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Research Article

Block Chain Technology Integration - In Menstrual Hygiene Supply Chains In Parts Of India

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ABSTRACT

Menstrual Hygiene Management (MHM) in rural India faces challenges due to high costs and lack of sanitary products. Despite various efforts, a gap exists in creating an efficient distribution framework. The proposal is to develop a supply network, optimizing distribution for high service levels and low costs. A mathematical model is suggested for optimal facility location strategies. The informational and financial flow is proposed to be hosted on a private blockchain network.

Keywords: Menstruation, Blockchain, Smart Contracts, Social Supply Chains

1. Introduction

Menstruation, a crucial phase in a woman's life, is often stigmatized in India, leading to various practices around menstrual hygiene[20]. These practices, influenced by local customs, can pose health risks if proper hygiene isn't maintained. The stigma can cause discomfort and shame, resulting in school absenteeism and high dropout rates among rural adolescent girls. Despite young girls under 20 comprising a quarter of India's female population, menstrual hygiene is an under-recognized issue. The Indian Government has initiated steps to address this, including a scheme launched in 2010 to provide subsidized sanitary napkins to rural adolescent girls. However, the scheme hasn't fully addressed issues related to menstrual hygiene and reproductive health. Concerns remain about the quality of napkins, frequency of supply, and disposal of used products. It's clear that more comprehensive solutions are needed to fully address these issues. Improving menstrual hygiene management in India is crucial for the health and well-being of millions of women. Continued efforts are needed to break the stigma and ensure access to quality menstrual hygiene products.
This paper delves into the critical issue of menstrual hygiene in rural India. The process commences with an all-encompassing review of literature to comprehend the existing menstrual hygiene practices. This step is vital for gathering information about current methodologies, challenges, and advancements in this area. The paper then outlines various initiatives and schemes that the Indian Government has implemented to address this issue. A specific algorithm designed to overcome the challenges hindering the successful implementation of these schemes is studied in detail. The paper also provides a cost estimate for implementing these schemes. The conclusion of the paper presents recommendations for more effective implementation strategies and a better location model for social welfare supply chains. The paper underscores the struggle faced by adolescents, a significant demographic in India, in managing menstrual hygiene. This issue, common in less affluent countries, affects approximately 68 million girls in India, impacting their education and health. The paper discusses the various programs initiated by the Indian Government, including a pilot project for sanitary napkin distribution and other state-level and individual initiatives, aimed at improving this situation.

2. Literature Review

Hygiene, especially during menstruation, is a critical health factor, yet it's a challenge for many women in rural India. A small fraction of Indian states report adequate use of hygienic protection during menstruation among young women as shown in Fig 1 below. Adolescents, a significant demographic in India and globally, often grapple with managing menstrual hygiene, a common issue in less affluent countries. Poor menstrual hygiene management affects about 68 million girls in India, impacting their education and health. The Indian Government has initiated several programs to improve menstrual hygiene and raise awareness, including a pilot project for sanitary napkin distribution and other state-level and individual initiatives.

