Six Failure Modes

A Pre-Deployment Diagnostic Framework for Tokenized Collaborative Economies

8th Distributed Ledger Technology Workshop – Pula 4-6 June 2026

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Motivation and Gap

Blockchain for Collaborative Economies Community token economies are designed for:

- Coordinating collective action
- Incentivizing prosocial behavior
- Enabling decentralized value exchange

Gap

Sustainability of community token economies is underspecified in the literature

Our Contribution

- **Framework** → Formalization of sustainability conditions through six failure modes
- **Three case studies:** a volunteer reward system, a peer-to-peer object lending system, a food redistribution system

Theoretical Foundation

Token Economies

Tokenomics
Token issuance, consensus mechanisms, game theoretic incentives structures

Token Economy
system designed to reward users

Tokenization
Convert real-world assets into digital tokens

Monetary Economics

Equation of exchange
MV=PQ
(Fisher 1911)

Sustainable monetary expansion
sustainable monetary expansion must remain proportional to real economic growth

MicroVelocity
Individual behavioral differences shape aggregare dynamics

Commons Governance and Collective Action

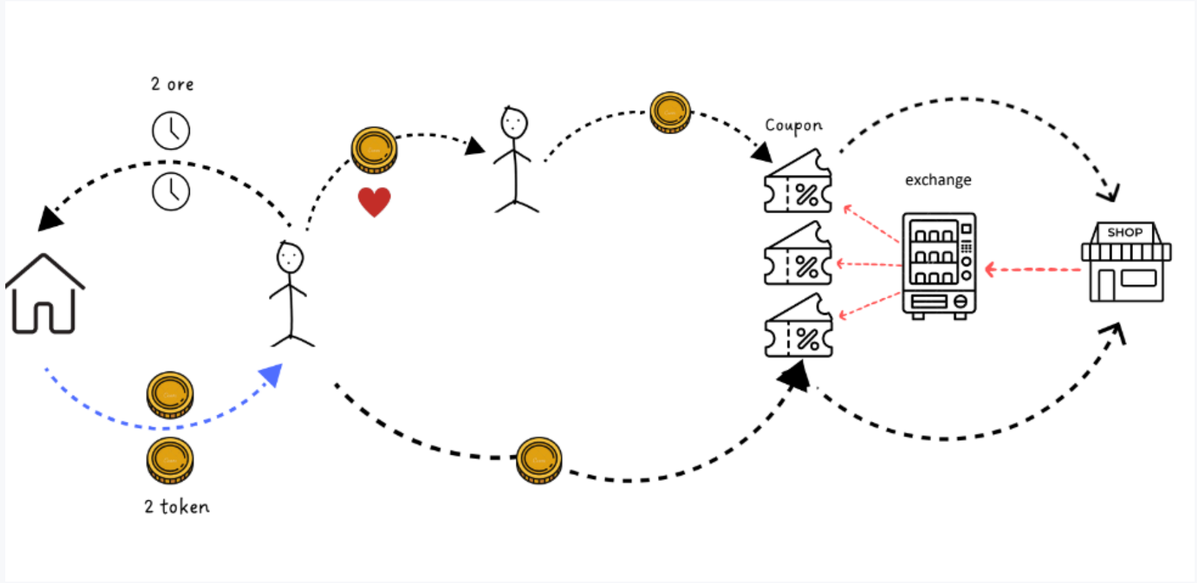
Design principles for sustainable collective institutions

