Members who don't necessarily fall into these ideological buckets still see LETS as opposing mainstream economics and a method for financial inclusion.[23] While DAOs do not face any outstanding ideological restraints, early adopters tend to be driven by cryptoanarchic, technophilic, and profit-driven imperatives. Nonetheless, we believe there is ample opportunity to serve both groups within the DETS framework.

➢ Food, gardening, elder and home care are the most desired LETS goods and services. Although some LETS members are self-interested and less communitarian than their peers, all members require these critical goods and services.

➢ LETS form geographically contingent networks and coalitions, working with a variety of public and private actors. Often, LETS help fill the institutional gap experienced by many last mile constituents that are geographically isolated.[24] LETS must seek consensus and buy-in from members biased towards the hyper-local when considering expansion.[24]

➢ LETS develop in both urban and rural environments and face many physical issues unapproached by digital institutions. With this, there is no one-size-fits-all approach to LETS, and a certain degree of design flexibility is needed to bootstrap their growth and maintain their sustainability.

Like start-ups, most LETS implementations fail. Lack of time, awareness, liquidity, a minimum viable diversity of goods and services, and a high dependence on network effects are all common reasons. Ecosystem development arms are thus needed to make markets of local goods and services, and are a must-have for any LETS to succeed.

1.2.1 LETS Policy-Making

LETS create alter-economic spaces that more effectively serve constituencies than other mainstream institutions. To do this, LETS govern and apply various policies to well-defined economic interiors. From empirical studies, these policies have demonstrated their efficacy in creating more productive and sustainable outcomes than traditional development paradigms.

Take, for example, the policies employed by the Sarafu-Credit by Grassroots Economics — a LETS of nearly 50,000 members:

Specific Rule	General Policy
New user signup: +50 CC.	Consumer Subsidy
User fills out profile: +400 CC.	Consumer Subsidy
User refers a new user who then makes an exchange: +100 CC.	Consumer Subsidy
Weekly bonus for high exchange activity.	Consumer Subsidy
Mpesa or Bonga (other local Kenyan currencies) deposited to the reserve receive bonus CC in addition to principle.	Currency Import Subsidy
If there is no trading activity, then 100 CC is deducted and added to the reserve.	Asset Forfeiture
Savings Groups can exchange 50% of their CC balance for Mpesa up to a maximum of 30k CC per month. They must demonstrate they have issued loans equal to their cashout.	Currency Export Quota
CC shop acts as backer of last resort, is sponsored by the treasury, and participating vendors must contribute to it.	Redistribution
CC shop profits are reinvested in community services.	Investment Subsidy

Figure 3: Policies in the Sarafu-Credit economy. Adopted from Sarafu-Credit UNRISD Study.[25]

Against a control group, members of the Sarafu-Credit enjoy increased employment, trade, and small business growth, as well as experience diminished economic volatility.[25] The LETS' stable liquidity is superior to cash transfer aid, or charitable investments that inadvertently introduce volatile cash-rich periods into communities.[26] The Sarafu-Credit is widely inclusive, covering actors such as businesses, informal sector workers, schools, clinics, and self-employed workers.[25]

In general, the Sarafu-Credit's policies possess many design considerations the DETS can utilize. LETS profits are reinvested in public infrastructure and ecosystem services through community governance — the foremost example is the community general store that acts as a Sarafu-Credit buyer of last resort. Many user acquisition subsidies help build trust in the system and stimulate network growth; first, for signing up, second, for identifying oneself, third, for referring additional users. Subsidies help facilitate increased money velocity by subsidizing lending, exchange activity, and minting additional CC with specific collaterals. Finally, to help preserve internal liquidity, large CC holders must satisfy various exit conditions to convert their account balance to the national currency.

2. Decentralized Exchange Trading Systems

Based on the previous sections, we posit three overarching design theses for the DETS:

> (1) DETS must be able to self-evaluate and set policies that accomplish the objectives of the SE.
>
> (2) Virtual currencies and their crypto-institutional issuers must be physically embedded in circuits of production and exchange to achieve widespread adoption and utility. Crypto-institutional growth can be streamlined by empowering already existing SE actors instead of bootstrapping new actor-networks.
>
> (2) Crypto-institutions are like infant industries and require economic mediation mechanisms that restrict capital flight until they harden their native currencies to a given maturity and credibility. When considering Mundell's Trilemma — the two out of three currency design trilemma between stable foreign exchange rates, an independent monetary policy, and free capital movement — the DETS explicitly eschews the latter.[27]

2.1 Key Principles

The DETS can be characterized as a modular institutional assemblage biased towards transformative localization:

➢ **Self-sovereign:** It is owned by a sovereign community and must be upgradable to suit that community's changing circumstances. We use a programmable, permissionless, and censorship-resistant public blockchain as its main infrastructure.

➢ **Accessible**: It must be affordable and easy for a small, minimally tech-enabled community to use and benefit from. These last-mile users are predominantly mobile-first and require low blockchain transaction costs. For these reasons, we propose to use the Celo blockchain. Overall, the DETS should reduce coordination and transaction costs across a broad and inclusive spectrum of actors.

➢ **Generalizable**: While initial design decisions are being made with a first pilot in Curaçao in mind, the DETS should be able to be used across many potential localities and environments. The system must be flexibly parameterizable, serving varying community approaches across heterogenous lived geographies.

2.2 Celo Bias

The Celo blockchain and ecosystem possess many favorable properties that provide a starting point for DETS implementation:

➢ Celo's work in automated market makers (AMM) and elastic stable-value assets — namely, the CP-DOTO algorithm and Mento — are used as the key mechanism of the DETS' monetary system.

➢ Celo made development progress on many potential policies that the DETS will utilize, namely: a social dividend function, demurrage/wealth tax, and a Tobin Tax.[28]

➢ Celo's lightweight and decentralized phone-identity maps phone numbers to wallet addresses and is well suited for the last mile of users.[29] As an added benefit, if some phone number is not yet registered, received crypto-assets are held until user verification. Finally, any mobile exchange system requires Unstructured Supplementary Service Data, which Celo supports.[30]

➢ Celo is compatible with the Ethereum Virtual Machine (EVM) and supports most EVM wallets and tooling.[31] The DETS relies heavily on the tooling, libraries, and primitives available in the Ethereum ecosystem. However, unlike Ethereum, Celo's high scalability and low transaction costs align with the DETS' accessibility principle.[28]

➢ Celo is working towards "natural-capital-backed assets such as tokenized forests" and "regional and utility assets that… foster local economies".[32] Both align with the DETS' natural capital currency system and the first planned reserve assets for the upcoming Curaçao pilot.

➢ Ideologically, Celo's mission statement "to build a financial system that creates the conditions for prosperity—for everyone" aligns with Kolektivo's principles and aims.[33]

2.3 System Overview

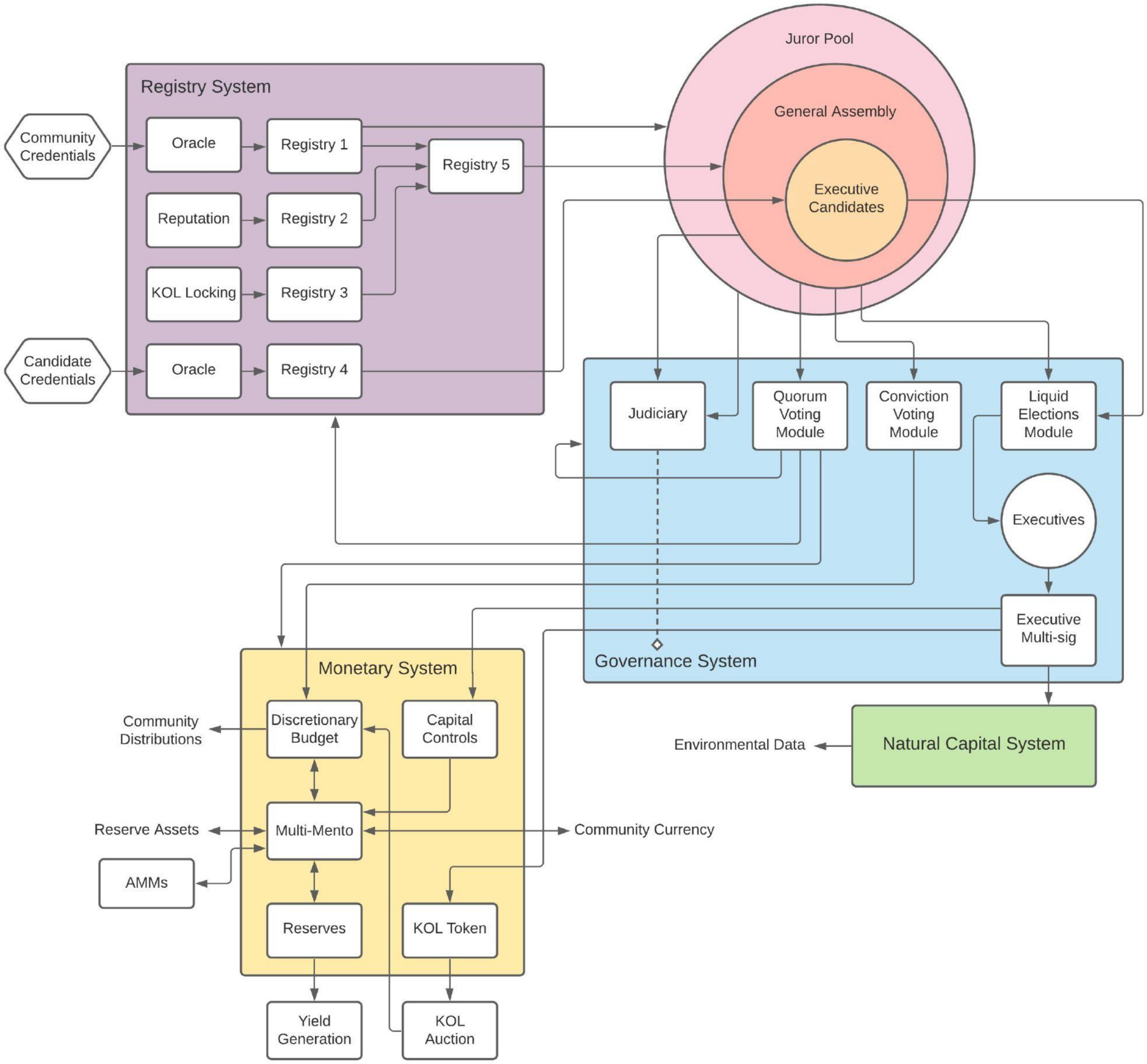

Figure 4: A high level overview of the DETS.

The DETS is a loosely coupled system of systems consisting of (1) **a registry system** that organizes and selects groups of persons, entities, or areas (2) **a governance system** that applies monetary and fiscal policies through (3) **a monetary system**, which resembles a hybrid central/investment bank that (4) aims to regenerate and maintain a healthy **natural capital system**. Each system will be discussed in turn; however, we start by defining the tokenomic primitives that each system ultimately selects, contains, or interacts with.

2.3.1 Tokenomic Primitives

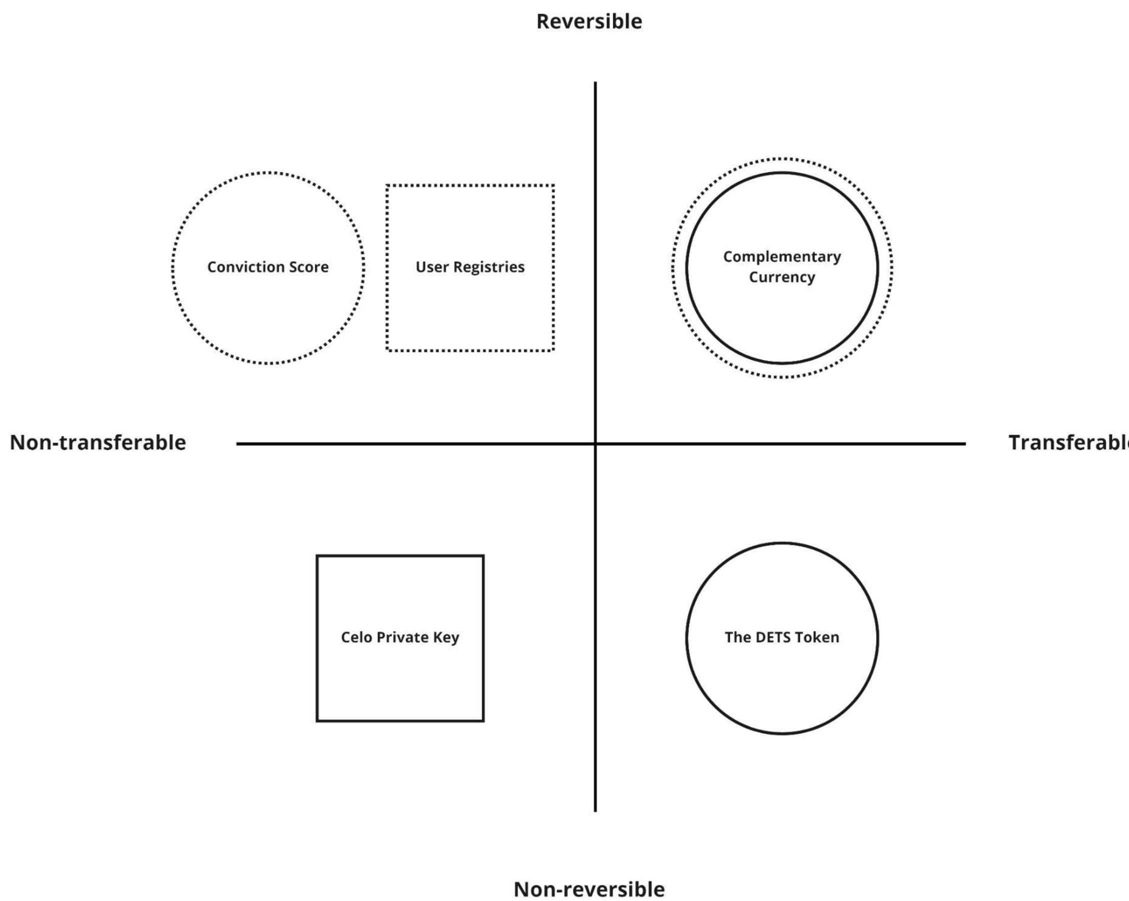

Figure 5: Taxonomy of DETS object primitives.

