Social Welfare Supply Chain Modelling weaving with Blockchain technology

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Abstract:-

This study aims to apply blockchain technology and smart contracts to a government organization's supply chain. The approach involves developing an optimal facility location model and a blockchain framework. The study could enhance the efficiency of benefit delivery systems and represents collaboration between an educational institute and the government.

Keywords: *Menstruation, Blockchain, Smart Contracts, Supply Chain, Optimization*

1.   Introduction

The plan to address social welfare challenges using blockchain technology and smart contracts is indeed innovative. Here's a brief explanation of how each challenge could be addressed:

1.   **Benefit Transfer System via Blockchain**: Blockchain technology can be used to create an incorruptible digital ledger for economic transactions[1]. This can ensure transparency and reduce leakage of funds or benefits[2]. The Direct Benefit Transfer (DBT) scheme in India is an example of this, where benefits are directly transferred to the people through their bank accounts[3].

2.   **Smart Contracts in Supply Chain**: Smart contracts are digital agreements that self-execute when predetermined conditions are met[4]. In the context of a supply chain, they can be used to automate processes such as releasing payment, recording ledger entries, and flagging a need for manual intervention[56].

3.   **Platform for Managing CSR and Government Funds**: Platforms like SAHYOG by Invest India have been developed to help corporates channel CSR funds to various government departments[7]. Similarly, India has regulated and mandated CSR for some select categories of companies registered under the Act[8].

4.   **Remodelled Supply Chain Design for Government Benefit Transfer Schemes**: The DBT scheme in India is a good example of a remodelled supply chain design. It uses a shared and immutable ledger that can only be accessed by members with permission[39].

This approach could potentially enhance the efficiency and effectiveness of social welfare schemes, ensuring that the benefits reach the intended beneficiaries in a timely and transparent manner.

The proposal focuses on the following key aspects:

1.   **Government Schemes and Subsidies**: Various schemes have been implemented to support different sectors, providing financial, infrastructural, and regulatory support.

2.   **Empowerment through Self-Help Groups (SHGs)**: SHGs play a significant role in empowering communities, particularly in rural areas. They bring women together, making them aware of the benefits of credit linkages, and other government schemes.

3.   **Decentralized Distribution Framework**: A scalable and efficient decentralized distribution framework is a need of the hour. Such frameworks have been proposed in the context of Federated Edge Learning (FEL), offering secure and communication-efficient model training schemes.

4.   **Conceptual Public Health Supply Chain Network**: An integrated public health supply chain is a coordinated network of organizations and stakeholders aimed at getting health products to the point of care. The use of Multi-Criteria Decision-Making (MCDM) methods in supply chain management has been widely recognized for their computational capabilities.

5.   **Supply Chain Strategies for Rural Recipients**: Strategies and development initiatives have been implemented worldwide to alleviate rural areas from various afflictions by formulating revenue-generating programs.

6.   **Decentralized Model for Fund and Information Flow**: Blockchain technology and smart contracts offer immutability, security, and transparency, which differentiates them from traditional contracts. They automate the execution of agreements in a distributed environment when conditions are met.

The proposal integrates these aspects into a single framework. It could potentially revolutionize public health supply chains, particularly in rural areas. However, it's important to note that while blockchain and smart contracts offer many advantages, they also come with their own set of challenges and vulnerabilities that need to be addressed. Further research and development in this area are warranted.