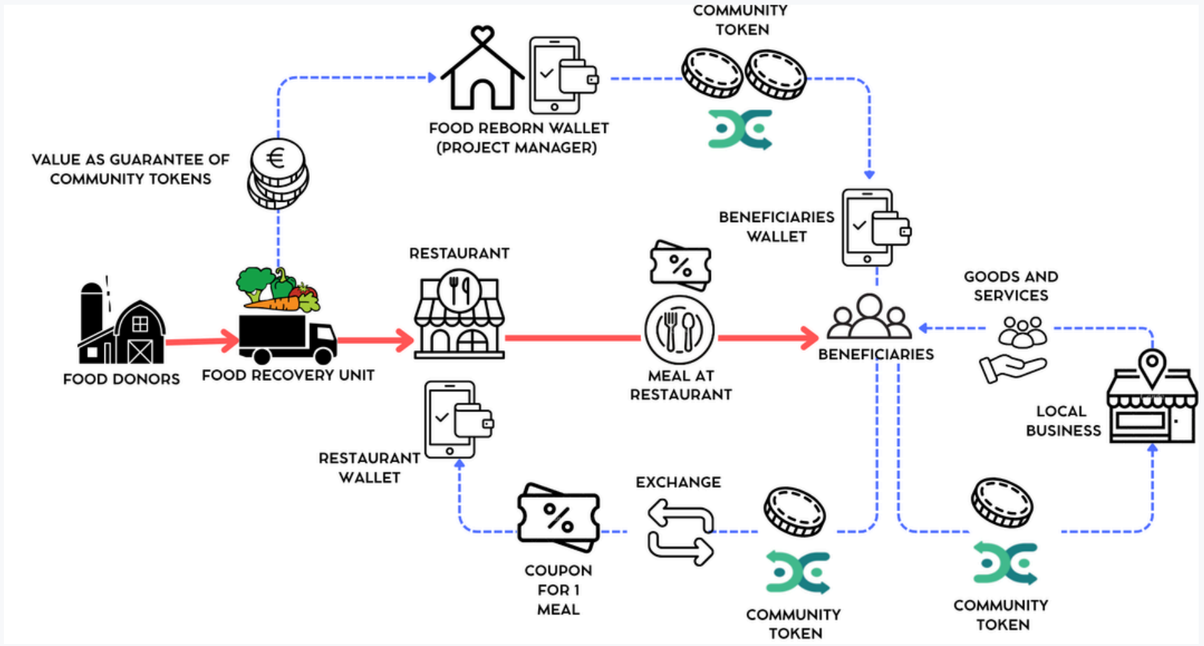
- Congruence
- Collective choice
- Monitoring

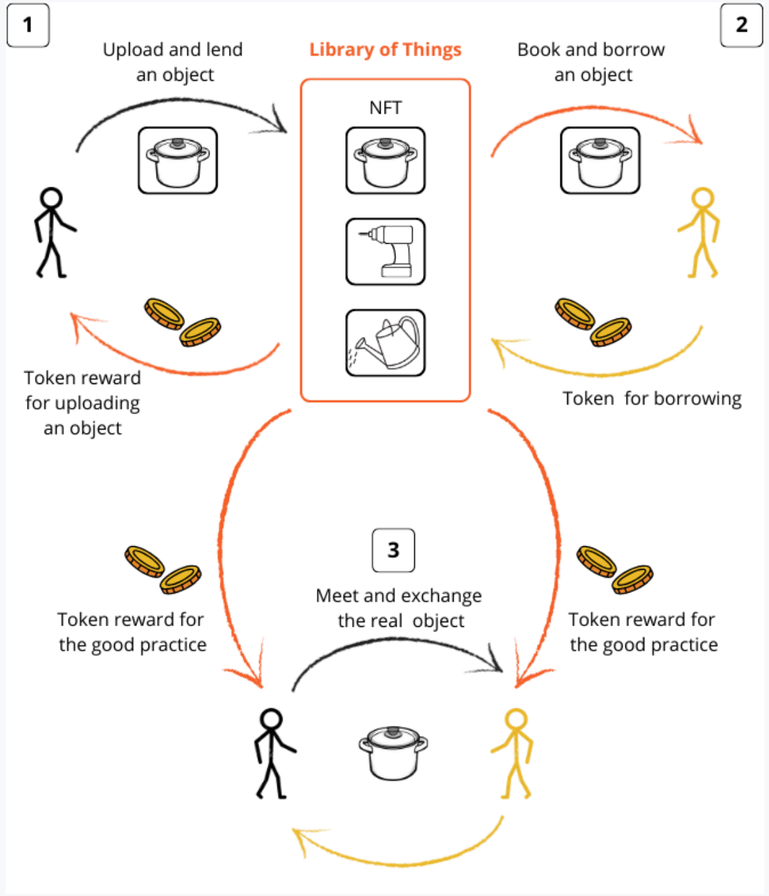
(Ostrom 1990)

Sustainable commons do not rely on purely financial incentives

Sustainability







Different kind of

- **Actors**
- **Tokens**
- **Transactions**

- **Supply Stability**
- **Incentive Balance**
- **Governance Integrity**
- **Participation Viability**

Framework.
Four sustainability dimensions

Supply Stability	Incentive Balance	Participation Viability	Governance Integrity
FM1 FM3	FM2 FM4	FM5	FM6

Six failure modes operationalize the conditions under which one or more of these properties breaks down.

