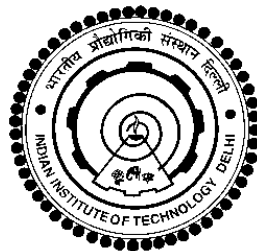


**A SELECT STUDY ON THE DECISION MODELS IN THE
HUMANITARIAN SUPPLY CHAIN**

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A SELECT STUDY ON THE DECISION MODELS IN THE HUMANITARIAN SUPPLY CHAIN

by

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Department of Management Studies

Submitted

in fulfilment of the requirements of the degree of **Doctor of Philosophy**

to the



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CERTIFICATE

This is to certify that the thesis titled “**A Select Study on the Decision Models in the Humanitarian Supply Chain**” being submitted by **Mr. Anchal Patil** to the Indian Institute of Technology Delhi for the award of the degree of **Doctor of Philosophy** is a record of original research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

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ABSTRACT

Humanitarian Supply Chain (HSC) has become one of the most critical research domains due to the increased occurrence of severe disasters worldwide. The extreme and consistent need for humanitarian assistance has compelled the HSC stakeholders to adopt more effective and result oriented practices. The increased pressure from the funding organizations, media, Government, and public has complicated the relief operations for Humanitarian Organizations (HOs). HOs require efficient decision models that can help improve their performance. Therefore, a requirement emerged to appraise the decision models facilitating performance improvement in HSC. The present research fulfils this requirement by accessing the performance measurement and improvement models. The present research work has been conducted in five phases.

In the first phase of the study, a comprehensive framework focusing on the Performance Measurement System (PMS) has been proposed by capturing feedback from humanitarian practitioners. This chapter identifies seventeen barriers preventing the implementation of PMS. The barriers have been ranked based on the degree of influence using the grey Analytic Network Process (ANP) approach. The interrelationship among the significant barriers has been established through modified total interpretive structural modelling. The issues concerned with the skills of personnel have been reported as the most significant barrier. The study synthesized several strategies aiming to improve Performance Measurement Activities (PMA).

Strategies synthesized in the first phase have been modelled using the grey Decision-Making Trial and Evaluation Laboratory (DEMATEL) methodology in the second phase. Results indicated that the most effective strategies can be fundraising for PMA, digital supply chain adoption, higher management support, public sensitization towards disaster data collection and relief worker training. It became clear that HOs have resource management challenges and require more effective means of allocating such resources. This chapter advances the understanding of PMS in the context of HSC. It provides a holistic approach to relieve the issues that occurred during PMA.

Further, a Situation-Actors-Process, Learning-Action-Performance (SAP-LAP) analysis has been performed to analyze resource allocation and the issues of inappropriate resource convergence. The problem-solving framework of SAP-LAP has been adopted to

synthesize strategies for resolving the resource convergence issue. The findings from the study have been verified by adopting the system dynamics simulation. Later, a case study focusing on pharmaceutical resources during a humanitarian crisis has been carried out to assess the effect of proposed strategies on the HSC. This chapter comprehensively approaches the issues of resource convergence.

In the subsequent phase, a framework based on a novel Fuzzy Best-Worst Method (FBWM) and ANP methodology has been proposed to investigate the management of heterogeneous relief resources. The study highlights the need to focus on managing medical and pharmaceutical products from the operational and environmental aspects. The outcome of the study reveals the interlink between barriers and sheds light on the socio-environmental aspect of donations. The study paves the path for future researchers to explore sustainability enablers in the relief supply chain.

The last phase of the study proposes a Decision Support System (DSS) facilitating resource estimation in response to disaster intensity. The DSS aims to reduce the hazard associated with resource convergence by appropriately accessing the need for resources. This study considers the case of the COVID-19 pandemic outbreak and estimates the health care resource requirements. A system dynamics simulation model has been proposed, integrating the health care capacity module with the Susceptible - Exposed - Infectious – Recovered model. The results reflect that a functional diagnostic capacity of five thousand five hundred thirty-three in Delhi seemed sufficient to prevent the epidemic when aggressive testing has been initiated on the eleventh day of the outbreak. Further, the study proposed two forecasting models for estimating potential infections. Proposed DSS can assist the decision-maker in short and long-term planning during the disease outbreak.

The present thesis has comprehensively explored issues associated with heterogeneous relief resources and PMS in HSC. The thesis provides various frameworks and decision-models that aim to improve the performance of humanitarian operations. Various insightful recommendations and managerial implications have been derived, with far-reaching impacts on humanitarian operations and supply chain research. Gaps identified in the literature review have been systematically addressed, benefiting the body of knowledge focusing on humanitarian research.

Keywords: Humanitarian Supply Chain, Performance Measurement, Simulation, MCDM.