2. Overview of the technology and methods

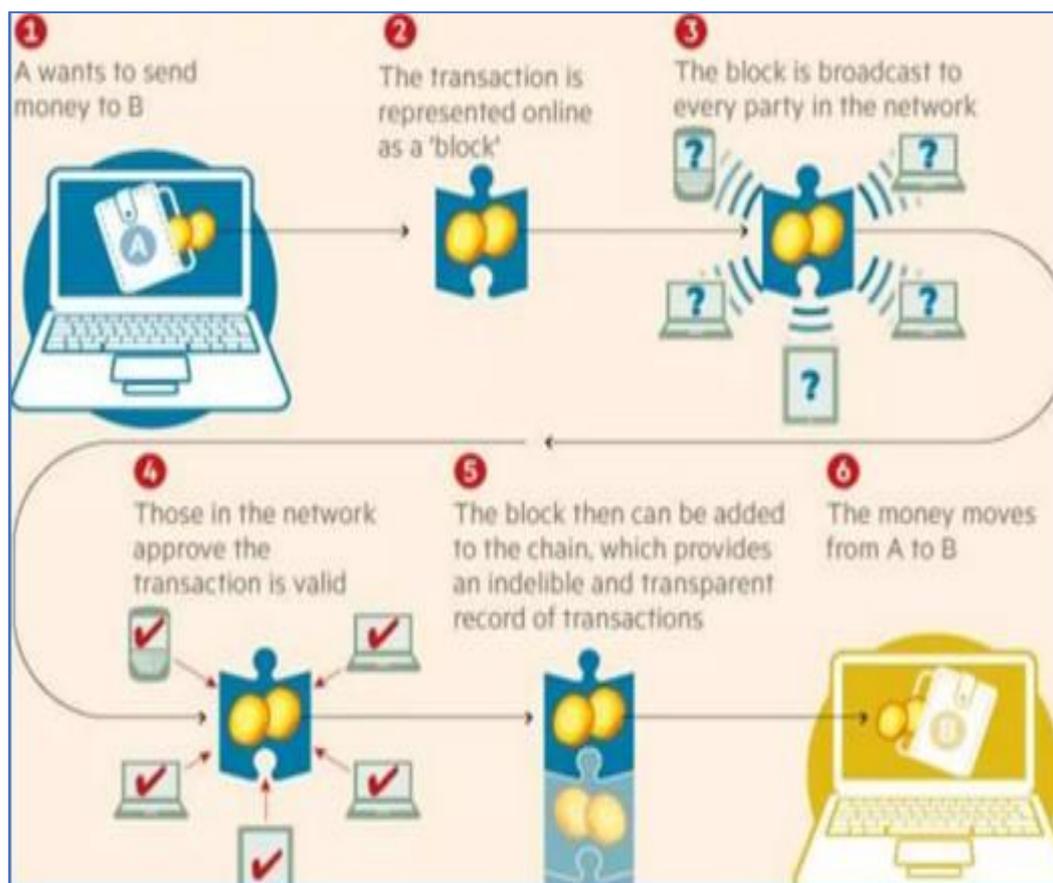An illustration of Blockchain technology transactions and Smart contracts are shown in Fig 1 and Fig 2.
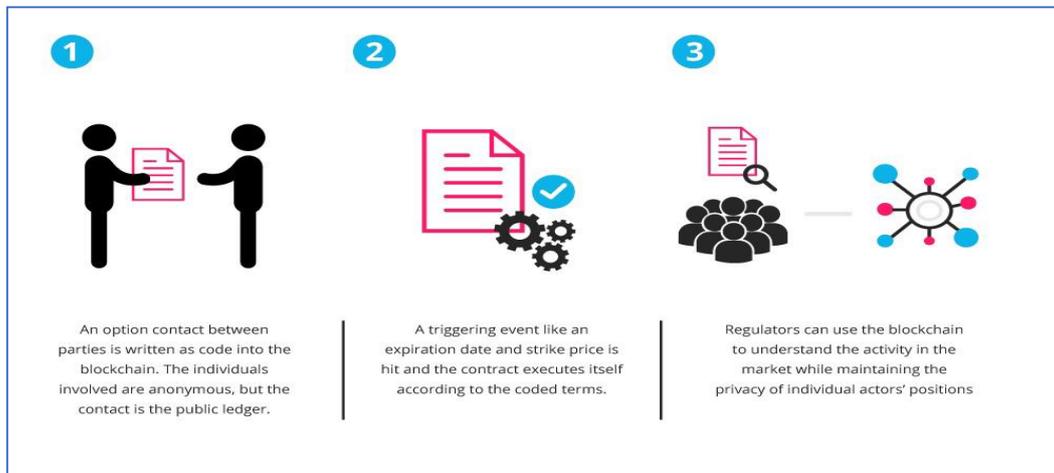

Fig. 1.Block chain transactions

Fig. 2.Smart Contracts

2.1 Data-Driven Confirmation of Hypotheses and Assumptions

A comprehensive study was conducted. The current landscape was assessed through a literature review, focusing on various schemes and initiatives by both government and non-government bodies.

The study also delved into the challenges and issues related to the supply chain and the delivered product/benefit. A survey was carried out to estimate the target population.