Tokenomics makes use of four object primitives taxonomically arranged along two axes of reversibility and transferability. For a primitive to be reversible, a governance body must be able to attribute and remove it from some address; for it to be transferable, the address owner must be able to do so. The DETS is likely to use all four object primitive types across its assemblage.

Non-Transferable and Non-Reversible: Private Key

Celo users possess a private key which is neither transferable nor reversible — it belongs to them and them alone.

Non-Transferable and Reversible: User Registries

On joining the DETS, users are added to a registry that grants them access to using the CC. This registry ($\mathfrak{R}_1$) is one of a generalized system of registries discussed at §2.3.2. As addresses can be removed from any $\Re_x$ through some governance process, they are reversible. The registry system exists to give the DETS the ability to select well-bounded user sets and nested sets with which it can apply policies.

Non-Transferable and Reversible: Vote Scoring

An address's *conviction score* is used to weigh decision-making authority in the DETS' conviction voting governance process. This governance process, discussed at §2.3.4, is broadly used to allocate community funding within $\Re_1$. Other point scoring methods may be used to assign voting rights for some DETS or $\Re_x$.

Transferable and Reversible: Complementary Currency

The DETS' CC is both transferable and reversible. Through some governance process, the CC can be frozen, removed, or transferred to or from an $\Re_1$ member. Nonetheless, CC freely circulates within $\Re_1$, and may circulate in other $\Re_x$ under some permissioned policy schema. Non-transferable and non-reversible crypto-assets — e.g. a standard ERC20 token — may be assigned transferability and reversibility for those users who wish to delegate guardianship to the DETS' governance.

Kolektivo Example: Tourists and CC-Guilder

A tourist visits Curaçao and wants to use CC-Guilder ($ƒ_c$) — the CC of the Kolektivo Curaçao DETS, equal in value to the Netherlands Antillean Guilder (ƒ). As the tourist's stay is temporary, they are not eligible to join $\Re_1$. They may, however, join $\Re_{tour}$ — a special registry where addresses are restricted and may only transact with only up to $ƒ_c$5,000 over the course of two weeks. However, tourists who join $\Re_{tour}$ may receive $ƒ_c$100 — a consumer subsidy to spur DETS tourism.

Transferable and Non-Reversible: The DETS Token
The DETS may raise external capital by minting and selling its own reserve token, which we refer to as kCUR (specifically referencing the DETS token of the first planned pilot in Curaçao). kCUR is analogous to CELO in that it has a collateralized relationship to an elastic-supply CC mediated by an AMM — this will be elaborated in §2.3.3. Factors driving kCUR demand include:

- ➢ Growth in the local economy increases money demand for its CC, which in turn drives demand for its reserve assets, which presumably includes the DETS token.

➢ The system's governance framework may require or incentivize members to lock kCUR to earn governance rights as discussed in §2.3.4.

➢ The system will not recklessly mint kCUR and will likely use some of its income to stabilize kCUR's price (e.g. from fiscal policies or lending the reserve).

➢ By introducing a levered reserve, $\mathfrak{R}_1$ users can arbitrage the difference between the cost of goods and services and the collateralization coefficient of kCUR, driving kCUR demand. This mechanism is elaborated in §2.3.3.

Kolektivo Example: A Locally Lost Wallet

An $\mathfrak{R}_1$ member, due to user error, loses access their private key. Their wallet contained CELO, kCUR, and f_c. The user did not delegate permission to the DETS to transfer their CELO. They did, however, delegate permission to the DETS to transfer up to 2,000 kCUR. Through some governance process, 2,000 kCUR and the entirety of the user's f_c are recovered and transferred to a newly generated private key registered to $\mathfrak{R}_1$.

2.3.2 Registry System

Each registry's addresses represent individual users, businesses, projects, or extent areas (see §2.3.5). Automated schemas for adding and removing addresses are possible, with removal, for instance, due to inactivity or not making some minimum transaction quota. As subsets, registries can inherit parameters and conditions to form nested structures. As the DETS fractalizes itself or joins fractal neighborhoods, it will need these inheritances to scale.[5]

Any $\mathfrak{R}_x$ should be thought of as a selector that extends properties, policies, and constraints to its members. As such, different methods and formulae create well-bounded and useful selections. Well-bounded selections are required for the DETS to issue targeted monetary, fiscal, and geospatial policies to specific socioeconomic groups and geographies.

There are, in general, three selector types, which may all be temporally restrained to some period t (e.g. all $\mathfrak{R}_1$ members who have transacted up to a certain date):

[5] For more on DAO fractalization, see https://ecosystem.daoincubator.org/fractalizing/.

➢ **Qualitative social selectors:** Examples could include a registry of local businesses who offer necessary services or a user's level of schooling Special attention must be paid to GDPR compliance when collecting personal information for the purposes of applying qualitative selectors.[6]

➢ **Geospatial selectors:** Selectors that use topology-based queries, such as an extent area, geographic distance, or some density of proofs-of-presence.[7] The DETS may wish to select all users within some bioregion, for example, and issue a regenerative subsidy for augmenting a positive ecological state change in that bioregion (see §2.3.5).

➢ **Quantitative network selectors:** Formulae that filter by network parameters such as node degrees of freedom or network centrality (using an algorithm like Pagerank or Celo's Eigentrust[28]). Network selectors partition the DETS' transaction network and assign the outputted subgraph to some $\Re_x$. Transaction network subgraphs can identify, isolate, and assign to various $\Re_x$ key flow motifs of goods and services throughout the DETS.[8] Monetary, fiscal, and geospatial policies can be applied to these subgraphs to improve the circularity and ecological sustainability of the DETS.

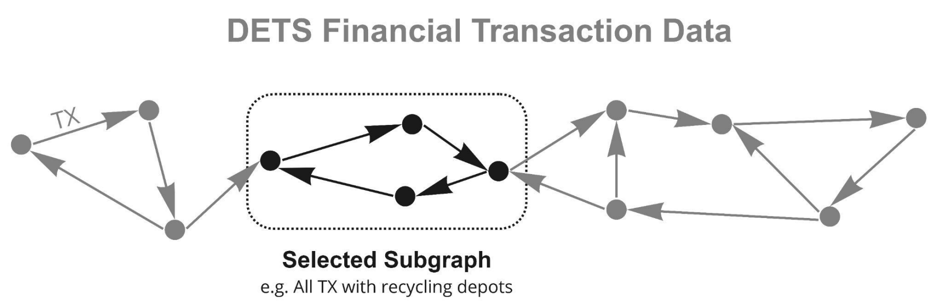

Figure 6: Selected subgraph from the DETS' transaction graph to which policies will be applied that attempt to regulate financial flows or the social metabolism.

We offer two network selector examples:

- **K-Cycle node centrality:** Researchers studying the Sardex LETS have introduced K-cycle centrality, a measurement of the portion of the network's trading cycles of length $k \geq 2$ in which some node participates. "The larger the value… the more important that node… removing a node with a 5-cycle centrality value of 0.5 will break down 50% of the cycles of length 5 in the whole network".[34] In reality,

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[6] GDPR compliance will not be discussed in this white paper. Please see "Blockchain and the General Data Protection Regulation" by the European Parliamentary Research Service for an extended discussion on GDPR and blockchain. https://www.europarl.europa.eu/RegData/etudes/STUD/2019/634445/EPRS_STU(2019)634445_EN.pdf.

[7] See FOAM (2018) for a deeper understanding of how proofs-of-presence function: https://blog.foam.space/video-foam-how-proof-of-location-works-46abe5de2f0a

[8] See https://valueflo.ws/ for a complete vocabulary and expansion of this topic.

these K-cycle nodes are popular businesses and community leverage points that provide necessary goods or services. Applying monetary or fiscal policies that sustain their good health is critical. A related network metric is K-cycle coverage, which “quantifies, for each node, the overlap of its cycles, and hence, how many different nodes appear in its cycles.”[34]

- **Community structures:** Transaction network nodes that “can be easily grouped into (potentially overlapping) sets of nodes such that each set of nodes is densely connected internally.”[35] Community search formulae can extract these structures for policy-making purposes.

Registration Mechanics

Each DETS, as a community currency system, will necessarily privilege a specified group as its operator and priority: the community it serves. This community is defined in the DETS using the registry system; we use the example of $\mathfrak{R}_1$ to reference this membership. Below, we list a few specific mechanisms that may be helpful to establish $\mathfrak{R}_1$ or other registries:

$\mathfrak{R}_1$ Verification Mechanisms		
Mechanism	**Definition**	**Discussion**
Proof of Humanity	Webs of trust, reverse Turing tests, and dispute resolution	Used for the recent Proof of Humanity UBI project;[36] mostly based on token-curated registries.[37]
Centralized Verification	Know-Your-Customer (KYC)	In this case, a centralized group — perhaps the DETS elected executives (see §2.3.4) — maintain the list directly.
Private proof of Membership	Zero-knowledge proofs	Using zero-knowledge proofs members can prove their membership in a registry without revealing any personal information. Though not yet widely available, these techniques are progressing quickly. See Decentralized Identity Foundation (2020)[38] and Sonnino (2020).[39]

Figure 7: List of DETS registry mechanisms for local communities.

2.3.3 Monetary System

At the core of the DETS sits a monetary engine that seeks to empower its user community. As such, it resembles a central bank and can apply monetary policies. The monetary system is designed with the following principles in mind:

➢ **Capital-circulating**: It aims to boost the circulation of a stable currency within the community even when the global economy experiences a downturn or shock. Generally, the reserve should extend users funding, in contrast to external investors extending credit (which leads to excess extraction)[9] or injecting foreign cash (a less consistent liquidity source). The reserve may be backed by less than 100% collateral to support internal liquidity needs. For their 20,000 user community, Grassroots Economics currently maintains a 25% target collateral ratio and speculates that 5% is possible.[40]

➢ **Extraction-resistant**: It must impose capital controls that limit capital flight and the risk of dollarization. The system mediates liquidity flows to and from itself, with outside users getting less beneficial relationships with the reserve (e.g. tighter spending constraints). This being said, outsiders should still be able to invest profitably in the DETS community.

➢ **Capital Generating:** As an investment bank of sorts, the DETS should support endogenous capital formation. It can do so through targeted investments and support for various collateralized reserve assets ($\mathbb{C}_x$) that back the CC. These reserve assets must include different risk parameters that affect their collateralization mechanics. The DETS should be able to use a community-controlled method to raise capital when the reserve's balance is low.

➢ **Reliable and low risk**

Monetary Architecture

For the reserve, we propose a modified version of Celo's Constant-Product Decentralized One-to-One Mechanism (CP-DOTO), or Mento,[41] building off the latest release introduced in CIP-33, which allows the specification of an initial token allocation provided the necessary collateral is available.[42] CP-DOTO is described and simulated at length in Celo's stability analysis paper, and will only be summarized here.[43]

[9] Beyond extraction, debt-money harmfully contributes to neoliberalism's monetary growth imperative, undermining financial, democratic, and environmental sustainability. For an extended discussion, see Arnspeger et. al. (2021) https://insight.cumbria.ac.uk/id/eprint/5993/ .

Mento provides a constant opportunity to exchange the target value of a reserve currency for one stablecoin, limited by the amount of the reserve asset held by the protocol. To compensate for oracle imprecision, the protocol maintains a Uniswap-style AMM to exchange the reserve asset and the stablecoin. If the oracle is inaccurate, this AMM ensures that the resulting arbitrage opportunity will not drain the reserve. The protocol updates the ratio between the AMM crypto-assets to always reflect the latest reported oracle price.

Mento Example

Say Mento's stablecoin is pegged to $1 and the reserve currency is CELO. The protocol allows anyone to exchange $1 of CELO for 1 stablecoin, or 1 stablecoin for $1 of CELO, at all times (unless there is no more CELO in the reserve). An oracle is consulted to determine how much CELO is worth $1 at any given time.