सार

गंभीर आपदाओं की बढ़ती घटनाओं के कारण दुनिया भर में सबसे महत्वपूर्ण अनुसंधान में एक कार्यक्षेत्र मानवीय आपूर्ति श्रृंखला (एच एस सी) उभर कर आया है। मानवीय सहायता की निरंतर और अत्यधिक आवश्यकता ने एचएससी धारकों को अधिक प्रभावी और परिणाम उन्मुख प्रयासों को अपनाने के लिए प्रेरित किया है। वित्त पोषण संगठनों, संचार संगठनों, सरकार और जनता के दबाव ने मानवीय संगठनों (एच ओ) के लिए राहत कार्यों को जटिल बना दिया है। एचओ को कुशल निर्णय मॉडल की आवश्यकता होती है, जो उनके प्रदर्शन को बेहतर करने में मदद कर सके। इसलिए एचएससी में प्रदर्शन सुधार को सुविधाजनक बनाने वाले निर्णय मॉडल की आवश्यकता सामने आई है। वर्तमान शोध कार्य इस आवश्यकता को पूरा करने के लिए प्रदर्शन मापन तथा सुधार मॉडल पर ध्यान केंद्रित करता है। वर्तमान शोध कार्य पांच चरणों में किया गया है।

पहले चरण में मानवीय आपदा प्रबंधकों से प्रतिपुष्टि प्राप्त करके प्रदर्शन मापन प्रणाली (पी एम एस) पर ध्यान केंद्रित करने वाला एक व्यापक मॉडल प्रस्तावित किया गया है। यह अध्याय पीएमएस के कार्यान्वयन को रोकने वाली बाधाओं की पहचान करता है। ग्रे एनालिटिक नेटवर्क प्रोसेस (ए एन पी) का उपयोग करके प्रभाव की श्रेणी के आधार पर बाधाओं का क्रम स्थापित किया गया है। महत्वपूर्ण बाधाओं के बीच संबंध स्थापित करने के लिए संशोधित कुल व्याख्यात्मक संरचनात्मक मॉडलिंग (टी आई एस एम) को अपनाया गया है। अध्ययन के नतीजों से पता चलता है कि कर्मियों के कौशल से संबंधित मुद्दे सबसे महत्वपूर्ण बाधा है। अध्ययन में प्रदर्शन मापन गतिविधियों को बेहतर बनाने के उद्देश्य से रणनीतियों को संश्लेषित भी किया गया है।

पहले चरण में संश्लेषित रणनीतियों को दूसरे चरण में ग्रे डिजीजन-मेकिंग ट्रायल एंड इवैल्यूएशन लेबोरेटरी (डी मै ट ल) क्रियाविधि का उपयोग करके अध्ययन किया गया है। परिणाम दर्शाते हैं कि प्रदर्शन मापन के लिए अनुदान संचयन, डिजिटलीकरण, उच्च प्रबंधन सहायता, आपदा आंकड़ा संग्रहण के प्रति सर्वजनिक संवेदीकरण और राहत कार्यकर्ता प्रशिक्षण सबसे प्रभावी रणनीतियाँ हैं। एक महत्वपूर्ण अंतर्दृष्टि जो प्रदर्शित करती कि जो एचओ संसाधन प्रबंधन के मुद्दों से जूझ रहे हैं, उन्हें संसाधन आवंटन के अधिक प्रभावी उपाय की आवश्यकता है। यह अध्याय एसएससी के संदर्भ में पीएमएस की समझ को आगे बढ़ाता है। यह प्रदर्शन मापन गतिविधियों के दौरान हुई समस्याओं को दूर करने के लिए एक समग्र दृष्टिकोण प्रदान करता है।

तीसरे चरण में संसाधन आवंटन और अनुचित संसाधन अभिसरण के मुद्दों का विश्लेषण करने के लिए एक स्थिति अभिनेता प्रक्रिया-सीखना क्रिया प्रदर्शन (सैप-लैप) का उपयोग किया गया है। संसाधन अभिसरण मुद्दे को हल करने हेतु रणनीतियों को संश्लेषित करने के लिए सैप-लैप की समस्या समाधान रूपरेखा को अपनाया गया है। सिस्टम डायनॉमिक्स अनुरूपण को अपनाकर अध्ययन के निष्कर्षों को सत्यापित किया गया है। बाद में एचएससी पर प्रस्तावित रणनीतियों के प्रभाव का आकलन करने के लिए आपदा के दौरान फार्मास्यूटिकल संसाधनों पर ध्यान केंद्रित करने के लिए एक केस स्टडी की गई है। इस अध्ययन में व्यापक रूप से संसाधन अभिसरण के मुद्दों पर चर्चा की गई है।

बाद के चरण में, विषम राहत संसाधनों के प्रबंधन की जांच के लिए एक नवीन फजी बेस्ट वर्स्ट मेथड और एएनपी क्रियाविधि पर आधारित एक रूपरेखा प्रस्तावित की गयी है। अध्ययन संचालन और पर्यावरणीय पहलुओं से चिकित्सा और दवा उत्पादों के प्रबंधन पर ध्यान केंद्रित करने की आवश्यकता पर प्रकाश डालता है। अध्ययन के परिणाम सतत बाधाओं के बीच के संबंधों को उजागर करते हैं और दान के सामाजिक-पर्यावरणीय पहलुओं पर प्रकाश डालते हैं। यह अध्ययन भविष्य के शोधकर्ताओं के लिए राहत आपूर्ति श्रृंखला में वहनीयता को बढ़ावा देने का मार्ग प्रशस्त करता है।