The collected data was tabulated and visualized using Tableau, including the creation of correlation graphs. This approach provides a holistic understanding of the situation. If there are specific aspects to discuss or explore further, please share.
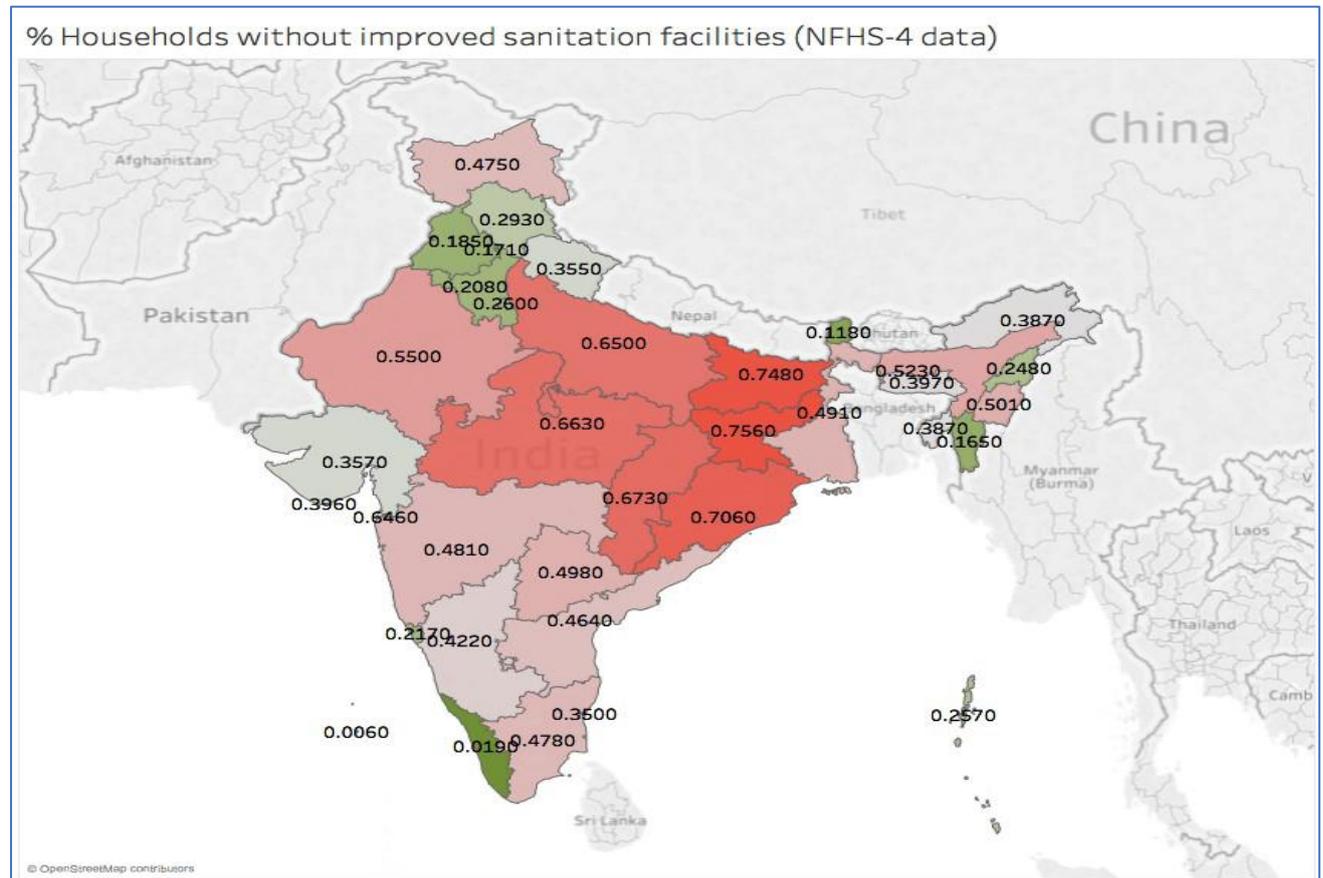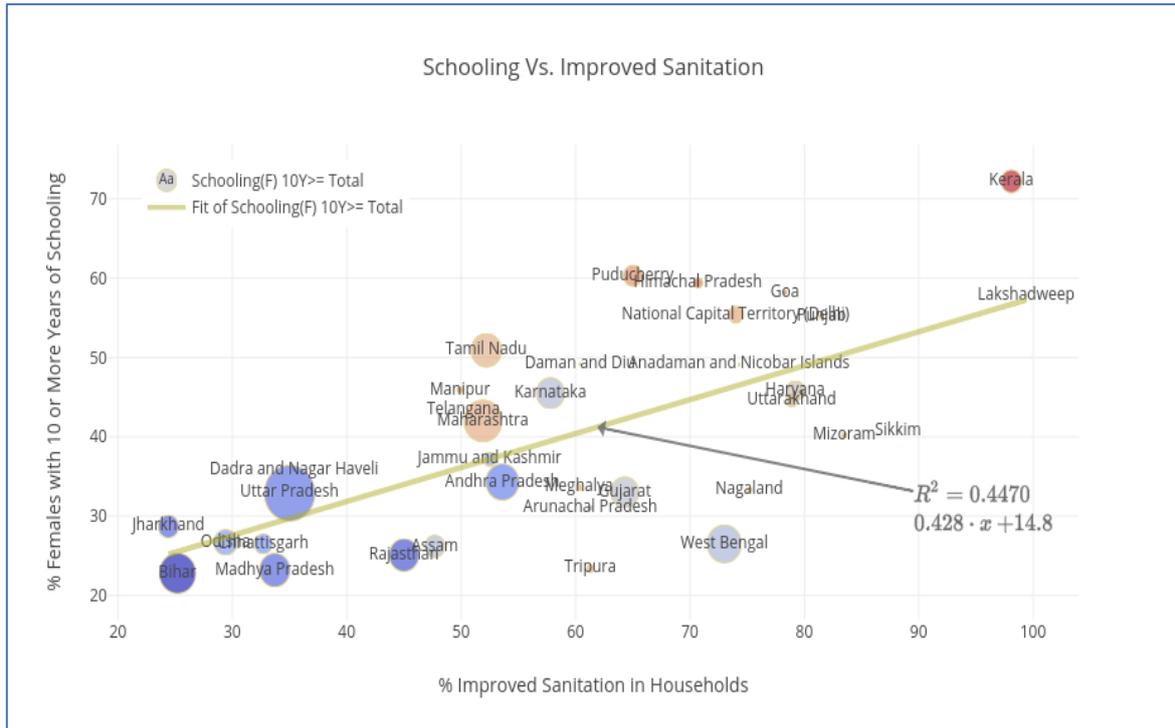
Fig 3. Data visualized on India Map