Six Failure Mode. Overview

#	FAILURE MODE	FORMAL CONDITION	DIMENSION
FM 1	Token Oversupply / Inflation	$\Delta(MV)/MV > \Delta Q/Q$	Supply Stbility
FM 2	Velocity Trap	$\bar{\tau} \to 1$	Incentive Balance
FM 3	Burn/Emission Imbalance	$E(t) - B(t) > g(t) \cdot M(t)$	Supply Stbility
FM 4	Free Rider Collapse	$\varphi < d/K; \gamma S \leq T - R$	Incentive Balance
FM 5	Insufficient Critical Mass	$N < 2Kd + 1$	Participation Viability
FM 6	Governance Capture	$\Gamma > 0.5$	Governance Integrity

FM1 Token Oversupply

Definition

Token emission persistently exceeds real economic activity growth → internal value erosion → self-reinforcing spiral of declining engagement.

Formal Condition

$$\Delta(MV)/MV > \Delta Q/Q$$

Consistent supply: Mcons = PQ / V
If planned emission >> Mcons → structural oversupply at launch.

FM2 Velocity Trap

Definition

Without holding incentives, rational agents spend tokens immediately upon receipt → high velocity compounds FM1 inflationary pressure.

Formal Condition

$$\bar{\tau} \to 1 \text{ (avg. holding time = 1 period)}$$

$V \geq 1/\bar{\tau}$ (systematic lower bound)
Fix: staking, governance rights, time-locked or tiered rewards.

FM3 Burn/Emission Imbalance

Definition

Without a burn mechanism token supply grows monotonically — FM1/FM2 inflationary pressures cannot self-correct at any emission rate.

Formal Condition

$$E(t) - B(t) \leq g(t) \cdot M(t)$$

Burn coverage ratio: $\rho = B(t)/E(t) \geq 1$
Critical: burn must be demand-driven (B linked to Q),
not rule-based on a fixed schedule.

FM4 Free-rider Collapse

Definition

If contribution is unrewarded, free-riders degrade the supply of goods and services → cascade collapse: fewer contributors → less value → even fewer contributors.

Formal Condition

$$\varphi \geq d/K \quad \text{and} \quad \gamma S > T - R$$

φ = contributor rate, K = offer variety
γ = detection probability, S = sanction, T = temptation
Blockchain transparency ↑ γ, lowering the required sanction S.

FM5 Insufficient Critical Mass

Definition

Below a minimum participant count the system is technically operational but socially inert: tokens accumulate unspent, participation yields no perceived value.

Formal Condition

$$N \geq 2Kd + 1$$

Spatially structured communities may sustain exchange
below this threshold via spatial reciprocity (conservative bound).

FM6 Governance Capture

Definition

Decision-making authority concentrates in a small subset of actors — violating Ostrom's collective choice and recognition principles, creating structural dependency.

Formal Condition

$$\Gamma \leq 0.5 \text{ (Governance Centralization Index)}$$

Centralization at bootstrap is expected; the actual risk is the absence of a planned transition pathway.

Case Studies - CommonsHood Platform

Volounteer Recognition

NLAB4CIT

ERC-20 tokens earned through civic participation activities, redeemable as coupons at 8 local merchants. Tokens terminate at merchant wallets, no recirculation

- **Emission**: 750 tokens/week
- **Burn**: none
- **Governance**: Γ = 1.0

Library of Things

COSO

Peer-to-peer object lending platform. Each item is an NFT. Tokens held in escrow during loan, released to lender on return. Multiple prosocial reward mechanisms.

- **Emission**: event based
- **Burn**: none (self bal)
- **Governance**: Γ ≈ 0.8

Food Redistribution

FOOD REBORN

Tokens anchored to physical surplus food: 1 kg × avg. CAAT market price = token emission. Beneficiaries redeem coupons at social restaurants. Coupons burned on redemption.

- **Emission**: food-weight anchor
- **Burn**: coupon burn
- **Governance**: Γ ≈ 1.0

Risk Profiles. Cross-case comparison

FAILURE MODE	NLAB	COSO	FOODREBORN
Token Oversupply	Critical E/M≈2.5	Low E/M≈0.10	Low-Med
Velocity Trap	High $\bar{\tau}$≈1.5	Low $\bar{\tau}$≈7 days	Medium
Burn/Emission Imbalance	Critical ρ=0	Low–Med. ρ=0	Low-Med
Free Rider Collapse	Low/High	Low	Medium
Insufficient Critical Mass	N < 2Kd + 1	High (item-specific)	Low-Med
Governance Capture	Critical Γ > 1.0	High Γ > 0.8	Critical Γ > 1.0

Key Findings

Universal absence of token-level burn

All three systems: ρ=0.
all would benefit from a demand-driven burn triggered at the point of service redemption.