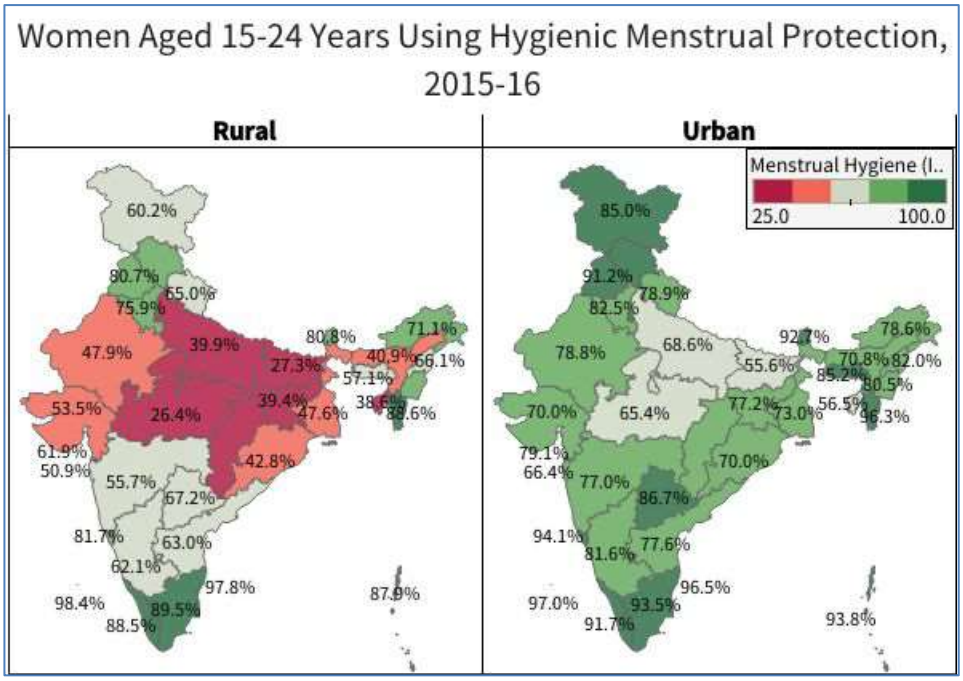

Fig. 1. Adolescent Women between 15 to 24 years using Hygienic Menstrual Protection

Identified the following factors to significantly affect regular and consistent use of MHM Products (in increasing order of relevance)
1. Knowledge: of products and their use
2. Community: norms on products' acceptability
3. Price: of products and accessibility to money
4. Access: to product and comfort purchasing product

Freedays scheme under Ministry of Health and Family Welfare, Govt of India:

The 'Freedays' scheme, launched by the Indian Government in 2010 under the National Rural Health Mission (NRHM), aimed to enhance menstrual hygiene across 152 districts in 20 states. The scheme involved:

- Community-based health education and outreach for menstrual health promotion.
- Regular provision of low-cost sanitary napkins.
- Menstrual health training for Accredited Social Health Activists (ASHAs) and nodal teachers.
- Training of ASHA and nodal teachers in Menstrual Health
- Safe disposal of sanitary napkins.

Initially, sanitary napkins were supplied in 107 districts in 17 states, with Self Help Groups (SHGs) catering to the remaining 45 districts. Adolescent girls received these napkins at a subsidized rate. During the 11th Five Year Plan, Rs. 70.65 crore was allocated for this initiative. The impact is studied and following are the gains:

1. It increased the school attendance among girls in Assam

In J&K elders are more confident to send their young girls to schools or work in offices as this facility of providing menstrual Hygiene has given them assurance and dignity to move on. ASHA workers also play a big role as the girls with confidence talk them in Menstrual Hygiene and related issues.

2.1 Implementation of the scheme in selected states of India

Findings from Kerala: An independent study[70] conducted by the Sree Chitra Tirunal Institute for Medical Sciences and Technology, in collaboration with NHSRC, evaluated the 'Freedays' scheme. The study found that the scheme's operation was generally successful, largely due to high literacy and awareness levels in some states like Kerala. However, it identified several issues, including irregular supply of sanitary napkins, lack of storage facilities, and quality concerns about the pads. These issues led to significant losses and rejection of the aid by some beneficiaries. The study suggests that integrating the scheme with existing health programs could increase its efficacy. It also highlights the need for better supply chain regulation and transparency. The study provides valuable insights into the scheme's implementation and response, contributing to our understanding of menstrual hygiene management in different geographical contexts.

2.2 Non-Government Organizations role

A comprehensive review of national-level menstrual health stakeholders reveals that NGOs, small enterprises, and even international donors have started addressing menstrual health issues.

- These organizations have identified the factors influencing the access and use of menstrual hygiene management (MHM) products, and have tailored their initiatives and operations based on these factors.

- EcoFemme[74]conducted a study on washable cloth pads as a menstrual hygiene solution in rural India. These pads were favored for their familiarity, cost-effectiveness, and comfort. The high cost of certain products makes them inaccessible for many rural households. This leads to a continued reliance on mass-produced sanitary pads.
- The National Family Health Survey (NFHS) is a recurring survey in India, providing data on health and family welfare. Done by the International Institute for Population Sciences, it aids in policy and program development. The fourth round, NFHS-4, was conducted in 2014-2015. Its findings contribute significantly to understanding health and family welfare issues in India.

2. Social Welfare Supply Chain study

3.1 Social Welfare Supply chains in Indian states and other countries

a) India's Public Distribution System (PDS), managed by the Food Corporation of India, provides subsidized basic commodities to the less affluent. It has evolved into the Targeted Public Distribution System (TPDS), focusing on the poor. The government procures food grains at higher prices to incentivize farming and sells them to beneficiaries at lower prices. Despite its reach, the system is criticized for inefficiency, discrimination, and corruption. Key challenges include poor infrastructure, logistics, and insufficient warehouses.

