ABSTRACT

India's Public Distribution System (PDS) plays a crucial role in ensuring national food security; however, inefficiencies in procurement, storage, and distribution persist, hindering its effectiveness. This thesis presents a comprehensive and systematic framework for optimizing the food grain supply chain through state-specific mathematical models and decision-support tools. The research begins with the development of mathematical models to optimize food grain movement under diverse operational constraints across states. These models aim to minimize transportation distances, streamline the distribution network, and enhance scalability.

To support practical implementation, the thesis introduces *Anna Chakra*, a route-optimization tool designed to automate data processing, execute optimization models, and facilitate data-driven decision-making for state governments. Built using Python, HTML/CSS/JavaScript, and MySQL, the tool incorporates robust error handling, validation checks, and flexibility to accommodate state-specific supply chain variations.

Building on the success of PDS movement optimization, the research extends to the procurement stage, modelling the movement of food grains from Procurement Centres (PCs) to mills and warehouses. Mathematical models have been developed for decentralised procurement states (DCP), such as Punjab and Haryana, resulting in a significant reduction in average transportation distance when implemented by state agencies. However, the location of procurement centres remains a persistent challenge, as current practices rely on annual grain arrival estimates. To address this gap, the thesis proposes a mathematical framework based facility location model to identify optimal PC locations, enhance accessibility, and mitigate regional imbalances in procurement infrastructure.

Overall, this research contributes a scalable, data-driven framework and a practical computational tool to strengthen India's food grain supply chain, from procurement to end-distribution, supporting more efficient, equitable, and resilient food security operations.