Fig 4. Correlation Graph
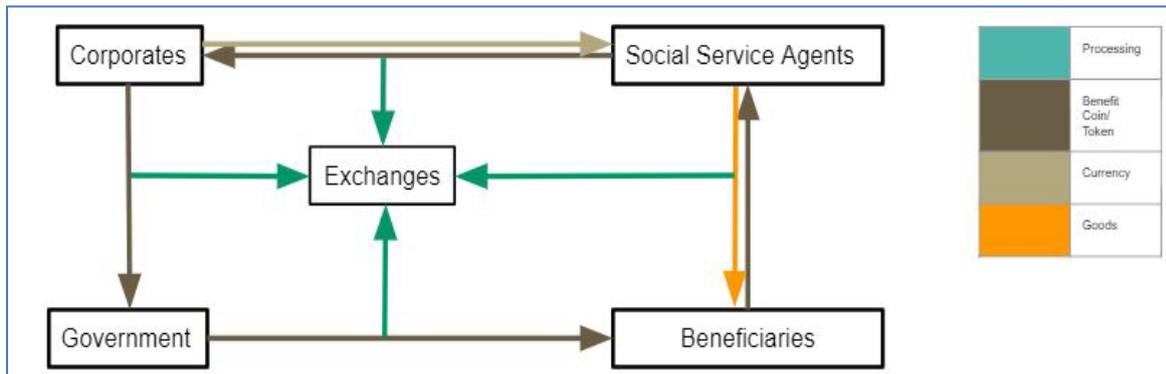
Proposal of a Benefit model as shown below in Fig 5.

Fig 5. Benefit model

3. Literature Review

The studies conducted by Srinivasan et al. in Kerala and Shah et al. in Gujarat provide valuable insights into the operational challenges faced by government schemes in India. These studies highlight the need for modifications and structures to design an effective supply network in a culturally diverse country like India.

The operation of the scheme is largely standard, with variations such as the number of storage units, incentives for ASHA workers, and suppliers of the subsidy, which are decided by the state steering committee unique to each state[7]. In states where Self-Help Groups (SHGs) are widespread, these groups, either already manufacturing the subsidy or having the capacity to do so, are the suppliers. In states where SHGs are inactive or non-existent, suppliers are decided through a competitive bidding process for manufacturers[7].

To design the supply chain network for the project, literature on similar supply chain systems was referred to. This includes:

1. The Public Distribution System in India, which is an Indian food security system established by the Government of India to distribute food and non-food items to India's poor at subsidised rates.

2. The Drug Distribution Project by Medpin, which uses a decision-support system to improve the operation of their charitable drug programs.

3. The distribution of Ready-to-Use Therapeutic Food (RUTF) products by UNICEF, which procures and distributes an estimated 75 to 80 percent of the world's RUTF supply.

These references provide valuable insights into designing the supply chain network for the project. The learnings from these systems can be adapted and applied to enhance the effectiveness of the current project.

3.1 Public Distribution System in India

Public Distribution System (PDS), initiated in the 1930s, aimed at food security by providing subsidized food grains to the Indian population. Over time, it transformed into the Targeted Public Distribution System (TPDS), focusing on the poor. TPDS operates through a network of ration shops or fair price shops. The Food Corporation of India (FCI), under the central government, procures food grains from farmers at Minimum Support Prices (MSP), typically higher than market prices, to stimulate agricultural production. FCI sets Central Issue Prices (CIP) to sell food grains to beneficiaries, which are significantly lower than the government's cost for procurement, transport, storage, and distribution. Beneficiaries are categorized into AAY, BPL, and APL based on their economic condition, with AAY and BPL receiving food grains at a lower cost than APL. The system's strengths include a vast administrative network, while challenges include poor infrastructure, logistics, and insufficient warehouses.
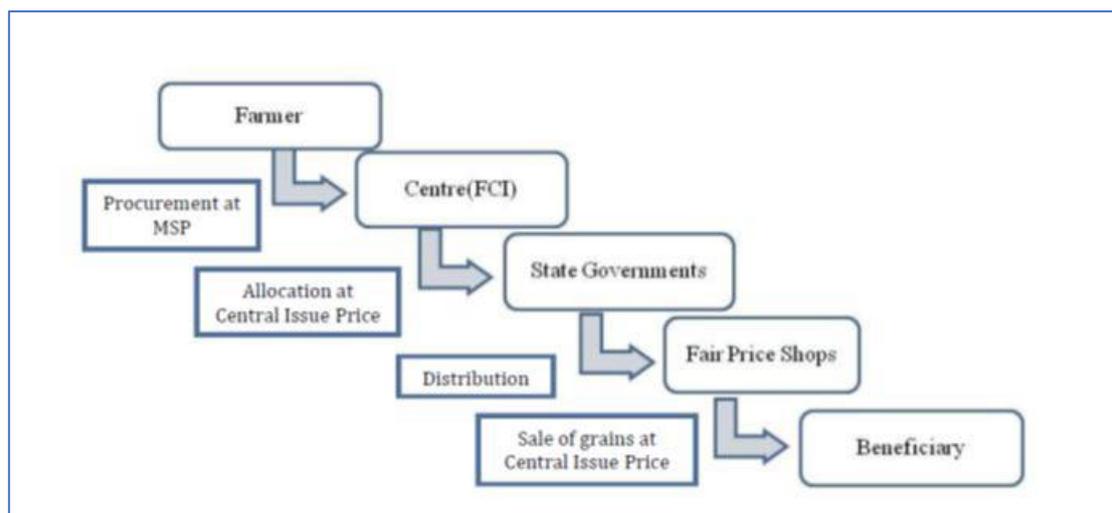