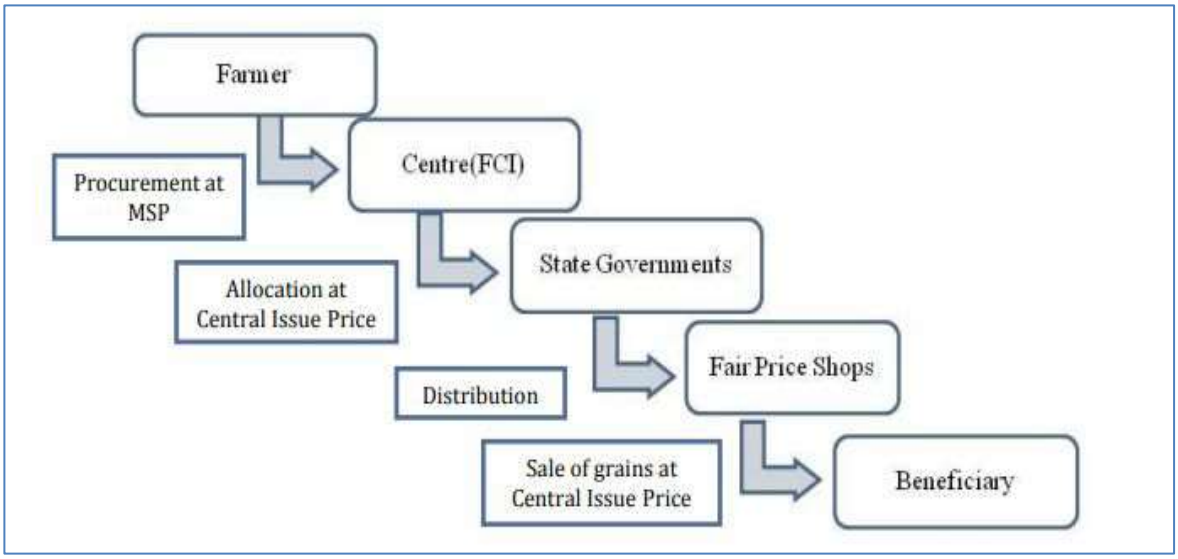

Fig 2. PDS Supply Chain Network

b) The Drug Distribution Project (DDP) in California (1999-2001) aimed to distribute $171 million worth of drugs freely.
The project had two main objectives:
1) Minimize the difference between the ratio of allocations and the weighted orders ofclinics
2) Minimize the leftover budget in every period.

Medpin used a priority matrix approach for efficient allocation, resulting in 2.6 million 30-day drug prescriptions filled over three years.
c) Ready to Use Therapeutic Food (RUTF) Products: UNICEF helps malnourished children in low and middle-income countries. Nutriset, a French firm, initially produced Plumpy Nut, a peanut-based RUTF. As demand grew, UNICEF decentralized the supply network, with most suppliers in developing nations. Nutriset provided these suppliers with production equipment, raw materials, and quality control systems.

d) Decentralization reduced costs and lead times, and boosted local economies. The project posed several questions related to facility location and customer service to minimize costs. The project assumed a single product in the supply chain, with inventory decisions related to facility opening and associated costs. This approach was defined as a "Social Welfare Chain",

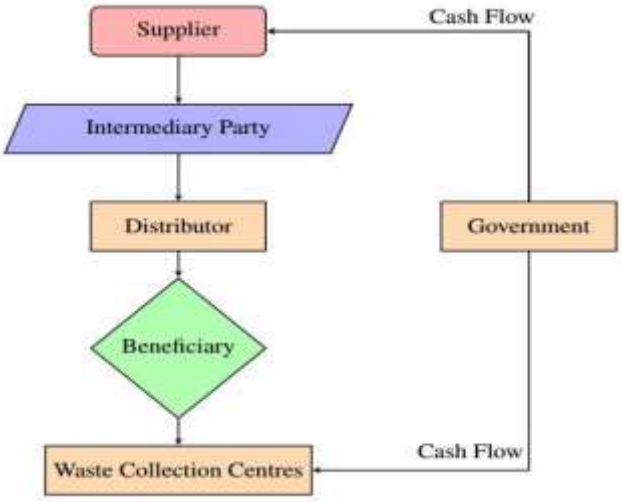

Fig 3. Movement of goods from supplier, beneficiary, and waste collection centre– Product Flow

3.2 Demand Model

Data canvassing: The study utilized open-source data from the Government of India's websites. Data was gathered from three primary sources and pre-processed for analysis. The algorithm developed for this study primarily used two parameters: transportation costs and demand values. This approach ensured reliable and accessible data for drawing inferences.