Governance centralization as bootstrapping necessity

Γ ≥ 0.8 across all cases reflects community onboarding realities, not design failure. The real risk: absence of an explicit transition roadmap toward distributed governance.

Inverted supply/matching risk profiles

Case 1: critical oversupply (E/M≈2.5) but simple matching.

Case 2: structural undersupply (E/M≈0.10) but hardest matching (item-specific).

The 25× gap — both ERC-20 — proves token standard is not a sustainability predictor.
Exchange mechanism and holding time structure are the decisive parameters.

Discussion

- Well-mixed population assumption in FM5: spatial structure can sustain exchange below the threshold
- Traditional monetary theory treats high velocity as a risk; in community currencies, rapid circulation is a sign of a healthy system
- Every community has different needs; an interdisciplinary approach is needed to design the system. Flexible tools and interaction with participants are fundamental

Next steps

- Framework provides the parameter space for simulation (6 axes)
- Failure mode vocabulary maps directly onto ABM output interpretation
- Naturally accommodates behavioral heterogeneity (fast vs. slow spenders)
- Development of new mechanism as purpose driven token and demurrage

Thank you

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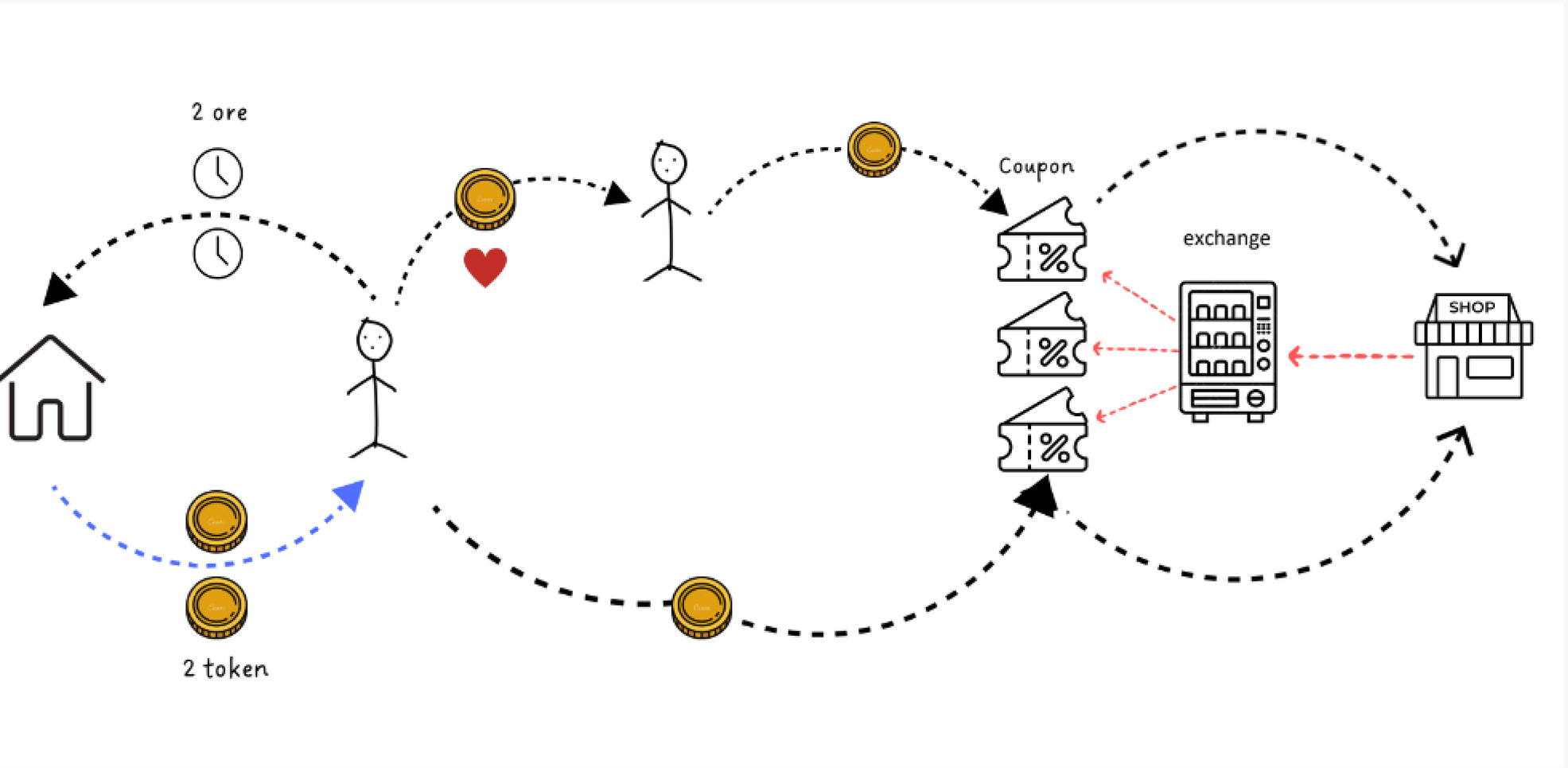