Fig 6. Public Distribution System

3.2 Medpin Drug Distribution Project

Between 1999-2001, an agreement between the Government of California and 25 Pharmaceutical firms led to the provision of $171 million worth of drugs free of charge over three years. This Drug Distribution Project (DDP) was managed by the Public Health Institute's Medpin program. Medpin approached 700 community clinics and local health departments in California, with 250 facilities approved based on specific criteria. DDP annual credit limits were assigned to each clinic, with constraints on order quantities.

Medpin focused on efficiency, effectiveness, and equity measures for this project. A priority-weight matrix was used when demand exceeded resources.

The project filled 2.6 million 30-day drug prescriptions over three years.

3.3 Ready to Use Therapeutic Foods (RUTF) Products: UNICEF

Ready to Use Therapeutic Food (RUTF) products, high in proteins, vitamins, and minerals, are utilized to treat severe acute malnutrition in children.

Nutriset, a French company, first produced a peanut-based RUTF, Plumpy Nut, in 1996. As demand for RUTF products increased through UNICEF, Nutriset became the primary provider. To cater to the global demand, UNICEF decentralized the supply base, developing a global supply network.

Most suppliers were from developing nations, where the need for RUTF products was higher. Nutriset equipped franchisees with production equipment, raw materials, quality control systems, and conducted training programs. Decentralization reduced costs and production lead times, and provided local economic development opportunities.

Did a paper-wise analysis to help us in designing our supply network complete

with facility location.

3.4 Supply Network Design and Facility Location

This is done as follows:

1.   The initial stage involves product suppliers in each state, responsible for producing and preparing products for distribution.

2.   The second stage includes multiple facilities within each district, acting as potential transshipment terminals for receiving and sending out products.

3.   The final stage consists of distribution centers that receive products from the transshipment terminals and handle the final delivery to customers or retail outlets.
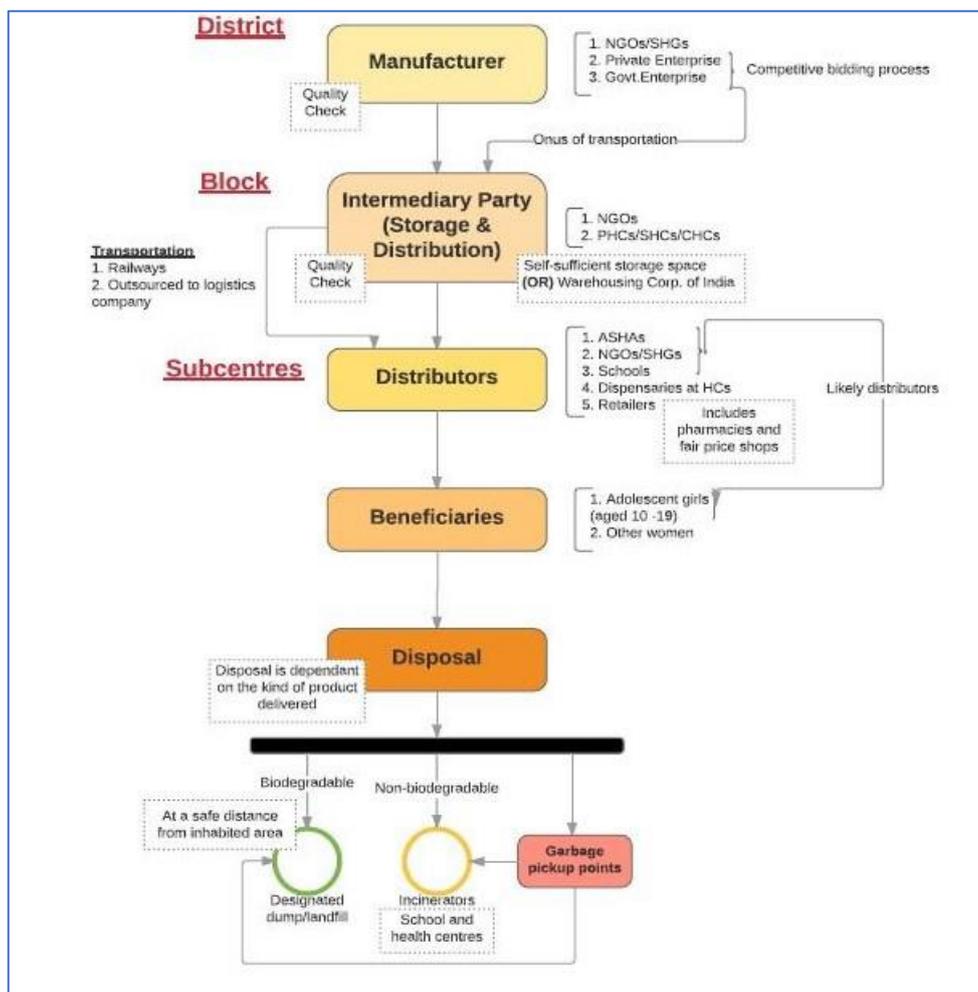
Fig 7. Stakeholder Model