The study utilized the 2011 India census data for its monthly demand model. This data, offering a detailed rural-urban population split and sex ratio, was incorporated at varioussupply chain stages. This approach allowed for a nuanced understanding of demand patterns across different regions.

The study determines transportation costs based on the road distance between two points, assuming a direct proportionality.

3.3 Model Proposed is:

A supply chain network that our model addresses is attached here for reference.

Legend: S: Suppliers, W: Warehouse, B: Blocks, L: Beneficiaries/ village locations

PHC: Primary Health Centres/ sub-centres for reverse logistics

The study seeks to optimize the supply network by deciding which facilities to open and determining the supply quantity between nodes. The goal is to reduce the overall expenditure to the lowest possible amount. This involves optimizing resources and processes to achieve the most cost-effective outcome. It includes establishment, procurement, quality, and transportation costs. This approach aims for cost-effectiveness and efficiency in the supply network.

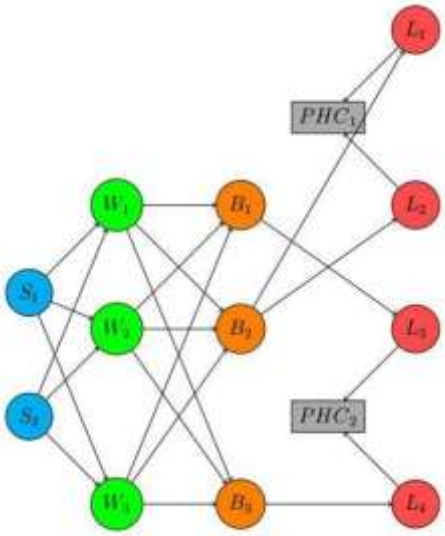

Fig 5. Supply Chain Network

In addition to developing the algorithm, it's essential to consider its practical implications, especially in the Indian context. Supply chain contracts, which guide supplier-buyer relationships, can significantly influence long-term decisions and government expenditures. Contracts based on such algorithms can ensure long-term

sustainability and improve the distribution of subsidized products to the intended beneficiaries. Thus, the algorithm has a broader impact, enhancing the effectiveness of supply chains in the Indian subcontinent.

Assumptions:
- Single period
- Single product
- Identical suppliers
- Supplier - capacities, location known
- Fixed Transportation Costs

Neglected Factors
- Inbound transportation costs, variable handling costs at Warehouses/Cross-Docks
- Inventory costs (cycle/safety/pipeline)

3.4 Model Formulation
Indices/Sets:
N Set of suppliers i 2 N
M Set of potential facility sites j 2 M
L Set of block-level storage facilities k 2 L

Input Parameters
S^i Quantity manufactured/supplied by supplier i
$dist_{ij}$ Distance between supplier and facility
$dist_{jk}$ Distance between facility and block
PcC_{ij} Cost of procurement from supplier i for potential warehouse j
TrC_{ij} Cost of transporting from supplier i to potential warehouse j
TrC_{jk} Cost of transporting from warehouse j to storage facility k
$tcoq_{yi}$ Total cost of quality for supplier i as function of yi
FC_j Fixed cost of setting up facility at j
$DMax_i$ Maximum acceptable proportion of defective by supplier i
X_{jk} Quantity needed at j to satisfy demand for block k
M = [1 x J] 3 J >= (S^*_{ij}+X_{jk}) R Requisite distance to satisfy Level of Service requirements

Decision Variables
Sij Quantity supplied by supplier i from potential warehouse j
Sij* Quantity of good product shipped from supplier i to potential: warehouse
yi Percentage defective from supplier i
z^j= 1 (if warehouse open) 0 (if closed)

3. 5 Input for constraints
MinPctInR Minimum percentage demand satisfied within R km of cross-dock/warehouse
d_k Total demand in a single period
z_{min}; z_{max} Lower/upper bounds on no. of cross-docks/warehouses to be opened
a_{jk} = 1 (if block k served by warehouse is within R km of cross-dock/warehouse
= 0, otherwise

