

Beanstalk notes

The Silo is a part of Beanstalk, which is a decentralized system that uses the Stalk System for coordinating protocol upgrades and enhancing security, stability, and liquidity.

Stalkholders contribute to peg maintenance and earn passive yield. Beanstalk adjusts the Bean supply, Soil supply, and Temperature to maintain an ideal equilibrium. The system addresses ownership concentration, relies on strong credit, and reduces friction for users by offering a low-cost solution.

Major components of Beanstalk include:

1. **Stalk System:** Depositing assets to earn Stalk and Seeds
2. **Governance:** Decentralized mechanism balancing decentralization and resistance to protocol changes
3. **Beanstalk Improvement Proposals (BIPs):** Supports multiple simultaneous BIPs
4. **Pods:** Primary debt asset of Beanstalk that provides yield
5. **Fertilizer:** Limited debt issuance used for recapitalization
6. **Peg Maintenance:** Encourages participation through protocol-native incentives
7. **Bean Supply, Soil Supply, and Temperature:** Adjusted to maintain ideal equilibrium
8. **Market:** Provides liquidity without fee-based emissions
9. **Depot:** Allows complex interactions with other Ethereum-native protocols in a single transaction

Definitions:

1. **Silo:** A component of the Beanstalk system used to coordinate protocol upgrades, security improvements, stability, and liquidity.
2. **Stalk System:** A mechanism allowing users to deposit assets and earn Stalk and Seeds.
3. **Stalkholder:** A user who deposits assets into the Silo and participates in the Stalk System.
4. **Beanstalk Improvement Proposals (BIPs):** Proposals submitted by Stalkholders to improve or modify the Beanstalk protocol.
5. **Bean:** A token issued by Beanstalk with a value peg.
6. **Pods:** The primary debt asset of Beanstalk, which yield from Sown and never expire.
7. **Fertilizer:** A limited debt issuance that automatically Fertilizes Sprouts in the Beanstalk system.
8. **Ideal Equilibrium:** A state where the Bean price and Beanstalk debt level are both stable at their optimal levels.
9. **Soil Supply:** The supply of Soil, adjusted by Beanstalk, based on the number of Pods that Ripen, Temperature, and other factors.

10. **Temperature:** A variable adjusted by Beanstalk at the beginning of each Season to maintain or move towards the ideal equilibrium.
11. **Peg Maintenance:** The process by which Beanstalk encourages widespread participation in maintaining the peg through protocol-native financial incentives.
12. **Market:** A component of Beanstalk that provides liquidity without fee-based emissions.
13. **Depot:** A part of Beanstalk that enables complex interactions with other Ethereum-native protocols in a single transaction.

Beanstalk is a decentralized stablecoin protocol that aims to create a trustless fiat currency with competitive carrying costs, stability, and liquidity. It uses a dynamic peg maintenance mechanism to regularly cross the price of 1 Bean (its stablecoin) over its value peg without centralization or collateral requirements. Beanstalk consists of five interconnected components:

1. Decentralized timekeeping and execution facility (The Sun): It provides a protocol-native timekeeping mechanism and incentivizes cost-efficient code execution on the Ethereum blockchain at regular intervals.
2. Decentralized governance facility: It allows the community to participate in the decision-making process and manage the protocol's parameters.
3. Decentralized credit facility (Sowers and Bean loans): Users can lend Beans that are not in the Silo to Beanstalk, and these loans are repaid with interest when the Bean supply increases.
4. Decentralized exchange (DEX) (The Market): It offers 0-fee trading to anyone using the Ethereum network, enabling users to trade Beans and other tokens.
5. Interface to interact with other Ethereum-native protocols (The Depot): It facilitates interactions with other Ethereum-native protocols through Beanstalk in a single transaction.

Beanstalk uses Ethereum block timestamps and defines a Season as an approximately 3,600-second (1 Hour) interval. The protocol relies on native financial incentives to coordinate its components, ensuring that the price of 1 Bean regularly crosses its value peg, attracting deep liquidity in a cost-efficient, permissionless, and decentralized manner.

timekeeping is managed through a mechanism called the Sun. The Sun creates a cost-efficient protocol-native timekeeping system and incentivizes cost-efficient code execution on the Ethereum blockchain at regular intervals. Time on the Farm is kept in Seasons, which are approximately 3,600-second (1-hour) intervals.