Since oracles are not perfectly accurate, the protocol also creates a [stablecoin / CELO] Uniswap pool, starting at the current oracle price. Let's say the oracle inaccurately reports the price of CELO as too high: arbitrageurs will be able to exchange CELO for more stablecoins than it is worth, and then sell those stablecoins at $1 each, making a profit. As they do, the Uniswap pool's price will become more accurate, helping eliminate the arbitrage opportunity before Mento's reserve is drained.

Multi-Collateral Mento

In our modified Mento, we propose a separate Mento instance and oracle for each reserve asset; yet all instances produce the same stablecoin. We call it *multi-collateral Mento* (MCM).

MCM introduces a leverage parameter to allow for a partially-backed reserve. While at first glance this introduces substantial systemic risk, this risk will be offset by various capital control policies the DETS selectively toggles for each reserve asset or registry. We imagine most DETS would only leverage high quality liquid assets (HQLA)[44] — such as stablecoins, ETH, or BTC — and apply stricter controls to low-liquidity assets.

As just mentioned, there is a constant opportunity to exchange the target value of the reserve currency for one elastic supply stablecoin and vice versa. This exchange is capped by the aggregate value of some reserve asset $\mathbb{C}_x$ held in the reserve. For MCM, to add leverage, we include a collateralization coefficient c_x [0, 1] to each $\mathbb{C}_x$. Any coefficient $c_x < 1$ therefore introduces leverage, enabling a partially backed or fractionalized reserve.

We immediately run into the issue that arbitrageurs may drain the reserve. Therefore, to exit, we introduce various capital controls — a type of constraint applied to some $\mathbb{C}_x$ or $\mathfrak{R}_x$. Recall again Mundell's Trilemma — the two out of three currency design trilemma between stable foreign exchange rates, an independent monetary policy, and free capital movement. To stabilize the CC, we must restrict the free flow of capital by limiting free capital movement.

Kolektivo Example: Partially Backed Reserves

Curaçao's native currency, the Guilder, is backed by only 19% USD reserves.[45] Imagine that the Kolektivo Curaçao DETS holds one reserve asset, kCUR, which is 50% collateralized (c = .5). The DETS considers kCUR an HQLA crypto-asset, as it has a given liquidity depth and was classified as such by DETS executives. Now the Kolektivo Curaçao DETS holds a greater %than the Central Bank in HQLA reserves.

Monetary Policy-Making

Leverage adds risks of the reserve being drained and the CC de-pegging from its fiat equivalent. To manage these risks, capital controls and other policies must be skillfully applied by reserve managers — a type of executive body (see §2.3.4). In general, policies should be simulated prior to implementation, conservative to start, and relaxed over time as system confidence and its economic interior grows.

$\mathfrak{R}_x$ **Monetary Policies**		
Mechanism	**Definition**	**Discussion**
Transaction Tax	A tax applied to transactions issued or received for some $\mathfrak{R}_x$.	Transaction taxes can be dynamically weighted according to some period *t*, where a user pays a higher tax the longer they have held some reversible crypto-asset, such as the CC. The transaction tax may be a straightforward way to ensure that economic exits are fully backed by the reserve. Let's say an $\mathfrak{R}_1$ user pays a 1% transaction tax on $5,000 in transaction volume, and the tax is burned. With this, the reserve's leverage ratio decreases, and they may now redeem $50 for the full exchange value of some $\mathbb{C}_x$ (assuming that the global exchange value for $\mathbb{C}_x$ has stayed stable; this may be more of a dynamically adjusting value vis-à-vis the global market). Note that users may opt to redeem CC regardless of whether they get the full exchange value — a partial exit — and exit rights accumulation is not the same as a rate limit (discussed below). The DETS' governance may opt to tax transactions higher for certain registries and re-apply accrued exit rights to a different

		registry. Exit rights may be structured as an automated market where rights are sold to arbitrage the difference between partial and full exits. Alternatively, users who have earned more exit rights than CC in their wallet could be forced to delegate excess, similarly to Alchemix's transmuter primitive.[46]
CC Ceiling	A maximum ceiling of CC that can be minted for some $\mathbb{C}_x$ or $\mathfrak{R}_x$.	The CC ceiling limits the amount of CC that can be minted from some collateral. It can also be applied across an $\mathfrak{R}_x$'s aggregate balances, or for individual addresses. All three ceiling types help target and mitigate various kinds of risk. In general, the volume of available goods and services available in the DETS should be catalogued to set effective ceilings.
Time Delay	Receive redeemed $\mathbb{C}_x$ after period *t*.	As the reserve is expected to lend assets to earn income on yield, introducing *t* is valuable for adjusting active positions in response to strong or unexpected capital flows. Vesting contracts can be configured for cliff, stepwise, and linearly streamed flows.
Rate Limit (Currency Import/Export Quota)	Up to X CC can be redeemed for $\mathbb{C}_x$ for some period *t*, or up to X $\mathbb{C}_x$ can be deposited to mint CC for some period *t*.	The rate limit attenuates the reserve exchange flow. This may be useful for responding to cryptocurrency market cycles. In bull markets, the reserve's crypto-assets will likely increase in fiat exchange value, and a higher redemption rate limit can be applied; in bear markets, a low rate may be favorable to maintain $\mathbb{C}_x$ stocks. The inverse is true for a deposit rate limit. A rate limit of zero is an autarkic gate.
Tobin Tax (Exit Fee)	Receive the full exchange value — the global spot price, or peg target — when redeeming $\mathbb{C}_x$ with CC, minus a % fee.	The Tobin Tax is the most common crypto-institutional monetary policy today, with implementations by the Commons Stack[47] and Celo's Mento.[48] In Celo, if the reserve falls below a certain threshold, a transaction tax is activated to build back up $\mathbb{C}_x$ stocks. This highlights an important design consideration for all policies in that they can be conditionally automated.
Reverse Tobin Tax (Entry Fee)	Receive the full CC exchange value when depositing $\mathbb{C}_x$ minus a % fee.	Entry fees shift the taxation burden to new DETS entrants. If the DETS is popular, and has a robust reserve, this may be a useful policy.
Negative Transaction Tax (Rebate)	A CC cash back subsidy applied to transactions issued or received for some $\mathfrak{R}_x$.	A negative transaction tax is a type of "cash back scheme" that can potentially be used to increase money velocity.[49] Cash back bonuses can be bound to a certain quantity of spending, or combined with fiscal policies — such as a holding tax or demurrage fee — for targeted money velocity management.
Currency Import Subsidy	A subsidy is issued for depositing a certain $\mathbb{C}_x$ to the reserve.	Currency import subsidies are useful for building up $\mathbb{C}_x$ HQLA stocks. In this way, a target portfolio composition can be crowdsourced by reserve managers.
Currency Export Subsidy	A $\mathbb{C}_x$ subsidy is issued for redeeming CC.	Currency export subsidies are similar to currency import subsidies: through positive incentives they nudge economic exits through a certain $\mathbb{C}_x$. Currency export subsidies must be combined with a time delay to prevent arbitrage.

Figure 8: List of DETS monetary policies.

Kolektivo Example: A Local Arbitrageur Seizes Opportunity

Jayden, an $\Re_1$ user of the Kolektivo Curaçao DETS, has $ƒ_c$500. He has exchanged $ƒ_c$20,000 of local volume at a 2% transaction tax rate, and may now exit $ƒ_c$400 from the reserve at full value (let us assume that the global market has stayed stable). One of the reserve assets, kCUR, is leveraged at a c of .8. The current exchange value of kCUR is ƒ1.79 in the global market. Imagine two scenarios:

(a) Jayden sees an opportunity to arbitrage the global kCUR market and increase his $ƒ_c$ ownings. He exits through the reserve — burning his $ƒ_c$400 of full exit rights — and receives ƒ480 worth of kCUR, or 268.15 kCUR (he receives ƒ400 for his full exit, and ƒ80 for his partial exit). Jayden re-deposits ~268.16 kCUR to the reserve, and mints $ƒ_c$600 (re-call c = .8). However, there is a reverse Tobin Tax of 5% applied to minting $ƒ_c$ from kCUR deposits, so Jayden only receives $ƒ_c$570.

(b) There is a time delay applied to kCUR exits, so Jayden instead decides to exit through USDC ($). USDC is leveraged at c = .2. Jayden receives $268.15, using a combination of full and partial exit rights, as in scenario (a). There is currently a permissioned gate for USDC deposits, so Jayden cannot re-deposit his USDC. However, kCUR deposits are not gated. Jayden exchanges his USDC for kCUR on the global market, deposits kCUR to the reserve, and mints $ƒ_c$600, as in scenario (a).

Reserve Yield Farming

With the rise of DeFi, tooling is now widely available to earn passive yield with relatively low-risk on held crypto-assets, a.k.a "yield farming" or "liquidity mining." With today's high global demand for dollar instruments, billions of stablecoins are earning an interest that exceeds the yields available with traditional financial institutions.[50]

Kolektivo's reserve will use available tooling and the current global monetary environment to earn passive yield. It will be up to the reserve managers of some $\Re_x$ to determine the DETS' risk tolerance and yield strategy. Similar to the aforementioned monetary policies, constraints should be applied to these managers, such as a ceiling on the reserve quantity they can farm with, or whitelisting the liquidity mining contracts they may interact with.

We expect yield farming and aggregation tooling to continue to improve. Of note is the recent release of yield-backed synthetic tokens by Alchemix: a type of self-paying loan where collateralized crypto-assets are repaid over time through low-risk yield farming.[10] We can imagine a similar module where some $\Re_x$ borrows CC against deposited stablecoins.

2.3.4 Governance System

Governance is no trivial subject for crypto-institutional systems, as these systems' goals often preclude typical corporate governance patterns. This is true for any DETS, as self-sovereignty requires a democratic approach to governance.

Some decentralized systems designers have elevated governance minimization[51] as the ideal: they see human fallibility as an unnecessary risk. Governance minimization, though, is nonetheless a governance form in which the initial governors — a technocratic class of systems engineers — possess absolute power in early stages, before disappearing forever and taking the keys with them. Maximizing the principle of self-sovereignty prevents recommending this option.

What is Governed?

DETS governance refers specifically to the process for deciding on and executing two types of changes to the DETS software:

1. **Parameter changes:** Changing system parameter values, such as the collateralization coefficient *c* in the monetary system.

2. **Manual system functions:** Activating particular system actions, such as policy-making or emergency interventions.

Challenges and Design Goals

Poor governance may compromise the DETS in innumerable ways. We summarize three key risks here (see §2.4 for more):

- **Capture:** If decision-making authority in the governance system becomes controlled by a group different from the community the DETS is intended to serve, the system has been *captured*. This may occur internally if some community subset captures the system, or externally if foreign entities capture the system.

- **Crisis response failure:** The DETS must strike a delicate economic balance, and it's likely the system will face crises that require manual responses. The governance system must be able to respond appropriately and punctually to crises.

[10] See §1 in the Alchemix Whitepaper (2021) for extended background on yield farming.

- **Gridlock:** Decision paralysis is common and debilitating in democracies. Notably, solving it can cross purposes with avoiding governance capture, as separating powers among competing governance bodies to reduce capture risk also tends to increase gridlock.

The governance system aims to address each issue in turn by being:

- **Representative:** Decisions by the governance system should primarily and accurately represent the needs of the community the DETS is intended to serve (identified by the registry system), rather than any particular subset or external group.

- **Resilient:** In case of crisis, the governance system should respond appropriately and punctually.

- **Practical:** The governance system must be usable and productive. Participatory actions should be no more difficult than the value it creates for participants, and decisions should not get mired by bureaucracy.

No single governance system can meet these needs sufficiently. Appointing all-powerful leaders is both practical and resilient but fails in representativity, as anyone who captures the leaders' ears may capture the DETS. Direct democracy is highly representative but fails in both resilience and practicality, as high community participation requirements mean slow and inflexible decision-making.

The DETS requires a balanced, composite approach to governance that involves empowering (and holding accountable) specific individuals that make high-frequency, day-to-day decisions and respond to emergencies, while putting larger, more fundamental decisions — like selecting those individuals — in the hands of direct community votes and processes. Other powers, such as a judiciary, may be added as well (see below: Optional Components).

Governance Body	Members	Responsibilities	Strengths	Weaknesses
General Assembly	Entire community	Big, infrequent decisions	Representative	Not practical nor resilient
Executives	Selected representatives	Small, frequent decisions and emergency responses	Practical, resilient	Less representative

Figure 9: DETS governance architecture, from a bird's eye view.