4   Implementation

4.1   Blockchain Framework

A token (representing the benefit/subsidy) was programmed using Solidity, an object oriented

programming developed exclusively to write smart contracts on Ethereum.

```solidity
pragma solidity ^0.4.16;

contract Pads {
    // This creates an array with all balances
    mapping (address => uint256) public balanceOf;

    // Initializes contract with initial supply tokens to the creator of the contract
    function MyToken(
        uint256 initialSupply
    ) {
        balanceOf[msg.sender] = initialSupply;              // Give the creator all initial tokens
    }

    // Send coins
    function transfer(address _to, uint256 _value) {
        require(balanceOf[msg.sender] >= _value);           // Check if the sender has enough
        require(balanceOf[_to] + _value >= balanceOf[_to]); // Check for overflows
        balanceOf[msg.sender] -= _value;                    // Subtract from the sender
        balanceOf[_to] += _value;                           // Add the same to the recipient
    }
}
```

After this, the token was deployed on the Ethereum Wallet application on a private network (roughly translating to the supply network).

Fig 8. Deployment on Ethereum Wallet

A virtual wallet application was developed (roughly translates to the application

a beneficiary would use) to access the to-

kens and perform transactions on the private network.

Fig 9. Ethereum Virtual Wallet on an

Android Platform

4.2   Proposed Network Design Problem

The National Rural Health Mission has a scheme for promotion of Menstrual Hygienecombining health education for adolescent girls in rural areas with providing a regularsupply of sanitary napkins and enabling other sanitation measures such as access to waterand toilets in schools and in the community. Ensuring quality control of the sanitarynapkins is a critical component of the program.

1.   Within the scheme, the need for sanitary napkins in each selected district is determined by 70% of the total population of adolescent girls in the target age group. In this model, the demand is assumed to be stochastic.

2.   The scheme sources sanitary napkins from manufacturers through a competitive bidding process. The scope of the problem for this model is defined at the State level.
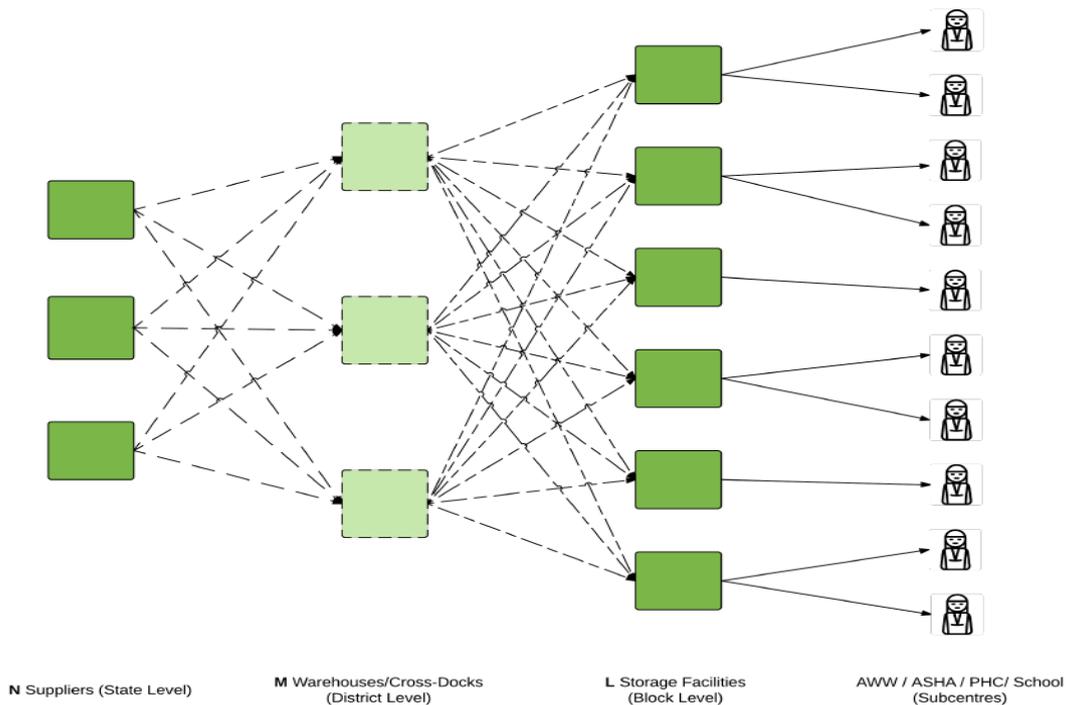

Fig 10. Proposed Network configuration

In the proposed network configuration 4.3, suppliers operate at the state level while stocking occurs at the Block level (schools/PHCs/ASHAs/AWWs). At present, no stipulatory obligations exist for states regarding the structure of the supply network. Given the response this scheme received from the pilot districts, a gap has been identified that could be explored through a facility location problem. The proposal includes the establishment of multiple warehouses/Cross-Docks at the district level. This arrangement aims to ensure a regular supply by complementing the physical network with the operational and scheduling guidelines of the scheme and conducting necessary quality checks.

