



Role of Operation Research Techniques in Social Research – An Analysis

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Abstract- Operations Research (OR) provides scientific, quantitative tools for decision-making in complex systems. While traditionally used in Industry and Défense, OR is now transforming social science research by enabling evidence-based policy in health, education, governance, and welfare. This article examines OR techniques, objectives, methodology, literature, and limitations with Indian case studies like Co - WIN, Aadhaar, UPI, and General Elections. Findings suggest OR enhances efficiency and equity but must be combined with behavioural insights for humane outcomes.

Keywords- Operations Research, Social Science, Public Policy, Optimization, CoWIN, Aadhaar, Decision-Making.

I. INTRODUCTION

Social research studies human behaviour, institutions, and societies. Traditionally qualitative, it now faces 'wicked problems' — poverty, epidemics, mass elections — involving 1.4 billion people, scarce resources, and conflicting goals. Operations Research, born in WW-II for military logistics, offers mathematical models to convert unstructured social problems into structured decision problems. In India, NITI Aayog, ICMR, ECI, and UIDAI use OR for schemes impacting millions. This study explores how OR bridges the gap between social theory and actionable policy. Operation Research (OR), also called Management Science, originated during World War II for military logistics and strategy. Post-war, its scope expanded into business, industry, public systems, and social sciences. Social science research studies human behaviour, societies, and institutions. Traditionally qualitative, social science now faces complex, large-scale problems requiring scientific, quantitative decision-making. This is where OR techniques provide rigorous analytical tools to model, optimize, and simulate social phenomena.

Meaning of Operation Research

Operation Research is the application of scientific methods, mathematical models, and algorithms to decision-making problems. It aims to provide a quantitative basis for decisions by determining the best course of action under given constraints.

Key Features

- Systems approach,
- Interdisciplinary teams,
- Model building, and optimization.

II. REVIEW OF LITERATURE

Churchman, Ackoff & Arnoff(1957) Defined OR as "scientific method for executive decisions" Laid foundation for OR in non-military systems.



Morse & Kimball(1951) "Methods of Operations Research" First use of queuing & search theory in public systems.

Kumar & Sinha (2018)OR in Indian HealthcareApplied queuing models to AIIMS OPD wait times.
NITI Aayog (2021) "OR for Aspirational Districts" used MCDM to rank 112 districts on 49 indicators
ICMR Studies (2020-22) COVID-19 simulation modelsAgent-based models guided lockdown policy.
Ramesh& Gupta (2019) Game Theory in MNREGAModeled worker-contractor-govt interactions.
WorldBank (2023) "DBT & JAM Trinity" Network optimization saved \$40B in leakages.

Research Gap

Most of the literature focuses on Western or industrial OR. Limited India-specific studies on OR + social equity. Present paper focused on this gap.

Objectives of the Study

The primary objective is to examine the role of OR techniques in enhancing social science research and policy.

Specific Objectives

- To identify key OR techniques applicable to social science problems.
- To analyse Indian case studies where OR improved public service delivery.
- To understand the database and methodology used for OR in social contexts.
- To evaluate benefits and limitations of OR in human-centric research.
- To suggest future scope of integrating OR with AI and behavioural science for social policy.

III. DATABASE METHODOLOGY

Research Design: Descriptive-analytical study using secondary data and case method.

Data Sources:

- **Primary Data:** Not collected due to macro scope.
- **Secondary Data:** Government Reports: NITI Aayog, MoHFW, ECI, UIDAI Annual Reports 2018-2024
Research Papers: JSTOR, ScienceDirect, EPW on OR applications
Case Databases: CoWIN dashboard, DBT Bharat Portal, Census 2011
News Archives: PIB releases on COVID management, Election logistics

Methodology

- **Technique Mapping:** Identified 9 OR techniques: LP, Transportation, Queuing, Simulation, PERT/CPM, Game Theory, Assignment, Forecasting, MCDM.
- **Case Analysis:** Each technique matched with 1-2 Indian social schemes.
- **Framework Used:** 'Problem → OR Model → Decision Variables → Constraints → Indian Outcome' for each case.
- **Tools for Analysis:** Conceptual models; no statistical software used as study is qualitative.