3.6 Model

$$\min(z)=\sum_{i\in I}\sum_{j\in J}(PcC_{ij}\cdot S_{ij})+\sum_{i\in I}\sum_{j\in J}(TrC_{ij}\cdot S_{ij})$$
$$+\sum_{i\in I}\sum_{j\in J}(TrC_{ij}\cdot(S_{ij}-S^*_{ij}))+\sum_{i\in I}\sum_{j\in J}(tcoq\cdot(1-y_i)\cdot S_i)$$
$$+\sum_{j\in J}(FC_j\cdot z_j)+\sum_{j\in J}\sum_{k\in L}(TrC_{jk}\cdot X_{jk})$$

subject to the constraints Supply Constraint $\sum_{j\in J} S_{ij}\le S_i$

Demand Constraint $\sum_{j\in J} X_{jk}=d_k$

Flow Conservation $\sum_{k\in L} X_{jk}=\sum_{i\in I} S^*_{ij}$

Quality-Quantity Linking $\mathbf{S}_{ij}(1-y_i)\ge S^*_{ij}$

No. of Facilities $\mathbf{z}_{min}\le\sum_{j\in J} z_j\le z_{max}$

Quality Tolerance $\mathbf{y}_i\le DMax_i \quad \forall i$

Facility Opening: Linking Constraint $(\mathbf{S}^*_{ij}+X_{jk})-z_jM\le 0 \qquad \forall j\in J,\forall k\in L$

LoSConstraint (ii) $\sum_{jk}\frac{(a_{jk}\cdot X_{jk})}{\sum_k d_k}\le MinPctIn30$

$$\mathbf{S}_{ij} \geq 0 \quad S_{ij} \in int$$
$$\mathbf{S}^*_{ij} \geq 0 \quad S^*_{ij} \in int$$
$$\mathbf{z}_j \geq 0$$
$$\mathbf{y}_i \geq 0 \quad y_i \in [0,1]$$

4. Flows and Technology Integration

The proposed social welfare chain aims to ensure fairness, responsiveness to beneficiaries' needs, protect donor agencies' interests through transparency and accountability, minimize costs, and maintain fiscal integrity. The logistical strategies employed can create a lean supply chain responsive to beneficiaries' needs. The capital is expected to be raised from donations or government funding, with performance measures based on responsiveness, costs, flexibility, and output variables' values.

Inventory control in social welfare chains is less challenging than in humanitarian relief chains due to predictable demand patterns. However, significant challenges could arise in implementing this configuration:

1. **Negligible recognition of logistics' importance**: In social welfare campaigns, logistics, especially last-mile logistics, is often thought to have a subsidiary priority function. This leads to inadequate funding for various support activities.
2. **Pad collection from end beneficiaries for disposal**: This is a crucial step in the process that needs to be efficiently managed.
3. **Coordination of multi-point transfers**: This needs to be done wherever and whenever possible to ensure smooth operations.
4. **Increasing awareness for efficient disposal and reverse logistics**: This includes educating beneficiaries about the need for disposal and managing the corresponding scrapping costs. Indeed, addressing these challenges is crucial for the successful implementation of the plan. It's important to tackle each issue systematically to ensure the effectiveness of the overall strategy.

Fig 5. Stakeholders Involved [5]

A smart contract is a code executed on the network's computers. All computers executing the code must reach a consensus, ensuring the code's correct execution.