4.3   Solving the Optimization Problem

IBM CPLEX Interactive Optimizer (ver. 12.7.1) was utilized to solve the linear programming (LP) problem. CPLEX is capable of solving linearly or quadratically constrained optimization problems, where the objective can be expressed as a linear function or a convex quadratic function. Variables in the model can be declared as continuous or further constrained to take only integer values.

Results

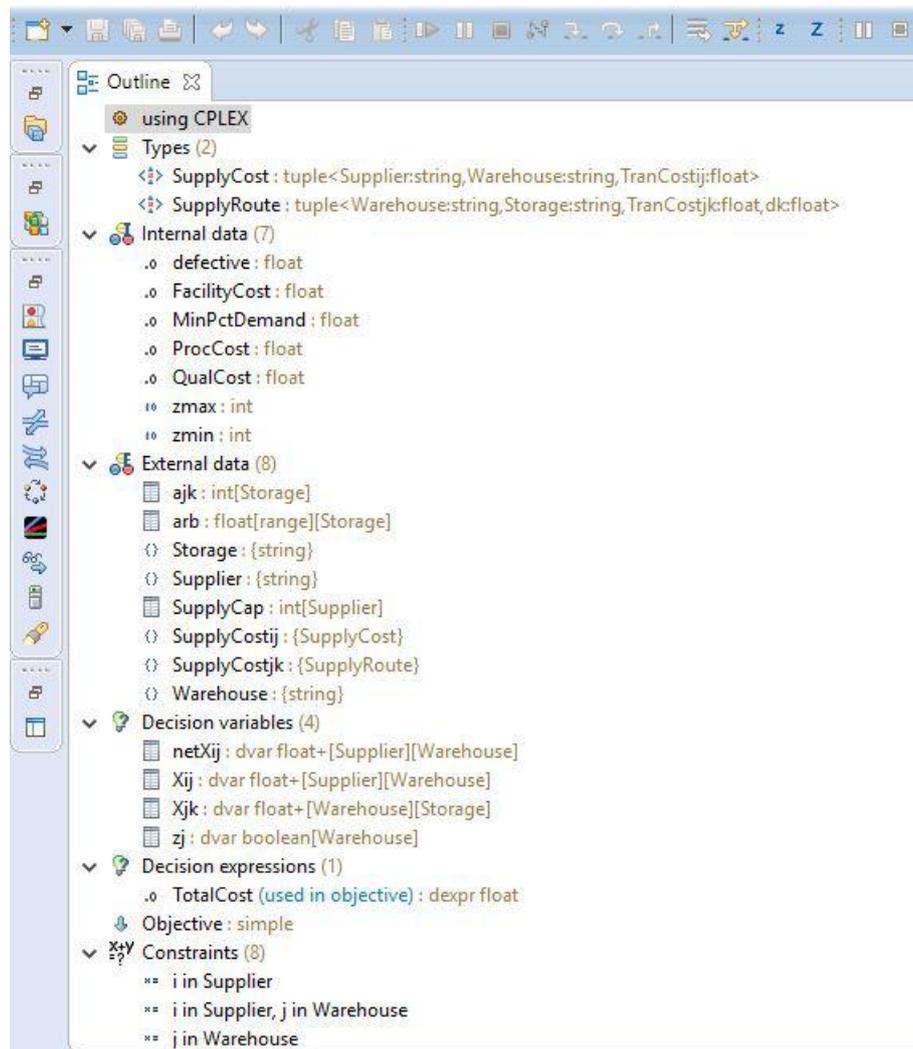Data was input using a .dat _le which speci_ed all the input parameters.