The first Season begins when a successful transaction on the Ethereum blockchain that includes a sunrise function call is mined. When Beanstalk accepts the sunrise function call, the necessary code is executed.

To encourage regular sunrise function calls even during periods of congestion on the Ethereum network while minimizing cost, the award starts at 25 Beans and compounds 1%

every additional second that elapses past E_{\min_t} for 300 seconds. The award for successfully calling the sunrise function for t (a_t), such that $a_t \in \{j \times 10^{(-6)} \mid j \in \mathbb{Z}^+\}$ and $1 < t$, in a block with a given timestamp (E_t) is:

$$a_t = 25 \times 1.01^{(\min E_t - E_{\min_t}, 300)}$$

To minimize the cost of calculating a_t , the Sun uses a binomial estimation with a margin of error of less than 0.05% of a_t . Thus, Beanstalk creates a cost-efficient protocol-native timekeeping mechanism and ensures cost-efficient code execution on the Ethereum blockchain at regular intervals.

expressions like $a_t \in j \times 10^{(-6)} \mid j \in \mathbb{Z}^+$ are used to define the set of possible values for a specific variable. Let's break down this expression to understand its meaning:

- a_t : This represents the award for successfully calling the sunrise function for a given Season t .
- \in : This symbol means "belongs to" or "is an element of" a specific set.
- $j \times 10^{(-6)} \mid j \in \mathbb{Z}^+$: This is the set of possible values for a_t . It is defined as follows:
 - $10^{(-6)}$: This is a scaling factor, which is used to represent the values in a smaller unit (in this case, microBeans, since 1 Bean = 10^6 microBeans).
 - $j \times 10^{-6}$: This expression represents the product of j and $10^{(-6)}$, which gives us the possible values for a_t in microBeans.

So, the expression $a_t \in j \times 10^{(-6)} \mid j \in \mathbb{Z}^+$ means that the award for successfully calling the sunrise function for a given Season t (a_t) belongs to the set of values that are multiples of $10^{(-6)}$ (microBeans), where j is a positive integer. This ensures that the award is always a positive value and is represented in microBeans. Similar expressions in the Beanstalk documentation follow the same pattern, defining the set of possible values for different variables within the protocol.

key terms unique to Beanstalk:

1. Bean: The stablecoin in the Beanstalk protocol, designed to maintain a stable value pegged to an external asset (e.g., USD).
2. Stalk: A governance token in the Beanstalk protocol, used for voting on protocol upgrades and other governance decisions.
3. Season: A timekeeping unit in the Beanstalk protocol, approximately 3,600 seconds (1 hour) long, used to manage various protocol processes.
4. The Sun: A decentralized timekeeping and execution facility in Beanstalk, responsible for maintaining protocol-native time and incentivizing cost-efficient code execution on the Ethereum blockchain.
5. Silo: A component of Beanstalk that holds Beans and Stalk, allowing users to deposit and withdraw their assets.
6. Field: A part of the Beanstalk protocol where users can deposit Beans and Stalk to

participate in governance and earn rewards.

7. **Market:** A decentralized exchange (DEX) in the Beanstalk protocol, offering 0-fee trading for Beans and other tokens on the Ethereum network.
8. **Depot:** An interface in the Beanstalk protocol that facilitates interactions with other Ethereum-native protocols in a single transaction.
9. **Sowers:** Users who lend Beans to the Beanstalk protocol, providing credit to the system.
10. **Temperature:** A metric in the Beanstalk protocol that represents the deviation of the Bean's price from its target peg. The protocol adjusts the Temperature to maintain the desired peg.
11. **R D (Reserve Debt):** A measure of the Beanstalk protocol's debt, used to determine the interest rate and manage the credit system.
12. **R D * (Target Reserve Debt):** The desired level of Reserve Debt in the Beanstalk protocol, used to adjust the Temperature and maintain the Bean's peg.
13. **Debt Level (RD):** Beanstalk establishes three RD levels to determine the debt level (excessively low, optimal, and excessively high).
14. **Position and Direction:** Beanstalk's position and direction concerning the ideal equilibrium is assessed at the beginning of each season.
15. **Acceleration:** The rate of change in Beanstalk's position (accelerating, steady, or decelerating) is determined at the beginning of each season.
16. **Demand for Soil:** Beanstalk measures the changing demand for Soil using two levels ($\partial\partial\Delta tS$ lower and $\partial\partial\Delta tS$ upper).
17. **Current State:** Combination of direction and acceleration with respect to the ideal equilibrium creates six potential current states.
18. **Optimal State:** Beanstalk's optimal state is when it is accelerating, steady, or decelerating toward the ideal equilibrium.
19. **Bean Supply:** Bean supply is adjusted based on various factors at the beginning of each season.
20. **Soil Supply:** Soil supply is determined at the beginning of each season, taking into account the number of Pods that Ripen.
21. **Temperature:** Beanstalk adjusts the Temperature at the beginning of each season in an attempt to maintain an optimal state.
22. **Flood:** If it is raining, the farm is oversaturated, and Beanstalk sells newly minted Beans to maintain the ideal equilibrium.
23. **Pods:** The primary debt asset of Beanstalk, representing the borrowed Beans in the system.
24. **Fertilizer:** A resource in the Beanstalk protocol used to facilitate the growth and development of Stalk and Seeds, potentially representing additional incentives or rewards.
25. **Ripening:** The process by which Unripe assets (e.g., Pods) mature and become Ripe assets, making them eligible for redemption or other actions.