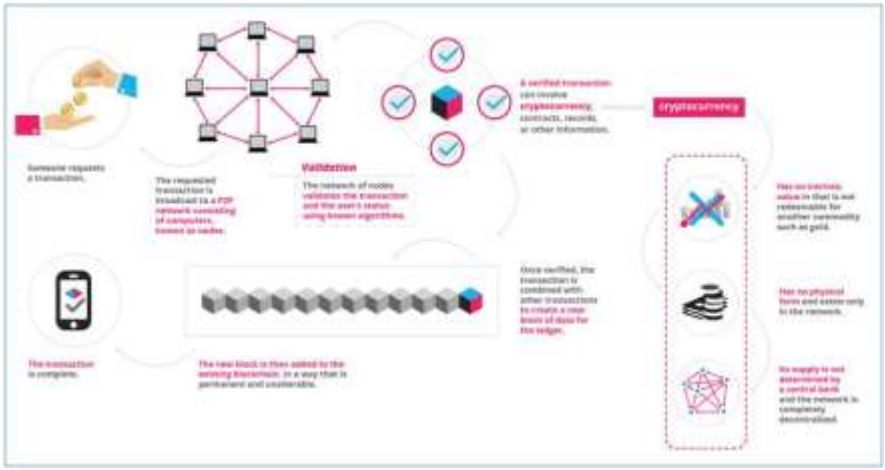

Fig 6. Infographic: Blockchain Technology

A token, which represents a benefit or subsidy, was created using Solidity. Solidity is a programming language specifically designed for writing smart contracts on Ethereum, a platform that utilizes blockchain technology. This token was then deployed on the Ethereum Wallet application within a private network. This can be seen as a digital representation of the nodes within a supply network. In addition to this, a virtual wallet application was created. This application, which would be used by the beneficiaries, allows for the access and transaction of tokens within the private network. This setup enables an efficient and secure method for the distribution and management of benefits or subsidies.

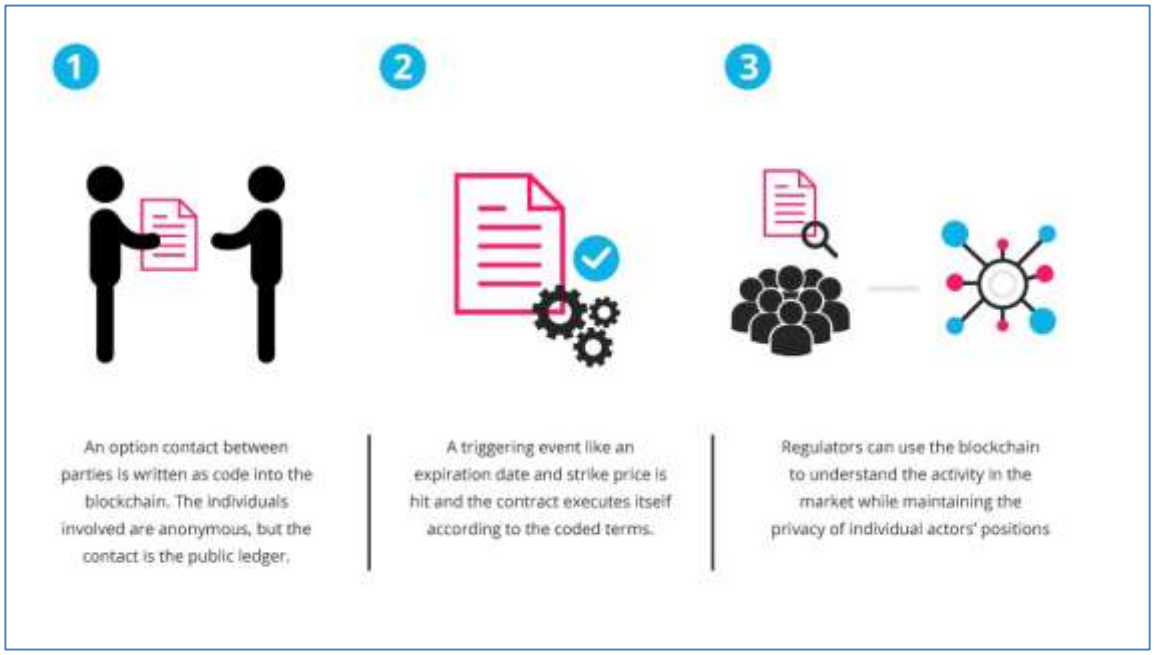

Fig 7. Infographic: Smart Contracts

5. Conclusions

Cost Frameworks: Establishing supply chains incurs varying costs across different states, as seen in Jharkhand and Kerala. These variations are due to unique state factors such as sex ratio, menstruating women count, and tribal population size. These elements influence the demand in each state. Transportation costs, a significant part of the cost structure, are largely dependent on the terrain, which differs from state to state. For instance, hilly terrains would incur higher transportation costs than flat areas. This implies that while the central government can provide policy direction, the detailed execution should be state-specific. Therefore, state governments should have the autonomy to tailor the implementation frameworks for successful scheme execution.

Future Work: This study successfully designs a four-tier humanitarian supply chain using a mixed integer linear programming approach, specifically for distributing subsidized menstrual hygiene products across India.

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