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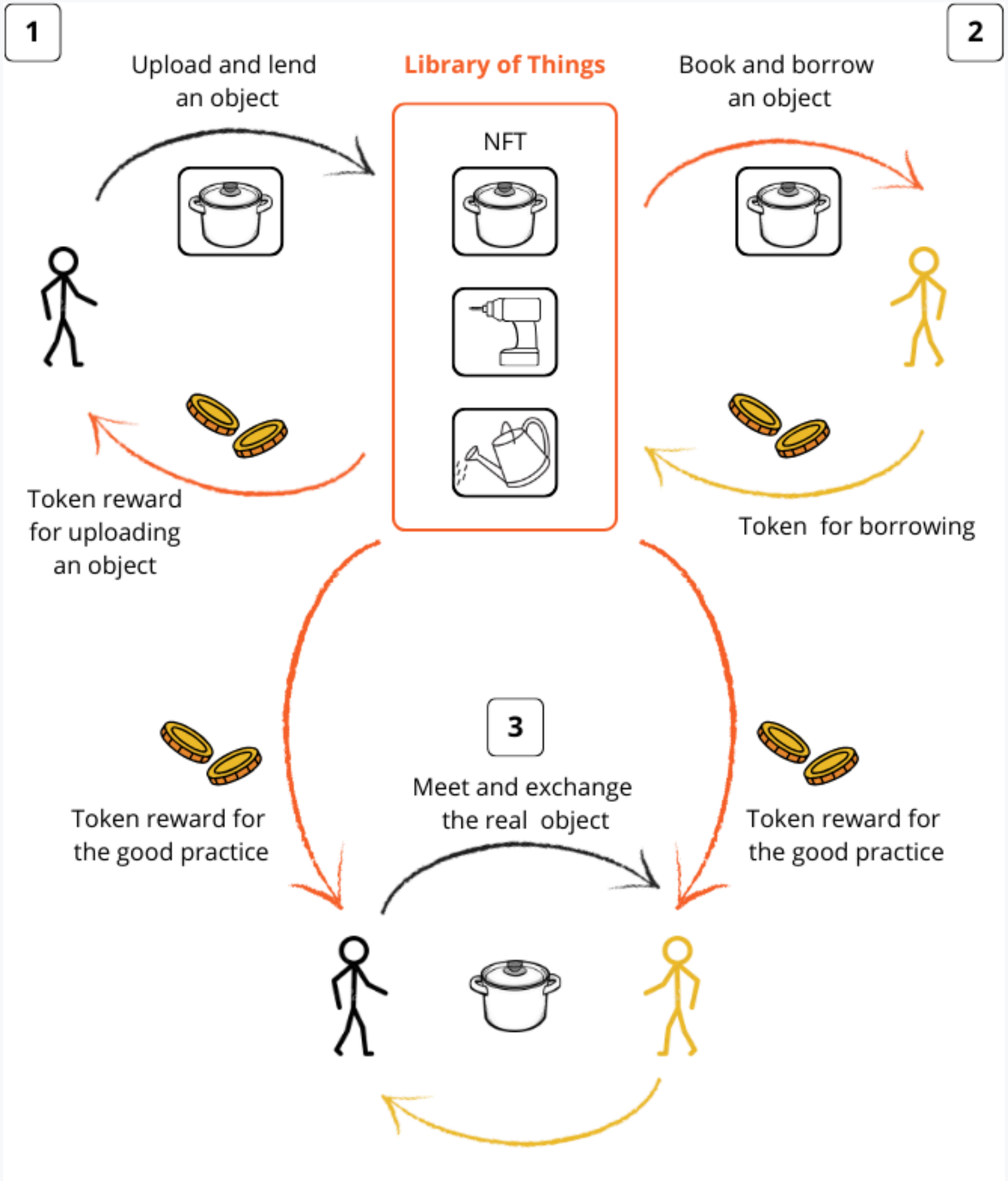