26. Unfertilized Sprouts: Sprouts that have not yet been exposed to Fertilizer, and therefore, have not yet begun to grow or develop.
27. Pod Rate (R D): A metric in the Beanstalk protocol that represents the interest rate on Pods, used to manage the credit system and maintain the stablecoin peg.
28. Ripe: A state in which assets (e.g., Pods) have matured and become eligible for redemption or other actions.
29. Unripe: A state in which assets (e.g., Pods) have not yet matured and are not yet eligible for redemption or other actions.
30. Revitalization: The process of restoring the functionality of Stalk and Seeds, making them Enrootable and able to participate in the Beanstalk protocol's growth and development.
31. Stalk: A governance token in the Beanstalk protocol, used for voting on protocol upgrades and other governance decisions.
32. Chopping: The action of converting Unripe assets into Ripe assets, making them eligible for redemption or other actions.
33. Rinse: The action of redeeming Rinsable (redeemable) Sprouts, allowing users to claim their rewards or benefits from the Beanstalk protocol.

key equations relevant to the Beanstalk protocol

1. Temperature equation: $T = \frac{P_{Bean}}{P_{Target}}$

Where (T) is the Temperature, (P_{Bean}) is the current price of 1 Bean, and (P_{Target}) is the target price of 1 Bean.

2. Reserve Debt equation: $R_D = \sum_{i=1}^n L_i$

Where (R_D) is the Reserve Debt, (L_i) is the loan amount provided by the (i)-th Sower, and (n) is the total number of Sowers.

3. Target Reserve Debt equation: $R_D^* = R_D \times \frac{T}{T^*}$

Where (R_D^*) is the Target Reserve Debt, (R_D) is the Reserve Debt, (T) is the Temperature, and (T^*) is the target Temperature.

4. Interest rate equation: $r = \frac{R_D^* - R_D}{R_D}$

Where (r) is the interest rate, (R_D^*) is the Target Reserve Debt, and (R_D) is the Reserve Debt.

Rain:


In the context of Beanstalk, "Raining" refers to a situation when $V < P_{t-1}$, where V represents the value peg of Beans, and P_{t-1} is the price of Beans at the end of the previous season. When it's Raining, the price of Beans is greater than the value peg, indicating an

increased demand for Beans. During this phase, Beanstalk may take actions like increasing the Bean supply and lowering the Temperature to maintain the ideal equilibrium.

Temperature:

In Beanstalk, the Temperature affects the system's state by helping to maintain an optimal state or to move from its current state into an optimal one. The Temperature change at the beginning of a season is determined by the debt level ($RtD-1$) and the current state of Beanstalk with respect to the ideal equilibrium. By adjusting the Temperature, Beanstalk aims to regularly cross the price of 1 over its value peg during long-run decreases and increases in demand for Beans, thus helping in achieving equilibrium.

For example, if the debt level is excessively high or low, Beanstalk changes the Temperature more aggressively. The Temperature can be raised, lowered, or kept constant based on the system's current state and whether it is moving toward or away from the ideal equilibrium. These adjustments in Temperature are done in an attempt to keep the Bean price stable and to balance supply and demand.

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