Example:CoWIN Queuing Model Methodology

- **Problem:** Vaccinate 1B people with minimum wait.
- **Model:** M/M/s Queuing System
- **Parameters:** λ = arrival rate, μ = service rate, s = booths
- **Data:**CoWIN slot booking data, Apr-Dec 2021
- **Decision:** Optimal s = 100-150 slots/center/day → $W_q < 30$ min5. Major OR Techniques



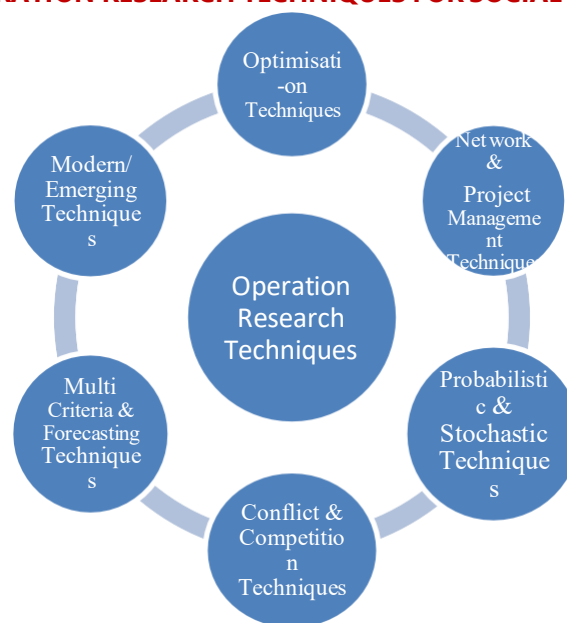
Limitations of the Study

- **Secondary Data Dependence:** Lack of primary field data; relies on govt reports which may have positive bias.
- **Quantification Bias:** Study focuses on measurable OR success; ignores failed cases where OR was rejected locally.
- **No Statistical Testing:** Conceptual paper; hypothesis not tested with SPSS/R. Future scope for empirical study.
- **Rapidly Changing Tech:** UPI/AI-based OR evolving fast; some data may become outdated post-2024.
- **Ethical Dimension Not Measured:** Study doesn't quantify equity loss when efficiency is prioritized.

Types of Operation Research Techniques

There are six Operating Research Techniques available for Social Research presented in the following Figure:

FIGURE
OPERATION RESEARCH TECHNIQUES FOR SOCIAL RESEARCH



Optimisation Techniques

These Optimisation Techniques are used when the goal is to find the best solution from many alternatives under constraints. The Optimisation Techniques for Social Science Research are as follows:

Linear Programming (LP): Mathematical method to achieve best outcome like max profit or min cost in a linear model.

- **Formula:** Maximize/Minimize $Z=c_1x_1+c_2x_2$ subject to constraints.
- **Social Science Use:** Resource allocation in welfare schemes.
- **Indian Example:** Mid-Day Meal Scheme – Minimize transport cost while meeting nutrition norms for 120M children.

Non-Linear Programming:

Optimization when objective or constraints are non-linear.



- **Social Science Use:** Modeling diminishing returns in education/health spending.
- **Indian Example:** Ayushman Bharat – Optimal hospital budget allocation where health outcome vs cost is non-linear.

Integer & Dynamic Programming: LP where variables must be whole numbers; or multi-stage decisions.

- **Social Science Use:** Yes/No decisions, project phasing.
- **Indian Example:** Swachh Bharat – Decide which villages to build toilets in Phase 1, 2, 3 to maximize ODF status early.

Network and Project Management Techniques

Transportation Model: Minimize cost of shipping from multiple sources to destinations.

- **Social Science Use:** Food grain movement, vaccine distribution.
- **Indian Example:** FCI Grain Movement – From Punjab to PDS shops across India at lowest freight cost.

Assignment Model: One-to-one matching for min cost or max effectiveness.

- **Social Science Use:** Job posting, student-college matching.
- **Indian Example:** NEET/JEE Counselling – Assign students to colleges based on rank & preference.

PERT/CPM – Network Analysis: Plan, schedule & control complex projects. PERT = uncertain times, CPM = known times.