Governance Architecture

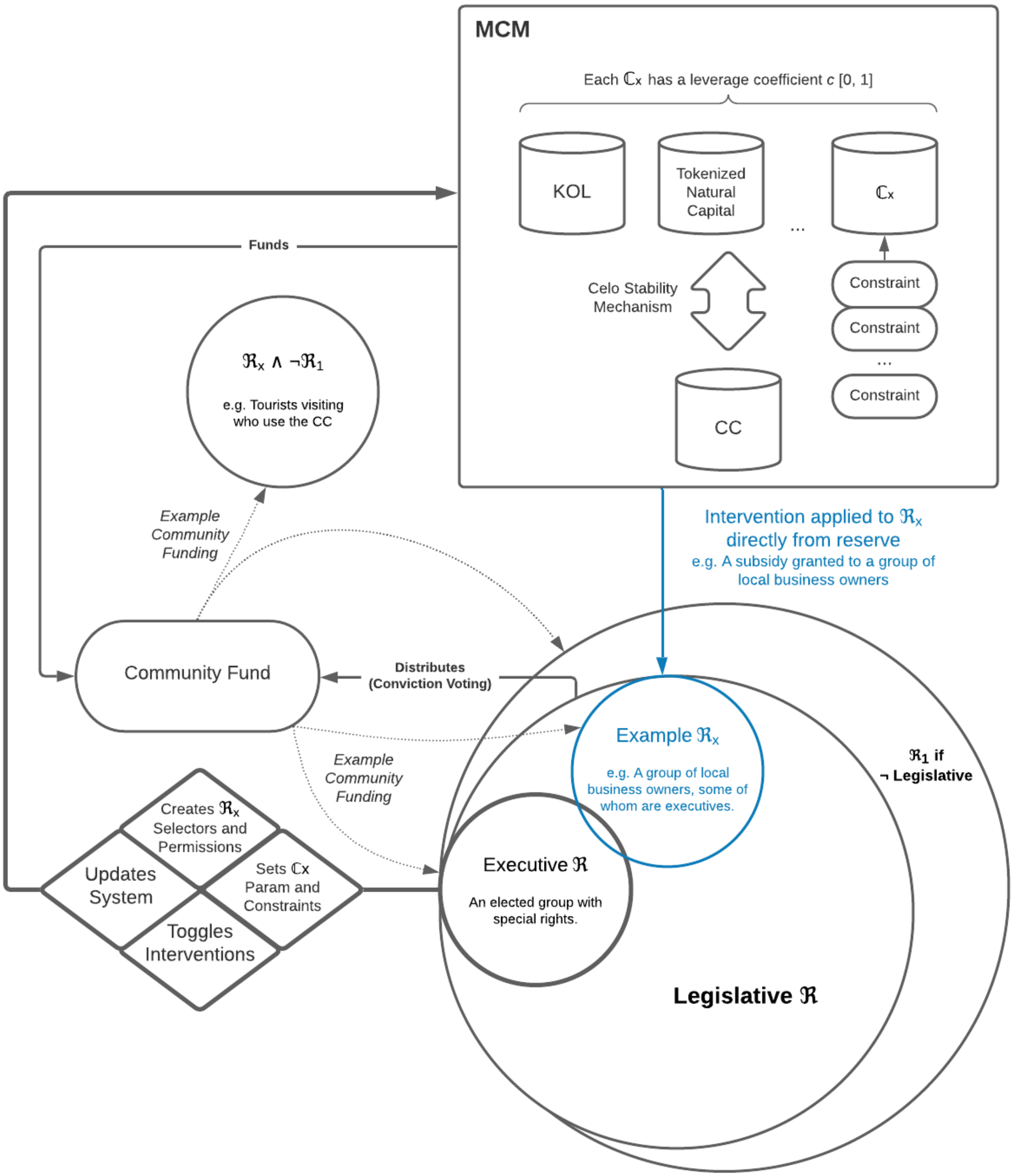

Figure 10: Example DETS governance flow.

Required Components

General Assembly

The general assembly, or the legislative branch, is the registry of users that have a non-null amount of voting power, which is determined differently by each DETS. Conceptually, the general assembly should primarily represent the self-sovereign community operating the DETS. Calculating voting power need not be determined by a single input. As an example — with placeholder values — voting power might be a weighted average of a user's:

1. $\mathfrak{R}_1$ membership (70% weight)
2. Locked kCUR tokens (10% weight)
3. Community-assigned reputation (accrued by doing work through community proposals, 20% weight)

The general assembly, as a highly representative but neither practical nor resilient governance body, is mostly responsible for significant, infrequent decisions. We break this down into three categories with different recommended decision-making mechanisms for each:

Decision Mechanism	Decision Type	Strengths	Weaknesses
Conviction Voting	Budgeting	Resists tyranny of the majority, low attention cost	Not punctual, less representative
Quorum Voting	Fundamental system changes (e.g. replacing governance systems)	Punctual, representative	High attention cost, tyranny of the majority
Liquid Elections	Electing executives	Representative, low attention cost	Limited applications

Figure 11: Governance decision type-mechanism matching for the general assembly.

➢ **Conviction Voting**: A novel, continuous social choice mechanism in which voting power gains strength over time through staking. To briefly summarize: voters express their preference by staking tokens on proposals they would like to pass, and their conviction score for that proposal increases over time until some algorithmic threshold is hit and funds are released. It offers many advantages, the most significant of which are its relatively low voter attention cost and its sybil resistance to the tyranny of the majority.[52] For more information, we recommend Emmett (2020),[53] Fritsch (2020),[54] Block Science (2020),[55] and 1Hive.[56]

- **Quorum Voting**: Simple voting — i.e. a referendum — in which passing a motion requires the relative majority of a minimum quorum of the general assembly (e.g. 25%). In contrast with conviction voting, quorum voting offers clearer time frames for decision-making and higher representativity but higher attention costs and greater risk of tyranny of the majority.

- **Liquid Elections**: Elections based on liquid democracy.[57] Each voter may delegate their votes to anyone qualified for the election (candidates could be sourced from the same registry as the general assembly or a separate, more exclusive registry). Delegates may further delegate votes. The top N delegates at any one time are the system's current executives. It may be prudent to limit when delegation (i.e. elections) can occur to create a stable executive group.

Executive Multi-sig

The executive multi-sig is controlled by executives elected by the general assembly. It is responsible for high frequency, day-to-day decisions, including facilitating (and paying for) work to be done and adjusting monetary, fiscal, and geospatial policies to react to changing global conditions.

The executive multi-sig makes decisions using a form of quorum voting called "*m* of *n*": at least m of the total n executives must sign an action for it to be executed. Generally, the closer m is to n, the slower and safer multi-sig decisions will be.

The multi-sig responds to time sensitive emergencies such as a reserve failure (see §2.4 Risks and Failure Modes), and may have a limited veto power on fundamental system changes proposed by the general assembly. Fundamental changes — such as updating the system's smart contracts — are the most transformative actions the governance system can take, and as such should have the most constraints applied.

Similarly to boundary-drawing in the general assembly, eligible executive candidates can be identified via the registry system. Eligibility may be contingent on $\Re_1$ membership — the main community registry — and possibly also one or more candidate-specific registries with credential or merit-based criteria.

Optional Components

Judiciary

A time delay and a judicial system might be inserted between decision-making and execution for all decisions other than emergency responses (and likely even, in some cases, for certain emergency responses). In this case, there is a set time between the moment a decision has been made, whether by the general assembly or by the executives, and the moment that it is executed. During this delay, community members may dispute the decision. A judiciary would then pass judgment on the decision, either letting it execute or not.

The governance system works in theory without a judicial system, but in practice, poor or malicious decisions could be made by the general assembly or executives, and a dispute system would be beneficial.

Kleros has built a sortition-based judicial system compatible with the DETS.[58] To summarize: Kleros' system is based on selecting jurors for each case randomly from a large group, such that it is unlikely the jurors can coordinate, and then rewarding jurors if they select the winning side of the dispute (creating an epistemological Schelling point[59]). To ease this process, a group should pre-agree on a constitutional document, with decisions disputed by evaluating their constitutionality.

The DETS must decide how jurors are selected. In Kleros and similar systems, anyone may become a juror globally. Putting an anonymous global network in charge of a local DETS' judicial system may conflict with the goal of self-sovereignty. We suspect many DETS will prefer to limit the pool of jurors to community members. However, limiting the pool too much may make the system corruptible through jurors coordinating, breaking the Schelling point effect.

Bootstrapping Governance

With a governance system of at least two interdependent parts, we must also consider the chicken-and-egg issue of how to launch the DETS. The DETS requires executives to operate, but these executives must be elected; however, elections require the DETS to be at least partly operational. There are at least two ways to navigate this issue:

1. **Gradual launch:** A DETS launches piecemeal: first the registries, then the elections, then the rest of governance and the full system.

2. **Handheld launch:** The full system would launch with some handpicked community members filling the needed inaugural executive roles. This tends to be the norm for launching digital organizations.

Fiscal Policy-Making

Similarly to the previous monetary policies, fiscal policies are available for DETS use:

$\mathfrak{R}_x$ Fiscal Policies		
Mechanism	**Definition**	**Discussion**
Token Offering	The sale of the DETS token or another crypto-asset by the DETS to some $\mathfrak{R}_x$ or $\neg\mathfrak{R}_x$.	To bootstrap the reserve, it is assumed that an offering of the DETS' native token takes place. Beyond this bootstrapping phase, impact bonds, NFTs, sharded NFTs, ERC20, and other token types can all be offered. Capital controls can be applied to token offerings as well (e.g. a rate limit or vesting contract). More favorable offering rates and access can be assigned to some $\mathfrak{R}_x$. Note that some of these mechanisms may be simply used to efficiently and periodically exchange $\mathbb{C}_x$. Many EVM-primitives exist today for token offerings: ➢ *Fixed Swap:* Token X is exchanged for token Y at some X/Y rate — the standard model for token offerings. ➢ *Liquidity Bootstrapping Pools (LBP):* LBPs allow a project to generate liquidity through the variable weighting of crypto-assets. Funds are raised by setting up a two-token pool with a project and a collateral token. Weights are initially biased in favor of the project token, then adjust to favor the collateral token by the end of the offering.[60] This sort of price-finding mechanism ensures fair price discovery for any fungible token and beneficially bootstraps liquidity for the secondary market. For more information, see McDonald (2020).[61] ➢ *Auctions:* Gnosis Auction is a primitive for simple batched auctions;[62] previously Gnosis also created a Dutch auction protocol.[63] See Antal et. al. (2020) for more auction implementations.[64]
Consumer Subsidies (Basic Income)	The reserve distributes funding to some $\mathfrak{R}_x$ or establishes a liquidity mining contract that releases funding under certain conditions.	Basic income is a subject of crypto-institutional experimentation, with the Impact Market project on Celo,[65] and the Proof of Humanity project on Ethereum.[66] This is a timely development, as multiple basic income policies are being adopted worldwide in response to the COVID-19 pandemic.[10] Consumer subsidies in general aim for the widespread distribution of funding on discrete (snapshotted merkledrop), periodic (repeats every *t*), or continuous (streamed) timeframes. Elaborate $\mathfrak{R}_x$ selectors can be subsidized, such as a registry of sustainable businesses, or a list of potential jury members who wish to earn rewards as arbitrators.[67] The second type of consumer subsidy — liquidity mining — is useful when combined with other policies, such as insurance. By offering incentives to farm some insurance pool, external capital can be put to use by the DETS to underwrite well-defined risks. There are billions of dollars of crypto-assets liquidity mining today.[68]
Investment	The treasury sends	Investment is common in DAOs, where discrete event proposal systems are

	funds or mints new tokens to some address.	used to release funds. In these systems, a user or group completes a proposal for the DAO, and is paid for their work, either *ex-post, ex-ante*, some split thereof, or through an escrowed release mechanic. Alternatively, funding matching rounds, such as quadratic funding, are used to maximize investment efficiency.[69] We are biased towards a community investment pool with *continuous* release of funds utilizing conviction scoring. Nonetheless, at lower levels of governance recursion — say, a local business that utilizes an M of N trust model for issuing payments — a proposal submission process is practical, using governance primitives like Giveth,[54] Snapsafe,[70] or Daohaus.[71] Investment is ultimately a procurement problem, where unmet socioeconomic needs are met by increased spending. To this end, the DETS requires a community-building arm that maximizes asset specificity by matching funding to community needs and desires. More favorable funding can be made available to consistent or particular $\Re_x$ (e.g. trusted or needed service or goods providers are compensated higher).
Redistribution (Taxation)	Reversible crypto-assets are redistributed from one selection of DETS users to another selection.	Redistribution may be applied based on parameters such as transaction volume, accumulation, or network selectors. Redistribution can be discrete (single event), periodic (repeats every *t*), or continuous (streamed). Redistribution targets and receivers can be limited to some $\Re_x$ or the reserve. Four types of redistribution are possible. For illustrative purposes, we focus on the accumulation parameter (CC balances) as the target of redistribution: ➢ *Regressive:* Users with low CC balances pay users of high CC balances. ➢ *Progressive:* Users of high CC balances pay users of low CC balances or the reserve. ➢ *Proportional:* An equal tax is applied to all balances ➢ *Flat:* An equal quantity of CC tax is applied to all balances (e.g. a membership fee). Redistribution can be structurally embedded in transactions, passed upstream to previous transactors of a unique CC-unit. This system is known as hypercatallaxy.[72]
Holding Tax	Tax on user balances greater than some threshold.	Holding taxes aim to mitigate harmful capital accumulation. As Celo has researched, “variable fees on transactions… [can be levied] that depend both on how long the tokens have been stagnating and the volume being traded,” or the “overall account balance.”[40] These types of dynamic taxation schema should be architecturally approached as conditional interactions between unique policies.
Demurrage	A currency decay (burn) applied upon a discrete event or for some period *t*.	Unlike taxes dealing with volume, demurrage is a temporal policy, applied upon some event (such as a transaction), periodically, or continuously. As a definition within this paper, we differentiate demurrage from redistribution by stating that demurrage burns CC, rather than redistributing it. Demurrage is hypothesized by the cLabs team to be an effective lever to