Fig 11. Problem Outline

The problem outline specifies the type of input parameters, decision variables, and constraints in the problem. The overview accesses the .dat file and assigns values to the parameters. After running the program, decision variables as well as the objective function (here, the total cost) also attain some values.
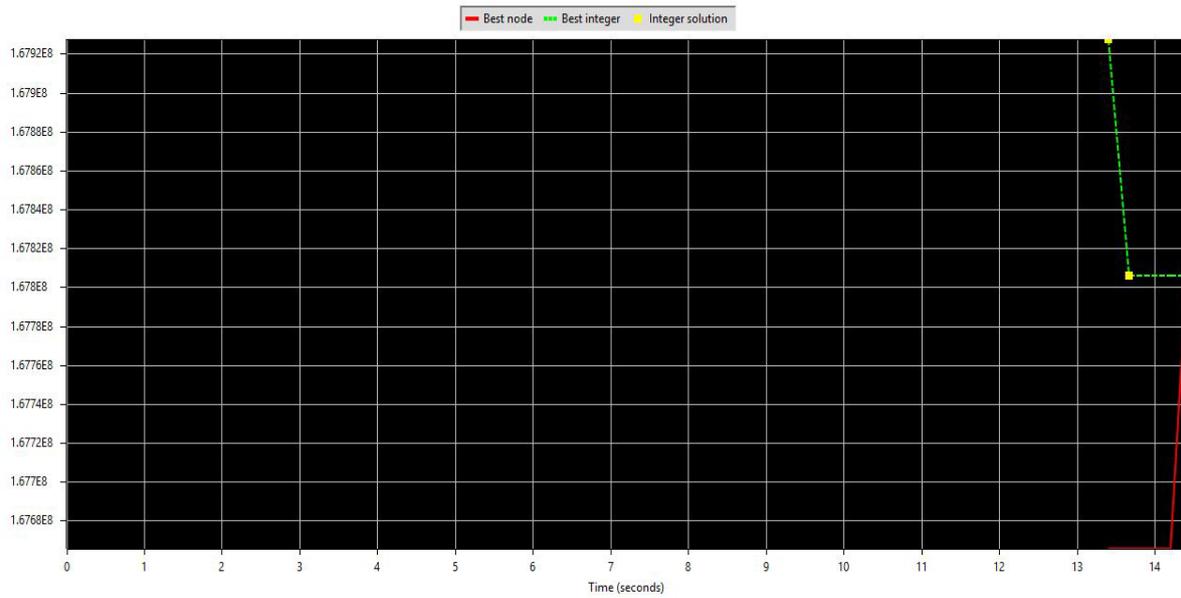
Fig 12. Problem and Solution Overview

CPLEX identi_es the problem as a Multi-Integer Linear Programming model and runs the optimizer for that setting and provides the solution in this form.

Fig 13. Solution

Fig 14. Program runtime for State of Madhya Pradesh

5.1 Inferences

The minimum _rst time cost to set up and operate this supply network in thestate of Madhya Pradesh is approximately INR 16.6 crore, out of which INR58 lacs is the _xed setup cost of the optimal number of facilities that can be

opened in the set at the district level.

The no. of facilities comes out to be 29 out of the 49 districts in the state.

Supplier (size 5)	"Bhind"	"Bhopal"	"Burhanpur"	"Chhatarpur"	"Damoh"	"Datia"	"Dewas"	"Dhar"	"Dindori"	"East Nimar"	"Guna"
"Balaghat"	0	140000	0	140000	140000	140000	13466.2...379082	0	140000	93247.4...176467	140000
"Chhindwara"	0	140000	0	140000	140000	140000	13466.2...379082	0	140000	93247.4...176467	140000
"Khargone "	0	140000	0	140000	140000	140000	13466.2...379082	0	140000	93247.4...176467	140000
"Sagar"	0	140000	0	140000	140000	140000	13466.2...379082	0	140000	93247.4...176467	140000
"Sidhi"	0	140000	0	140000	140000	140000	13466.2...379082	0	140000	93247.4...176467	140000

Fig 14 Total Supply from Supplier to District (Partial)

Supplier (size 5)	"Bhind"	"Bhopal"	"Burhanpur"	"Chhatarpur"	"Damoh"	"Datia"	"Dewas"	"Dhar"	"Dindori"	"East Nimar"	"Guna"
"Balaghat"	0	126000	0	126000	126000	126000	12119.6...941174	0	126000	83922.7...058821	126000
"Chhindwara"	0	126000	0	126000	126000	126000	12119.6...941174	0	126000	83922.7...058821	126000
"Khargone "	0	126000	0	126000	126000	126000	12119.6...941174	0	126000	83922.7...058821	126000
"Sagar"	0	126000	0	126000	126000	126000	12119.6...941174	0	126000	83922.7...058821	126000
"Sidhi"	0	126000	0	126000	126000	126000	12119.6...941174	0	126000	83922.7...058821	126000

Fig 15. Net Supply (Total Supply - Defectives) from Supplier to District (Partial)

5   Conclusions

The study's contribution is two-fold: it offers practical benefits to government schemes and expands the literature in novel and significant directions. A methodology, grounded in technology and operations research, is provided to address challenges stemming from the government's benefit transfer schemes. These schemes often grapple with a deficit of technical support for productivity and efficiency analysis.

Future Work

The proposed approach effectively describes the problem and necessitates the development and execution of an optimization model, ideally with real-life data from recent years. Main challenges such as transparency, security, accessibility, and repudiability have been addressed by establishing a blockchain framework for the

system. Optimum efficiency possibilities remain to be explored through a new network configuration and data digitization, which could potentially reduce redistribution efforts.

This study contributes to existing literature in several key aspects. It introduces the novel concept of blockchain technology in a benefit delivery scheme, significant for researchers engaged with social issues. The unavailability of statistically reliable data for running optimization models can be circumvented by employing fuzzy demand and fuzzy supply parameters, presenting a new application for fuzzy optimization. Future work could include the design and development of a web-based decision support system.

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