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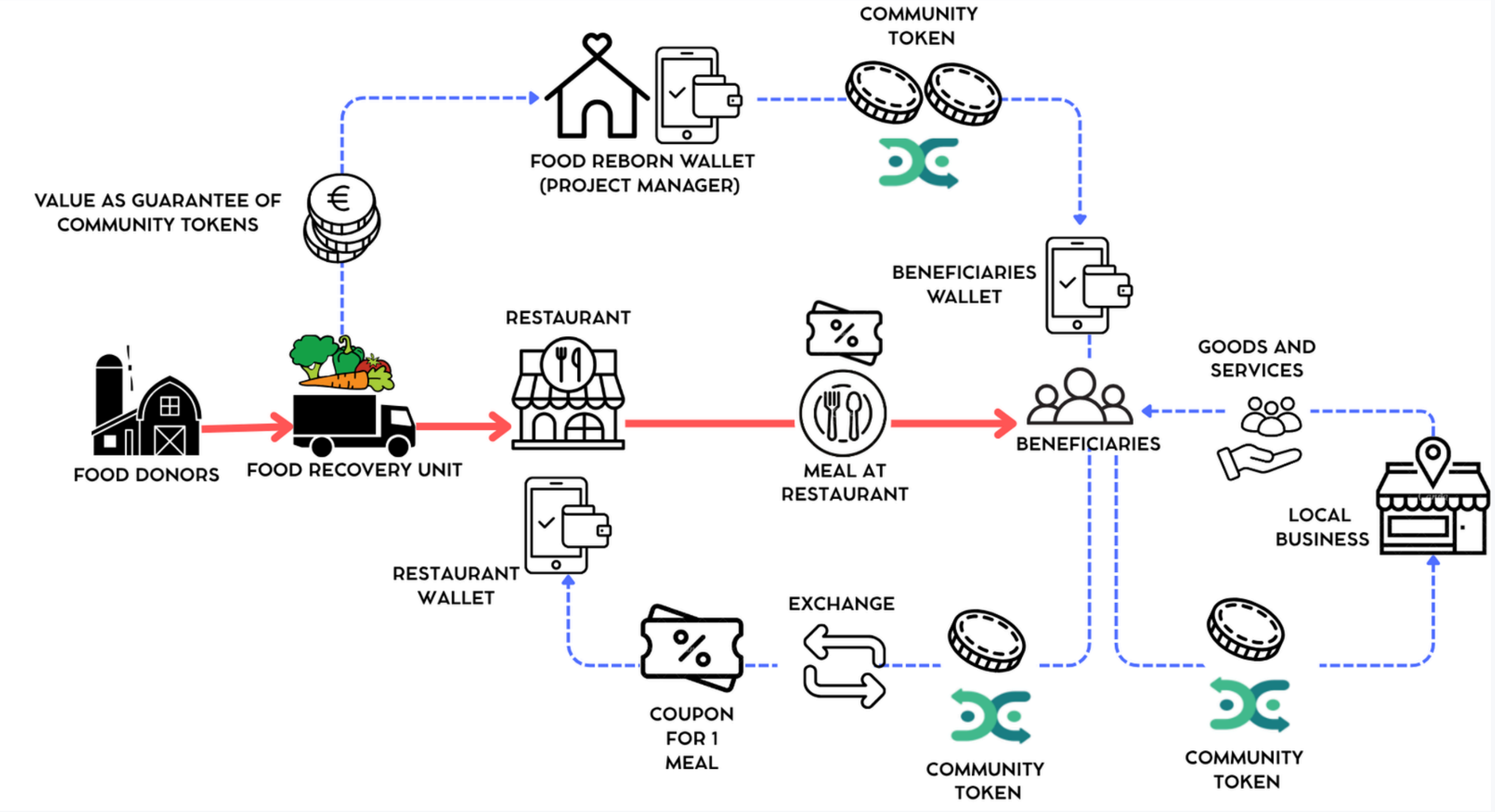
Food Reborn



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