		control money velocity, with alternative linear or log decay rates.[49]
Insurance (Mutual Aid)	Some crypto-asset or the balances of some $\Re_x$ are deposited in a DETS governed insurance smart contract and are redistributed upon certain well-defined events occurring.	Mutual aid is typically bounded through subjective agreements. That is, insurance contracts release and distribute funding based on well-defined conditions. Release mechanisms, and the quantity released, may be determined by an oracle, arbitrator, governance body, watcher, assessor, or other decision-makers. Combining insurance with ecological state measurements introduces novel mechanics where a lapse in the ecological state can result in a payout designated for restoration (§2.3.5). The balances of some $\Re_x$ can be designated as insurance collateral and redistributed according to an insurance's conditions. Imagine a permissioned liquidity pool, where liquidity providers (LP) are assigned to $\Re_{LP}$ and receive a liquidity mining subsidy. However, they simultaneously cover some form of risk by depositing their LP tokens to the liquidity mining/insurance contract. The DETS should insure its reserve and smart contracts using blockchain industry providers like Nexus Mutual to mitigate the risk of total loss.[73]
Crypto-asset Seizure (Asset Forfeiture)	Some amount of a user's CC holdings are frozen or seized.	There are, ultimately, only two punishment policies trustlessly available to the DETS, and both require reversibility (see §2.3.1): (1) Removal from some $\Re_x$ (2) Asset freeze or seizure The second policy is extreme and infringes on self-sovereignty. Nonetheless, if a member is attempting to sabotage the DETS, or commits a crime against another DETS member, crypto-asset freeze or seizure can be applied through some governance process. Ideally, as the blockchain industry's privacy tooling becomes more sophisticated, certain key governance decisions will be made private, so as not to bias governance processes that may alienate and risk retaliation from disgruntled users.
Obligation-clearing (Invoice clearing)	CC debt network cycles between some $\Re_x$'s members are netted and cleared.	While the DETS is not positioned in this paper as a mutual credit system, its members may extend credit to each other. Within Celo's ecosystem, the Resource Network is working on such a mutual credit protocol.[74] This protocol could be applied to some $\Re_x$ of interlinked users of high social trust. In this scenario, obligation-clearing becomes possible, with cyclical debt structures resolved within that $\Re_x$.[11] Note that obligation-clearing may still occur within the DETS as long as p2p credit relationships are accurately reported, with discrete, periodic, or continuous clearing for any period *t*.
Redenomination	A scalar transformation is applied to kCUR or the CC.	In the event the CC de-pegs, an elastic algorithm can be applied which splits or combines the supply when the token's price reaches a level ± the target price. This rebasing should be considered a nuclear option of last resort.

Figure 12: DETS fiscal policies.

[11] Liquidity clearing is a powerful tool to boost community liquidity in times of crisis. See Fleischman, T., Dini, P., & Littera, G. (2020). Liquidity-Saving through Obligation-Clearing and Mutual Credit: An Effective Monetary Innovation for SMEs in Times of Crisis. *Journal of Risk and Financial Management, 13*(12), 295. https://doi.org/10.3390/jrfm13120295

2.3.5 Natural Capital System

Following our proposal that the DETS must augment environmental resilience (see §1) to effectively combat interdependent financial and biospheric risk, a natural capital system is required that represents ecological systems as economic actors of their own. To this end, traditional environmental conservation schemes and their respective financing must be revisited and updated to reflect the latest crypto-institutional capabilities.

Historically, many environmental management efforts are funded through payments for ecosystem services (PES), defined as the "transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources."[75] Effective PES is difficult: calculating the economic value that ecological actors generate and consistently financing their regenerative efforts are both tall roadblocks.[76]

Blockchain PES tooling is not yet available that can apply economic policies in support of well-defined ecological objectives. In parallel, blockchain-enabled environmental monitoring technologies are still early-stage. For Kolektivo, we propose the integration of a p2p spatial data layer for Web3-empowered PES. Blockchain technology's open data ecologies empower PES by providing an interoperable layer to which extent geographies can be demarcated and ecological state data can be aggregated. Monetary and fiscal policies can be created that fund and support actors who own, operate in, and verifiably improve these zones. In general, we see the Kolektivo Curaçao DETS as one blockchain actor among many who collectively are beginning a movement towards effective ecological stewardship using Web3 technologies.

We propose using the Astral Protocol, a new geospatial smart contact standard that lets self-sovereign users register geographic zones on Ethereum as NFTs — which we refer to as GeoNFTs. Astral Protocol extends the NFT contract with geospatial operators and can verify, for instance, if a supplied point exists within a specific zone's boundaries.[77] GeoNFTs may be ERC721 or hierarchical ERC998 tokens, representing some extent area(s), their constituent data-producing inputs, or a combination of areas and inputs.[78] A GeoNFT is a mutable data object whose state adjusts over time to reflect changes in ownership, ecological state, or contributing data producers.[12] Astral Protocol introduces several helpful tools for formulating and manipulating GeoNFTs:

- **Geographic decentralized identifiers (GeoDIDs):** In short, GeoDIDs are irrevocable, cryptographically-verifiable identities for spatial data assets. From Astral's documentation:

[12] See https://blog.ceramic.network/what-is-ceramic/ for a discussion and overview of mutable data objects. Ceramic can notably be used as well for trust-minimized off-chain voting, which is relevant to minimizing the cost of DETS governance for the last mile of users. See also: https://blog.ceramic.network/trust-minimized-off-chain-conviction-voting/

> "A DID identifies any subject (e.g., a person, organization, thing, data model, abstract entity, etc.) that the controller of the DID decides that it identifies. DIDs are URIs that associate a DID subject with a DID document allowing trustable interactions associated with that subject...
>
> ... Spatial data assets are identified in the service endpoints of the GeoDID document... [they are] classed as either Collections or Items. Each "Collection" contains a number of child Collections or Items; and each "Item" will contain several service endpoints that dereference to geospatial data assets. This hierarchy of encapsulating linked data within the GeoDIDs will allow for user's to find or create the data/datasets that they need easily ...
>
> ... For example, consider GeoDID representing a collection of satellite imagery. We should be able to specify a sub-collection, or even item, that defines a spatial and temporal query in the GeoDID itself. That way, a user could store a single GeoDID that specifies a single image, *clipped to a particular area* [emph], extracted from the GeoDID Collection ...
>
> This would be crucial for the auditability of spatial finance applications. A satellite image might prove that a particular green infrastructure project was completed by a certain date, or that *some insured natural capital warranted a payout* [emph]."[79]

➢ **InterPlanetary Linked Spatial Datasets:** Borrowing from the Cloud-Optimized GeoTIFF[80] and SpatioTemporal Asset Catalog standards (which can represent time series spatial information),[81] Astral enables Web3-native geospatial capabilities through IPLD-encoded raster and vector spatial datasets, such as satellite imagery and LIDAR scans. GeoTIFFs allow georeferencing information to be embedded in a TIFF file, such as map projection, coordinate systems, ellipsoids, datums, and anything else required to establish spatial reference.

➢ **Verifiable spatial data registries:** These registries allow users to designate 2D polygonal or 3D polyhedral zones that represent areas or volumes of space on, beneath — such as marine areas — or above the Earth's surface (for the latter: imagine GeoNFTs representing airspace or orbital flight paths). By establishing clear spatial boundaries to GeoNFTs, we can measure and apply our previously discussed monetary and fiscal policies to extent geographies to optimize ecological state, i.e. regenerative land management.

➢ **Location proofs:** Location-based proofs-of-presence are a form of trustless verification that some person, device, or microchipped fauna was at a particular place at some time. Astral Protocol is developing a standard format to help integrate location proofs into Web3 by wrapping trustless proofs and relevant proof information into a GeoDID. These proofs will likely require social verification by some $\Re_x$, i.e. an attestation that someone was somewhere, or that a photo was taken at some location. We hypothesize that verifiable in-situ evidence of ecological state will be a cheap and crowdsourced way for the DETS to measure ecological state.

Natural Capital Currencies

With Astral's geospatial tooling, the DETS can identify and assign management of various GeoNFTs to some geographically-bound $\Re_x$. Ideally, this helps redirect funding and social attention to more effective management of stocks of ecosystem assets (EA) and their corresponding ecosystem services (ES).[13]

Multiple EA and ES overlay any geography, and each can have a corresponding crypto-asset representing them. Since many last mile users do not have well-enforced or well-maintained ownership records, tokenized EA are likely to not be the only NCC with value. We can imagine alternative NCCs such as some tokenized verifiable change of ecological state — a form of tokenized ES.[82] Together, these tokens can be hierarchically structured as composable data tokens — imagine a top-level GeoNFT for the entire island of Curaçao that encapsulates all ecosystem assets and verified ecological state. Collectively, these three token types make up our *natural capital currencies* (NCC):

Crypto-asset	Overlay	Example	Primitives	Social Trust
Natural Capital (EA and commodity asset stocks)	Ownership	A landowner collective tokenizes the ownership of their land as a sharded NFT, creating a community land trust.[14] A legal contract is drawn up that assigns ownership of the land to the token holders. As tokenized ownership deeds interface with the law, a high level of social trust is needed for these tokens to be redeemable, such as a functioning legal system, or strong community norms. Ownership GeoNFTs may likely be more popular in the Global North, where there are strong property rights and a growing SE community using land trusts for solidarity activities, such as neighborhood and urban revitalization.	Centrifuge,[83] Spectre[84]	High
Ecological State Tokens (ES from natural capital)	Truthfully reported ecological state (*s*)	A reported ecological state for some GeoNFT. State is reported by in-situ, remote, or expert monitoring.[15] Expert monitoring could include a variety of formats, such as mobile phone video recordings, or human-administered sensor readings. The reported state is in many instances monetizable as datatokens — fungible and non-fungible tokens that grant access to	Ocean,[88] Streamr,[89] Regen Network, Astral Protocol, Spectre	Medium

[13] For a categorical breakdown of ES, see https://en.wikipedia.org/wiki/Ecosystem_service#Categorization

[14] For the purposes of sharding NFTs, we propose using the upcoming Spectre ERC-1155 protocol standard, as it introduces a number of useful parameters and permissions for effective shard issuance, management, liquidity provision, and recomposition — that is, taking the fungible shards and recomposing them *back* into an NFT.

[15] For an early conceptual overview of these monitoring processes, see Liang et. al. (2002) https://www.isprs.org/proceedings/XXXV/congress/yf/papers/935.pdf

		some data service.[85] In the Regen Network, these measurements and their corresponding algorithms, conditions, and parameters are collectively referred to as *ecological state protocols*. The basic function of such protocols is to evaluate “state and change of state for a *specified area* [emph].”[86] The economic value of a certain ecological state can be estimated through multiple methodologies examining the area and land use of a GeoNFT, the service area that benefits from it, or some valuation formula, such as a risk algorithm estimating future benefits, or a biodiversity index. See Voshgnir (2021) for an example of carbon cost accounting applied to elephant conservation.[87] These calculations are useful for the insurance use case discussed later on in this paper. Some types of ecological state may be cultural or anthropocentric, such as the % of employed persons in some GeoNFT. Imagine parametric insurance applied to an ideal employment level, with funding released if full employment is not reached.		
Composable Data Tokens (CDT)	A composition of the previous tokens	The ERC998 token is a hierarchically composed token basket of the former categories. CDTs could represent multiple natural capital or ecological state tokens, and may be useful for creating a nested ecological digital twin for some GeoNFT. Ecological value chains are holonic and exist at multiple scales and temporalities, and any corresponding digital twin needs to mirror this complexity.[16] ERC998 is particularly useful as many in-situ and remote monitoring devices will provide data streams and reports for some GeoNFT.[88]		Medium
Augmented Digital Space	Ownership of Spatial Augmented Reality	Land is subdivided and owned in augmented reality.	Geo Web[90]	Low

Figure 13: Types of geospatial overlays composing some GeoNFT.

[16] The combination of the registry and natural capital systems together satisfy the conditions for a minimal viable eco-holonic architecture, where multi-scale metabolic mediation is attempted between the DETS and its local environment. See Ávila-Gutiérrez et. al. (2020) https://www.mdpi.com/2071-1050/12/5/1889/pdf.

When dealing with socioecological systems, we should bear in mind that any whole system may be merely a part of another system at a higher scale. Questions of hierarchical sovereignty are an issue with ownership tokens, as certain GeoNFTs may require boundary arbitration (perhaps by the DETS' governance process). Using Astral's spatial.sol library, we can detect border collisions trustlessly for those spatial registries that do not permit topological intersections and instigate governance processes that mediate border conflicts.

Both sticks and carrots are available to incentivize local ecological state data production for GeoNFTs. Carrots exist in the form of PES subsidies or revenues from sales of ecological state datatokens by reporters. Trusted GeoNFT zone members may pool their data as a collective to protect the value and uphold standards of their truthful reporting. One potent stick to consider is that the DETS may opt to remove members if produced data is *not* delegated to some $\Re_x$ data collective. Both these sticks and carrots may be distributed absent legal intervention.