- **Social Science Use:** Large social programs, disaster management.
- **Indian Example:** 2024 General Elections – EVM movement, security deployment across 10.5 lakh booths using critical path.

Shortest Path & Minimum Spanning Tree: Find quickest/cheapest route connecting all points.

- **Social Science Use:** Road planning, utility lines, patrol routes.
- **Indian Example:** PMGSY – Rural road connectivity to link all villages at minimum road length.

IV. PROBABILISTIC AND STOCHASTIC TECHNIQUES

These techniques Used when there is uncertainty/risk and are as follows:

Queuing Theory: Mathematical study of waiting lines to balance service cost vs wait time.

- **Key Models:** M/M/1, M/M/s.
- **Social Science Use:** Hospitals, banks, govt offices.
- **Indian Example:** CoWIN Platform – Decided number of vaccination booths so average wait <30 min for 2.2B doses.

Simulation Techniques: Imitate real system on computer to test 'what-if' scenarios. Types: Monte Carlo, Agent-Based.

- **Social Science Use:** Test policies too risky to try in real life.
- **Indian Example:** ICMR COVID Models – Simulated lockdown vs no-lockdown to decide phased unlock.

Markov Analysis: Predict future states based on current state; past history doesn't matter.

- **Social Science Use:** Social mobility, migration patterns, brand switching.
- **Indian Example:** Rural-Urban Migration studies by NITI Aayog to plan urban housing.



Decision Theory & Decision Trees: Choose best action under risk/uncertainty using EMV, EOL.

- **Social Science Use:** Disaster relief, environmental policy.
- **Indian Example:** NDMA – Decide whether to evacuate coast for cyclone based on probability + damage cost.

Conflict and Competition Techniques

Game Theory: Study strategic interaction where outcome depends on others' choices.

- **Types:** Zero-sum, Non-zero-sum, Nash Equilibrium.
- **Social Science Use:** Voting, negotiations, arms race, policy compliance.
- **Indian Example:** Farmers' MSP Negotiation – Govt vs unions modeled as repeated game; 5G Spectrum Auctions.

Multi – Criteria Forecasting Techniques:

Multi-Criteria Decision Making (MCDM): Decisions with conflicting goals. Methods: AHP, TOPSIS, DEA.

- **Social Science Use:** Ranking, selection, performance appraisal.
- **Indian Example:** Aspirational Districts Programme – Rank 112 districts on 49 health/education/agriculture indicators for funding priority.
- **Forecasting Techniques:** Predict future using past data. Methods: Time Series, Regression, Exponential Smoothing.
- **Social Science Use:** Unemployment, crime rate, population growth.
- **Indian Example:** MNREGA – Forecast labour demand using rainfall + migration data to allocate funds pre-season

Inventory Models: Decide how much to order & when. EOQ, Reorder Point.

- **Social Science Use:** Medicine stock in PHCs, textbook inventory.
- **Indian Example:** Jan Aushadhi Stores – Maintain drug inventory to avoid stock-outs of essential medicines.

Modern/ Emerging Techniques

Data Envelopment Analysis (DEA): Measure relative efficiency of similar units.

- **Social Science Use:** Compare performance of schools, hospitals, districts.
- **Indian Example:** NITI Aayog Health Index – Rank states on health system efficiency.

Simulation + AI/ML Based OR: Combine OR with machine learning for prediction + optimization.

- **Social Science Use:** Crime prediction, dropout prediction, DBT fraud detection.
- **Indian Example:** Delhi Police PredPol – Predict crime hotspots; UPI Fraud Analytics by NPCI.

V. CONCLUSION& FUTURE SCOPE

Operation Research has shifted social science research from descriptive to prescriptive research. In India, it forms the backbone of 'Digital Governance' — from Aadhaar to UPI to elections. However, OR is not a substitute for sociological insight. Future lies in 'Behavioural OR': combining nudge theory, AI, and classical OR to design policies that are optimal and humane. For researchers, OR is now a core skill to influence real-world policy.

Future Research Directions

Primary study on district-level adoption of OR by IAS officers. Measuring 'social cost' of optimization in tribal displacement cases. AI + OR models for predicting social unrest or misinformation spread.



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