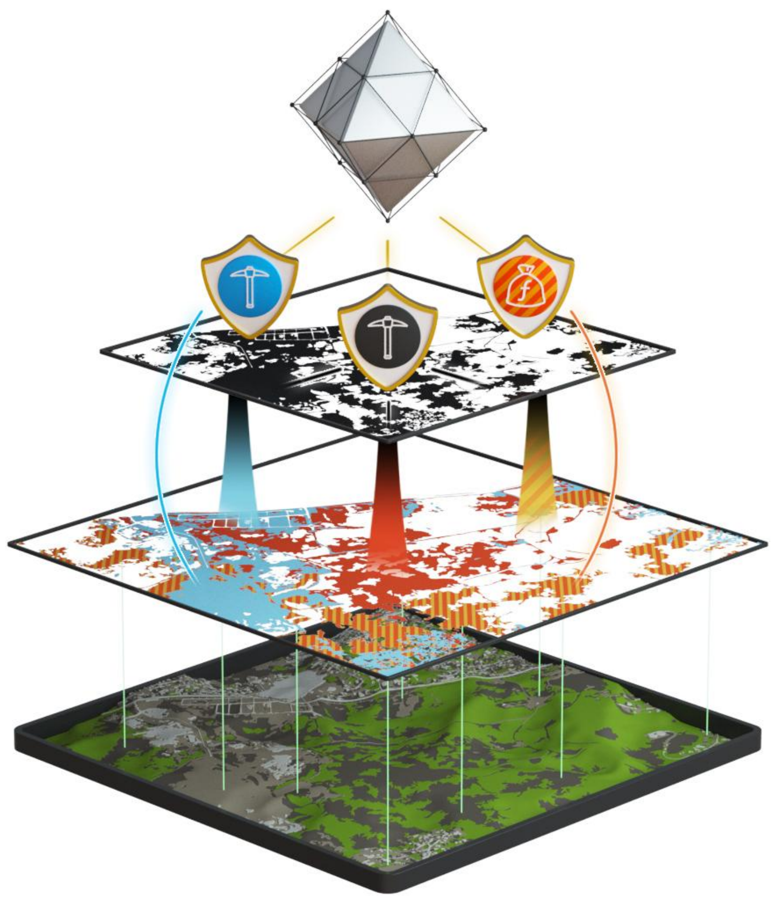

Figure 14: (Bottom layer) The geographic GeoTIFF and multiple reporting data sources. (Second from bottom) Two GeoNFTs: in blue we have a rocky zone GeoNFT, and in red, a forest GeoNFT. The striped red/yellow areas represent areas of policy expansion, where the DETS aims to expand the forest. (Second from top) The black areas represent an indexed GeoNFT that consists of the rocky zone, the forest, and the forest's expansionary zone. (Top icons) The DETS, represented as an octahedron, issues three policies: the first an insurance policy to underwrite the ecological state of the rocky zone GeoNFT; the second, an insurance policy for the black composite GeoNFT; the third, investment spending to help the expansion of the forest GeoNFT.

One bold idea is to aggregate, tokenize and use as collateral all ecosystem services, natural and commodity assets for some GeoNFT. As nonrenewables deplete over time, the collateralization ratio would decrease, providing a clear accounting signal that policies must be applied by the DETS to maintain key EA and commodity stocks. In general, when dealing with EA and ES, a full accounting must include all degradation, whether destroyed by extraction, shipping, or use.[91] To cut down a forest area that is a collateralized EA would be equivalent to cutting the DETS' available money supply — a prescient issue that reserve executives would notice. Ultimately, the aim of an exact accounting of the economic value of the ecological state is to reveal and mediate the metabolic rift that exists between the two systems.

One final edge case is the potential for particularly activistic DETS to *only* collateralize NCCs instead of a native DETS token like kCUR or CELO. They may, in the most radical cases, skip collateralization entirely, and only use NCCs as a medium of exchange.

Parametric Insurance

To make clear the variable utility of our second NCC-type — ecological state tokens — we introduce its foremost use case: parametric insurance. Consider the following timeline:

$$s_1t_1 \longrightarrow s_2t_2 \longrightarrow s_2t_3$$

Let's say some sharded NCC, GeoNFT$_x$, has some reported ecological state (s_1) measured through a combination of inputs at time t_1. These inputs are aggregated from cyberphysical remote and in-situ monitoring as well as trusted user reports, such as a designated specialist of some $\mathfrak{R}_x$ that submits a *reality proof*, or verifiable *s* claim related to GeoNFT$_x$. A user-submitted reality proof could combine other remote and in-situ inputs, such as the DID of a satellite image (an IPLD-encoded GeoTIFF), the DID of the vector geometry used to clip the image, and the content identifier of the algorithm used to analyze it.

Just as most PES systems work today, a cost-benefit analysis is conducted,[17] and the optimal ecological state given available spending is determined to be s_2 (as ratified through the DETS' governance system). A new $\mathfrak{R}_x$ is created with actors who would like to transition s_1 to s_2. These actors receive investment from the DETS to execute the desired ecological state change.

After some time and work, s_2 is confirmed by a combination of verified inputs at t_2. A new problem now exists in that s_2 must be *maintained* to not degrade back to s_1 at some future t_3. In

[17] Other PES spatial targeting models include multi-objective optimization, data envelope analysis, and methods for specific issues. This being said, cost-benefit analysis is the most widely used. This may shift if cost becomes less of a concern. See Guo et. al. (2020) https://www.sciencedirect.com/science/article/pii/S2666683920300183.

addition to investment, the DETS can apply a new policy — parametric insurance — to prevent degradation. Parametric insurance is triggered when specific verifiable ecological state conditions are met, such as the recording of wind speeds greater than x for some GeoNFT.[92] Unlike PES today, parametric smart contract insurance would automate spending to support the ecological state of a well-defined geography (we emphasize the importance of well-bounded borders: they are necessary for a tidy claims process). Parametric insurance is discussed at length by the Astral Protocol team:

> "With this, we trustlessly insure physical assets in space... land parcels or administrative jurisdictions (maritime, terrestrial, airspace etc)... [A]gents would register their land parcel in an Astral verifiable spatial data registry, possibly represented using a GeoDID identifying a polygon or polyhedron. Additional information like the policy duration, indemnity process and, crucially, insured parameter and data source, would be specified upon policy creation ...
>
> ... Periodic checks to the parameterized data feed could be made, and a payout could be triggered automatically if the parameter threshold is exceeded. Alternatively, the insurance contract could be reactive, requiring a policy holder to submit a claim transaction. In this event, the contract would trigger the oracle to fetch both the land parcel information and the relevant parameterized external information... some entity — a trusted individual or DAO committee... [may] assess the evidence off chain and submit an attestation to settle a claim or trigger automatic indemnity..."[79]

By combining parametric insurance with a consumer subsidy, we can incentivize a network of *shield miners* to underwrite the risk of degradation back to s_1. This incentivization would take place through the implementation of an LP token liquidity mining program for some GeoNFT_x exchange pairs. That is, in return for depositing [GeoNFT_x / other crypto-asset] LP tokens to the insurance contract, shield miners earn rewards. However, through a configurable claims process, these LP tokens could be seized and used to finance restoration in case of s_1 degradation.

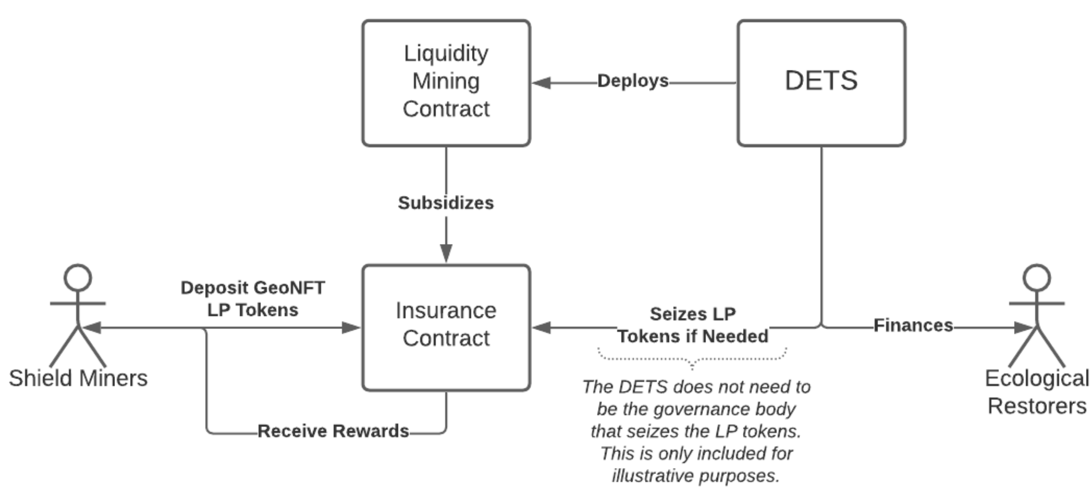

Figure 15: A generalized parametric insurance flow with liquidity mining.

Hypothetically, as long as the liquidity mining subsidy is greater than the risk-adjusted cost of shield mining, LP providers can expect to earn a profit. If nobody underwrites the parametric insurance, it's likely due to uncertainty, implying that a convincing risk model has not been formulated, or the insurance itself is not well-bounded with specific conditions. To attract liquidity, the DETS is therefore incentivized to collect or purchase relevant data and hire specialists to build and publish feasible cost models.

The DETS, by nesting (as CDTs) and insuring multiple overlays for various ecological Δs, can now finance policy objectives that aim for an idealized s which issues parametric insurance payouts (a form of PES) when objectives are not met. Over time, ideally, the DETS will begin to understand how financing relates to some Δs or all Δs, and how ecological state changes relate to each other. When we are dealing with ecological systems, we are dealing with complex adaptive systems, and fiscal therapies applied to one GeoNFT may inadvertently improve another. This requires accurate ES valuation models and precise loss measurement — that is, indemnity payments seized from shield miners.

Kolektivo Example: Insuring s_2

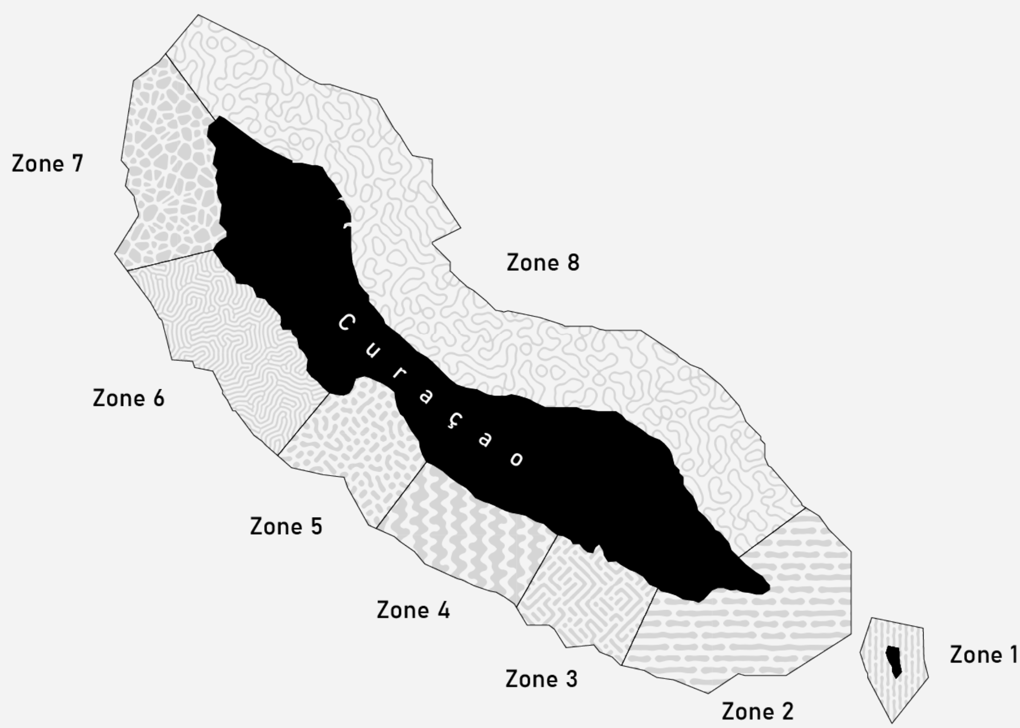

Figure 16: "The eight zones of Curacao. Each zone, in the aggregate, can be distinguished from other zones based on the combination of human impact, fish and benthic communities. Site characteristics may vary considerably within a zone, but sites in each zone are more similar to each other than other zones," adapted from the WAITT Institute (2017).[93]

Imagine Curacao's coral reef coastlines are split into eight zones based on a combination of human impact and fauna distribution. Each zone is a sharded $\text{GeoNFT}_{[z1\text{-}8]}$, with corresponding data stream inputs for each zone delegated to the sharded GeoNFT. A three-person M of N committee of experts is assigned to administer each zone ($\Re_{[z1\text{-}8]}$). Each $\Re_{[z1\text{-}8]}$ committee is assigned responsibility for measuring the current ecological state and modeling the ideal ecological state. Their calculations of the ideal state include a probabilistic risk assessment and a cost-benefit analysis of various present and future scenarios each zone would have in combating climate change by protecting coastal and island assets.[18] Ultimately, the DETS selects one of the ideal ecological state scenarios — perhaps the most conservative — and embeds these properties in the insurance policy for each $\text{GeoNFT}_{[z1\text{-}8]}$.

50% of each zone's shards are seeded as initial liquidity to a freshly established [kCUR / $\text{NFT}_{[z1\text{-}8]}$] AMM liquidity pool. The other 50% are assigned to each $\Re_{[1\text{-}8]}$ committee to help finance their endeavors and ensure they have sufficient access to the corresponding data sets they need for modeling (re-call that datatokens are a form of *access token*).[85] A liquidity mining contract is deployed by the DETS, but liquidity locked in the farm is subject to the insurance schemes drafted by $\Re_{[z1\text{-}8]}$. Each policy states that any detrimental change of ecological state related to the initial risk assessment and cost-benefit analysis may result in some LP tokens seized to pay for regeneration.

Through remote sensing, it's observed that zones 2 and 4 have been damaged due to storms. The insurance policy is activated, and $\Re_{[z2,\,4]}$ put out RFPs for initiatives to reverse the decline. After a round of proposal submissions, some [kCUR / $\text{NFT}_{[z1\text{-}8]}$] LP tokens are seized by the DETS to fund the topmost submissions. In addition, the DETS agrees to mint f_c to co-fund the regenerative initiative. From the seized LP tokens and the f_c co-budget, a round of funding is distributed by $\Re_{[z2,\,4]}$ to those proposals best suited to repair coral reef zones 2 and 4. To subsidize and promote local stewardship, coastal residents of zones 2 and 4 who provide a proof-of-presence with their proposal receive some tax rebate.

[18] Nature-based adaptation methods, or green infrastructure, is "emerging as a cost-effective option to reduce the impacts of storm surge and waves." See Reguero et al. (2018) https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0192132 for a comprehensive risk and cost-benefit calculation methodology example for the Southern US cost.

GeoNFT Transformations

Monetary and fiscal policies may be applied manually or automatically in support of some intended transformation of the environment. Any policies applied to GeoNFTs have practical implications for identifying, measuring, and manipulating some extent geography.

$\Re_x$ Geospatial Transformations		
Mechanism	**Definition**	**Discussion**
Indexing	Two or more GeoNFTs are added to a single basket or pool as some CDT or indexed artifact.	Sharded GeoNFTs can be combined through liquidity pools or the ERC998 datatoken standard. Multiple data-producing in-situ sensors producing different datatokens across the island could be nested and represented as a single token.
Expansion and Contraction	Some GeoNFT's area is increased or decreased, either through policy or naturally.	Every expansion is a contraction of the extent ¬GeoNFT. A polygon, for instance, demarcating some owned land that expands *is simultaneously contracting the area of land it doesn't own*. Astral Protocol aims to detect and update topological relationships between related GeoNFTs. Some $\Re_x$ could determine and identify areas for expansion and allocate funds to initiatives that verifiably prove they have contributed to GeoNFT expansion. Once the expansion area has reached some ideal *s*, then it is merged into the original GeoNFT. Note that expansion and contraction can happen due to natural causes and that GeoNFT boundaries are generally mutable over some period *t*. Some boundaries will update less frequently than others, such as administrative jurisdictions vs. seasonal vegetation zones.
Combination	Two or more GeoNFTs are combined to form a new GeoNFT.	The DETS may realize that two GeoNFTs would be better represented as a single token for more accurate *s*. Each GeoNFT is dissolved and combined.
Fragmentation	A GeoNFT is split into two or more GeoNFTs.	The inverse of combination. An example would be a land parcel that is split into two areas with separate owners. The original GeoNFT is thus fragmented into two GeoNFTs.
Dissolution	Some GeoNFT is burned.	A GeoNFT that contracts completely should be dissolved, as it represents nothing. Burning a GeoNFT for a contraction that improves *s* — for example, by eliminating an invasive species from some area — can be considered a proof-of-impact, with a corresponding payout.

Reconstitution	A sharded GeoNFT is unsharded.	Each sharded GeoNFT needs preconditions for reconstitution, where it is made whole. Using the upcoming ERC-1155 protocol, these preconditions can be embedded into the shards when issued. One example is that of a *buyout multiplier* as in the Spectre Protocol, where if a user pays some multiplier of the total market capitalization for the shards, they can reconstitute the NFT to themselves.[84] Imagine an idealized s_2 is reached and a sharded NFT is reconstituted and re-released to token holders with a new allocation that better represents the updated ecological state. Reconstitution conditions could be applied to many $s_x t_x$, as key ecological milestones are reached, perhaps as a tool that rewards early speculators who purchase the NCC at a poor *s*.

Figure 17: Geospatial transformations.

2.4 Risks and Failure Modes

2.4.1 Bootstrapping Failure

To bootstrap the system, as Grassroots Economics notes, "some level of guarantee from goods or services in the local community"[40] is required. Simply put: if nobody accepts the CC, then it is not a useful medium of exchange. A sufficient threshold of non-business users is also required — heuristics such as the "3.5% rule" offer insight on what a lower bound may be for virtuous feedback cycles to begin organically expanding some DETS' network effect.[94] This is salient in the case of Curaçao, as it implies a threshold of approximately 6,000 users.[95]

DETS bootstrapping simultaneously requires a functional coalition willing and able to educate, train, and support users, as it must solve many sociotechnical onboarding challenges. It is difficult to get an initial balance into one's cryptocurrency wallet of choice, often requiring a fiat on-ramp native to a given jurisdiction. At the time of writing, Valora — Celo's default mobile wallet — struggles with this issue.[96] To help mitigate onboarding, subsidies can be utilized by the DETS, i.e. signup and referral bonuses. Nonetheless, effective fiat ramps are needed for any jurisdiction that hosts a given DETS to help bootstrap and funnel liquidity to its reserve (see §2.5).

2.4.2 Network Fragility

Patterns of exchange will quickly unravel if key users leave the DETS. Imagine a large grocer no longer accepts CC after having done so for some non-trivial period. This shock could create a cascade effect where many users who rely on this grocer no longer gain utility from the DETS.

Mitigating the potential for crisis requires identifying these types of key nodes and examining their properties and relationships. Different network centrality measures can yield helpful insights for understanding how the network may behave when key nodes are removed, such as degrees of freedom, eigencentrality, or specific algorithms such as PageRank.[97] Simulating counterfactual network shocks and developing resilience standards are two key challenges for token engineers to help transition unexpected shocks to predictable and planned contingencies.

2.4.3 Reserve Failure

Just like Mento today, MCM stability is compromised when there is a decrease in demand "greater than the total value of its reserves."[43] This solvency scenario can be backstopped to an extent through emergency minting and offering of the kCUR token, or the establishment of swap lines with other DETS in case of solvency.

If the kCUR token is sold, there exists the scenario "in which there exists enough value in the reserves to handle a contraction in demand, but not enough market liquidity to sell the amount of crypto assets." This is mitigated through HQLA diversification — as the Celo reserve has explicitly done with ETH, BTC, and DAI[98] — or pre-emptive deepening of liquidity pools through liquidity mining campaigns. In general, a portfolio of low-risk HQLA $\mathbb{C}_x$ should be held alongside less liquid $\mathbb{C}_x$.

2.4.4 Instrumentalization

To serve its constituency, the DETS must avoid instrumentalization by other institutions or powerful local elites. No governance system is perfect, and we acknowledge instrumentalization potential despite system constraints. Instrumentalization is more insidious than an outright governance sybil attack — economic pressure to perform well by GDP measures can ideologically infiltrate any intended communitarian ethos. We note that while this whitepaper focuses on policy-making through incentives, they should not — as the UN warns — "constitute themselves a reason" for the DETS to exist.[24] One means of mitigating this risk is for DETS implementation to be constitutionally embedded with SE norms.

2.5 Fiat Ramps and Bookkeeping

A growing, competitive market of fiat ramp APIs is emerging — i.e. mechanisms for moving in and out of state-issued currencies to crypto-assets. Key APIs include Ramp, Moonpay, Nash, Wyre, and Simplex.[99] Selecting a particular API is outside the scope of this paper, but we highlight the paramount importance for DETS users to be able to seamlessly move in and out of fiat.

Similar issues arise in DETS bookkeeping and its accounting in general. To favorably interact with regulators and tax authorities in various jurisdictions, effective bookkeeping systems and accounting interfaces are needed for the DETS and its users. Unlike fiat ramps, the development of effective accounting interfaces in blockchain is lagging, and for DAOs, entirely non-existent. This is problematic from a regulatory standpoint, especially in consideration of FATCA[100] for US taxpayers.

From a technical standpoint, these interfaces become complex when considering the different transaction types the DETS will execute, such as lending and exchanging reserve assets,[19] burning elastic-supply stablecoins, and investing in local enterprises (e.g. a tokenized food forest). Bookkeeping is further complicated by cryptoeconomic mechanisms that channel financial flows, rather than issue discrete payments.[101] Each of these actions is interpreted differently by authorities depending on the jurisdiction. While navigating this tricky regulatory terrain is outside the scope of this paper,[20] identifying the need to develop specific jurisdictional regulatory solutions is paramount. It is a long-term challenge for project developers who extend the Kolektivo framework.

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[19] Some cryptocurrency accounting softwares, such as Bitwave, are making progress in DeFi accounting best practices. However, they are largely addressing the individual user market, and not the organizational market.

[20] A recent, brief discussion on DAO taxation by TokenTax concluded that "although there seems to be a relatively clear argument that DAOs could be taxed, no country has outlined a plan to do so. This means that right now, there is no clear method for filing taxes on profits DAOs make through fees, investment strategies, or other means." https://tokentax.co/blog/crypto-taxes-for-daos/

3. Solidarity Economy

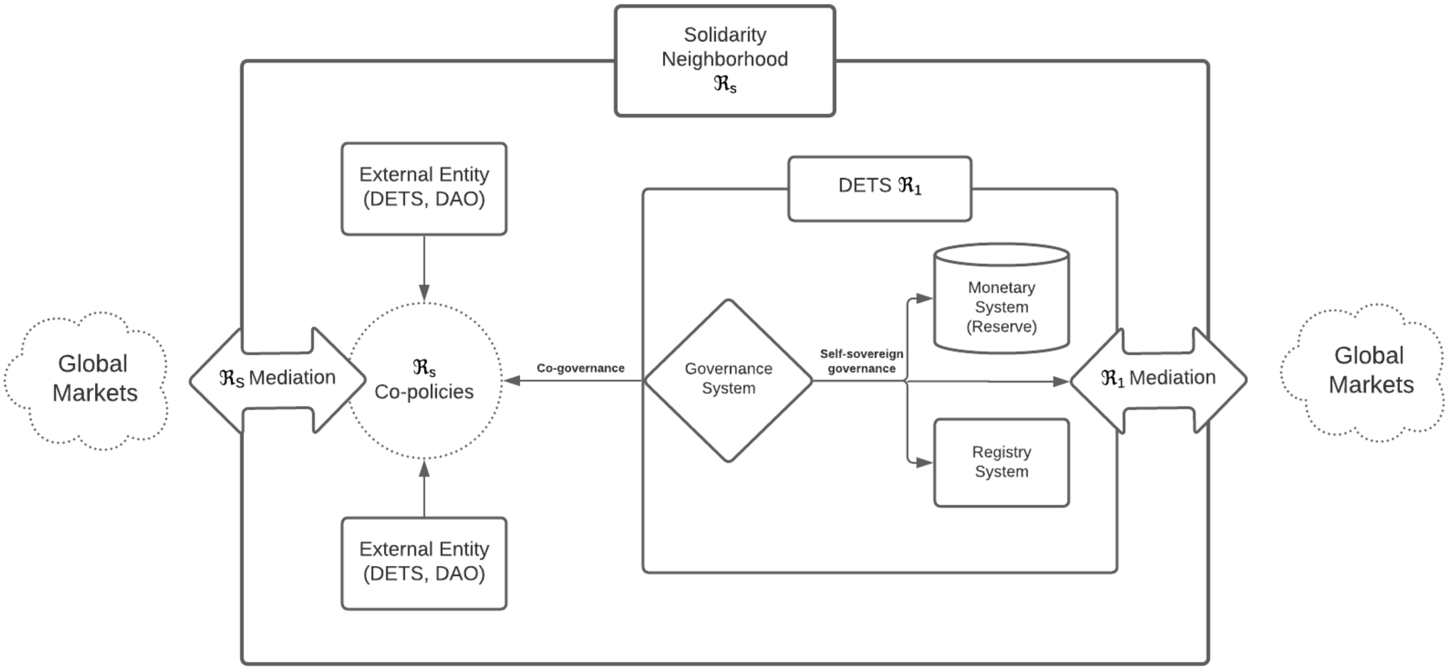

Figure 18: A fractal DETS ecosystem. Each agency is part of $\mathfrak{R}_S$, the DETS' SE neighborhood. Note that there is no inheritance occurring between $\mathfrak{R}_S$ and each agency's $\mathfrak{R}_1$ as each $\mathfrak{R}_1$. Nonetheless, $\mathfrak{R}_S$ is useful for collaborative policy-making for some neighborhood.

A registry can be extended to other agencies through the co-formation of a combined $\mathfrak{R}_S$, creating a *solidarity neighborhood*. Other agencies could be DETS, DAOs, or other blockchain-native forms. To bootstrap the neighborhood, the parties must undergo negotiations that move towards agreement through an iterative concession-making process. We introduce a model of conditions and outcomes that can be used to serve a large variety of complex contracting arrangements. This negotiation protocol is designed to lower coordination costs between and across DETS through mutually beneficial policy-making for some $\mathfrak{R}_S$.[21]

The protocol itself uses the Gnosis Conditional Token Framework (CTF), which offers the possibility for any address to "[t]rade any asset under the condition that a specific event happens".[102] The CTF extends beyond simple escrow logic to allow for more complex conditional negotiation environments. This allows key negotiations to be made on-chain, sidestepping the high social trust environment required for legal contracting or good faith.

[21] The proposed negotiation protocol is discussed in greater depth at https://blog.curvelabs.eu/d2d-towards-decentralized-negotiation-protocols-e37d164e91e6, and is a product of ongoing R&D by Curve Labs

Furthermore, it removes the need to write bespoke escrow smart contracts for complex agreements.

Architecture and Flow

To explain a typical CTF negotiation flow, we use the simple example of a co-funded joint venture (JV). There are two stages: negotiation and agreement. For the former, a JV proposal is drafted by the respective agencies with both a high-level overview of the collaboration and key information such as the quantity of funds that each agency will commit to the JV by some date. The proposal is then uploaded to IPFS and parameterized via a web interface. Through the interface it is constructed according to a shared standard to bring conceptual clarity to the terms agreed upon by the parties. A checksum is created for the information for verification. This off-chain negotiation stage thus repeats and resolves until both agencies have reached a formal consensus to advance the proposal, each according to their respective governance systems.

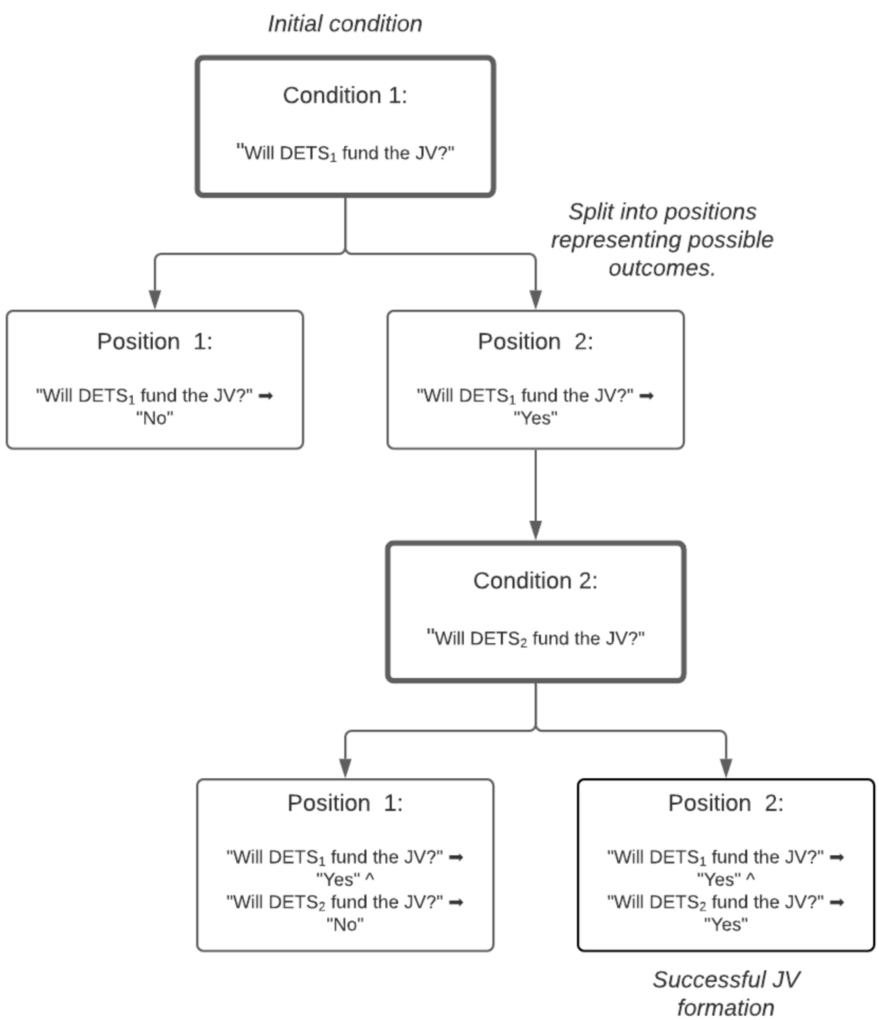

Figure 19: Possible condition trees of a negotiated JV utilizing conditional tokens.

Upon mutual ratification of the proposal, the parties create an initial CTF condition. In this case, it is “Should we form this JV for this amount?” Both parties supply collateral to back their positions via their respective treasuries, receiving conditional tokens in return. The parties then subsequently create deeper conditions by ‘splitting’ one of their positions (e.g. ‘Will $DETS_1$ fund the JV? Yes’) by the other party’s condition, creating combinatorial positions (e.g. ‘Will $DETS_2$ fund the JV? Yes’ and ‘Will $DETS_2$ fund the JV? Yes’).

The key CTF property being utilized in this stage is *the possibility of tokenizing all of the potential outcomes of the particular question*, with the tokens representing the outcome that was reported to have occurred being redeemable for collateral later on. By creating nested binary conditions regarding whether both parties have co-funded the JV wallet, each party may recover their side of the co-funding in case the counterparty does not follow through with its commitment. This is possible by transferring the conditional tokens representing the outcome of both parties funding the joint venture (in this instance, the ‘yes’ positions for each condition) to the JV wallet, and keeping the other tokens (the ‘no’ positions). If both parties do co-fund the wallet, the tokens held by it are redeemed for the underlying collateral used by both parties when creating the initial conditions. If not, these tokens are worthless, and the tokens held by each party representing all other outcomes can be redeemed for the underlying collateral.

Negotiation mechanisms of non-binary resolution are also implementable using the CTF. It is possible to create closed markets where only $\Re_X$ members can exchange assets. A simple example is for the DETS to auction kCUR to another agency within $\Re_S$ at a discounted rate to the $\neg\Re_S$ spot price.

3.1 Collaborative Policy-Making

$\Re_S$ is a collaborative policy space that DETS’ and other blockchain-native agencies can polycentrically govern. While any policy available to $\Re_1$ is available for $\Re_S$, several additional co-policies become feasible as well:

$\Re_S$ Collaborative Policies		
Intervention	**Definition**	**Discussion**
Co-liquidity	A co-collateralized liquidity pool by collaborating $\Re_S$ agencies.	Collaborative liquidity pools can be either static or floating.[22] Static pools allow the exchange of one crypto-asset for another at a fixed price — effectively, a fixed exchange rate. Floating pools use some AMM formula to calculate the exchange rate. This $\Re_S$ floating exchange rate can be different in price to the $\neg\Re_S$ spot price, similar to a dual exchange rate.[148]

[22] Grassroots Economics uses the term “bonded” to refer to floating pools, given that many utilize an AMM bonding curve. See Ruddick (2021).

		When combined with swap lines and open market operations, co-liquidity pools open up many options for monetary co-policies between agencies.
Open Market Operations	A DETS deposits liquidity to a shared liquidity pool, or purchases at scale crypto-assets native to the treasuries of some $\mathfrak{R}_S$ members.	Using the DETS reserve to inject liquidity or purchase crypto-assets common to $\mathfrak{R}_S$ members is a form of quantitative easing that benefits the solidarity neighborhood, e.g. some DETS spot purchases food forest tokens that are collectively owned by many $\mathfrak{R}_S$ members, or even collateralized by a neighboring member's reserve. A similar policy, the parity grid,[104] may stabilize the price of two distinct crypto-assets vis-à-vis a given oracle-reported basket of goods. This policy was used by European states before the introduction of the Euro to stabilize their currencies relative to each other.
Co-insurance	A common fund is created that releases funds to $\mathfrak{R}_S$ users under certain conditions.	Mutual aid societies have historically been part of the SE. Today, blockchain insurance designs tend to incentivize staking into some insurance pool to expand underwritten collateral.[23] DETS co-insurance schema should be considered for many social goods, ranging from climate crisis to smart contract coverage.
Token Swaps, Swap Lines	Two $\mathfrak{R}_S$ agencies agree to exchange crypto-assets. The exchange can be either permanent or lent.	Token swaps and lending can be generalized to any $\mathfrak{R}_S$ members, perhaps with unique registries offering favorable rates for targeted interventions. To stabilize liquidity needs, one agency may pre-establish swap lines with another — the right to borrow at some interest rate by posting some collateral.
Co-governance	$\mathfrak{R}_S$ members can accumulate governance rights in some neighboring agency, perhaps asymmetric to $\mathfrak{R}_1$ members.	For two agencies that have a close relationship, but no physical or economic proximity, this may be an effective means of granting a weighted voice to non-local actors.
Co-investment	$\mathfrak{R}_S$ agencies co-fund a particular organization as a JV or collaborative initiative.	See previous section to understand the JV use case. The co-funding of common initiatives can be achieved through a proposal inverter mechanism, which provides semi-automated payment flows through pre-negotiated contracts. Using it, a trusted group may be funded by multiple agencies for continuous work, with funds allocated

[23] See Alchemix (2021) and https://alchemixfi.medium.com/a-prelude-to-alchemixdao-c69fa9b0bb30 for examples

		per context-appropriate policy.[105] Figure 21 (below) schematizes this process.
Co-subsidies	$\mathfrak{R}_S$ members receive a collaboratively financed airdrop, or basic income; alternatively, they receive favorable rates to co-farm some liquidity pool.	This mechanism can virally grow a given economic interior through sign-up and referral bonuses or a minimum basic income. Co-farming can be used to attract $\mathfrak{R}_S$ liquidity to common services such as co-insurance.
Sanctions	Members of some $\mathfrak{R}_S$ maintain a blacklist of addresses and associated agencies that cannot interact with the solidarity neighborhood or its reversible crypto-assets.	This mechanism may help mitigate regulatory concerns by tightening the boundary vis-à-vis problematic actors.

Figure 20: Collaborative policies.

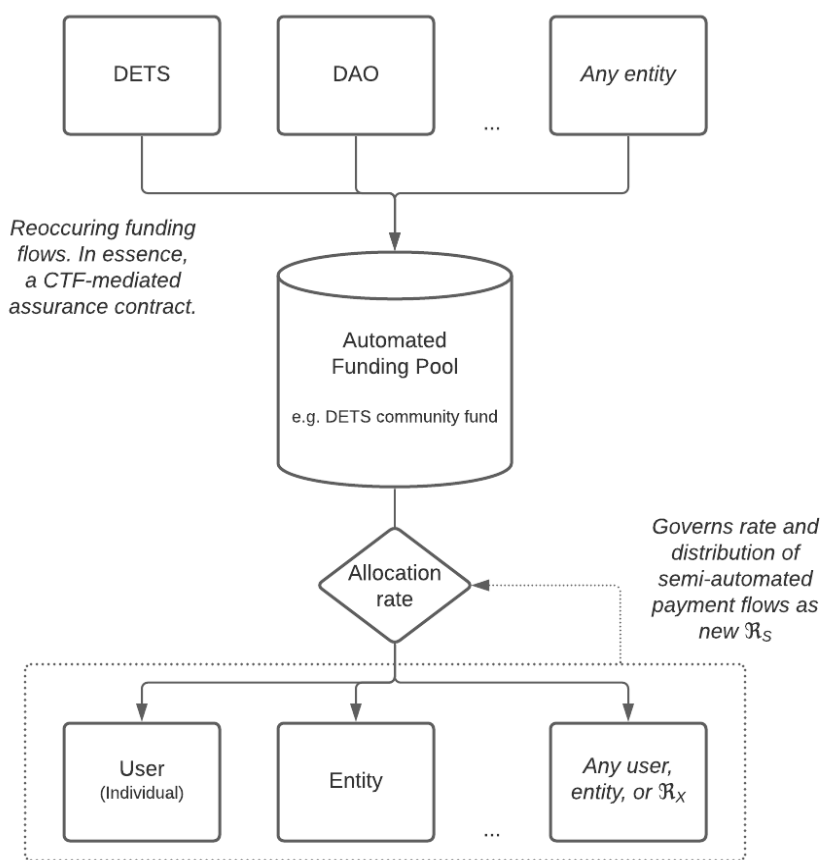

Figure 21: The Proposal Inverter mechanism.

4. Conclusion

Our intent is for the DETS to merge already existing SE networks with the latest in crypto-institutional design. We believe that proposed crypto-institutional frameworks like Kolektivo have a key role in implementing the SDGs. By unifying DAOs and LETS, we mitigate institutional weaknesses of each while simultaneously reinforcing their respective strengths. By introducing NCCs, we help economically account for the reality of precarious ecosystems unrepresented by the institutional order today. Finally, by introducing collaborative policy tooling, we hope to help unify local actors — especially those of a communitarian and humanistic ethos — to form coalitions that challenge today's institutional status quo, helping rebalance power and autonomy towards the local.

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