अंतिम चरण में आपदा प्रसार के अनुसार संसाधन आकलन की सुविधा प्रदान करने वाली एक निर्णय सम्बंधित समर्थन प्रणाली प्रस्तावित की गयी है। इस निर्णय सम्बंधित समर्थन प्रणाली का उद्देश्य संसाधनों की आवश्यकताओं को उचित रूप से समझ कर संसाधन अभिसरण से जुड़े खतरे को कम करना है। यह अध्ययन कोविड-19 सर्वव्यापी महामारी के प्रकोप के मामले पर विचार करता है और स्वास्थ्य देखभाल संसाधनों की आवश्यकताओं का अनुमान लगाता है। एक सिस्टम डायनॉमिक्स मॉडल का प्रस्ताव दिया गया है जो स्वास्थ्य देखभाल क्षमता मॉड्यूल को अतिसंवेदनशील - उजागर - संक्रामक - स्वस्थ (एस इ आई आर) मॉडल के साथ एकीकृत करता है। अनुरूपण के परिणाम दर्शाते हैं कि दिल्ली में ५५३५ परीक्षणों की कार्यात्मक निदान क्षमता महामारी को रोकने के लिए पर्याप्त है जब प्रकोप के ११ दिन परीक्षण शुरू किया गया। इसके अलावा अध्ययन ने संभावित संक्रमण के आकलन के लिए दो पूर्वानुमान मॉडल प्रस्तुत किए हैं।

प्रस्तावित निर्णय संबंधित समर्थन प्रणाली महामारी के प्रकोप के दौरान छोटी और लंबी अवधि की योजना बनाने में निर्णय लेने में सहायता कर सकता है ।

वर्तमान कार्य में मानवीय आपूर्ति श्रृंखला में विषम राहत संसाधनों और प्रदर्शन मापन से जुड़े मुद्दों का व्यापक रूप से अध्ययन किया गया है । यह शोध-ग्रंथ विभिन्न रूप रेखा और निर्णय मॉडल प्रदान करती है जिसका उद्देश्य मानवीय कार्यों के प्रदर्शन में सुधार करना है । मानवीय कार्यों और आपूर्ति श्रृंखला अनुसंधान पर दूरगामी प्रभावों के साथ विभिन्न कार्यान्वयन योग्य सिफारिशें तथा प्रबंधकीय निहितार्थ प्राप्त किया गया है । पूर्व वैज्ञानिक कार्य में पहचाने गए अनुसंधान अंतराल को व्यवस्थित रूप से संबोधित किया गया है जिससे मानवीय अनुसंधान पर केंद्रित ज्ञान को लाभ हो सकता है ।

संकेत शब्द: मानवीय आपूर्ति श्रृंखला, प्रदर्शन मापन, अनुरूपण, एम सी डी एम।

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LIST OF ABBREVIATIONS

DMS	Disaster Management System
HSC	Humanitarian Supply Chain
EM-DAT	Emergency Events Database
HO	Humanitarian Organization
3PR	Public-Private-People Relationship
PMS	Performance Measurement System
PMA	Performance Measurement Activities
RCP	Resource Convergence Problem
BWM	Best-Worst Method
ANP	Analytic Network Process
DEMATEL	Decision Making Trial and Evaluation Laboratory
SAP-LAP	Situation-Actors-Process, Learning-Action-Performance
TISM	Total Interpretive Structural Modeling
MCDM	Multi-Criteria Decision Making
CE	Circular Economy
DSS	Decision Support System
HL	Humanitarian Logistics
BDPA	Big Data and Predictive Analytics
CSC	Commercial Supply Chain
AHP	Analytics Hierarchy Process
BSC	Balance Scorecard
KPI	Key Performance Indicators
ARIMA	Auto-Regressive Integrated Moving Average
ANN	Artificial Neural Network
ANOVA	Analysis of Variance
SDS	System Dynamics Simulation
CFCS	Converting Fuzzy Data into the Crisp Scores
ISM	Interpretive Structural Modelling
CLD	Causal Loop Diagram

SFD	Stock and Flow Diagrams
GMIR	Graded Mean Integration Representation
CR	Consistency Ratio
MLP	Multi-Layer Perceptron
IT	Information Technology
PMF	Performance Measurement Framework
PC	Pharmaceuticals Convergence
HPSC	Humanitarian Pharmaceuticals Supply Chain
WHO	World Health Organization
IDC	International Distribution Centre
NDC	National Distribution Centre
RW	Regional Warehouse
LDP	Local Distribution Point
MPP	Medical and Pharmaceutical Products
HMSC	Humanitarian Medical Supply Chain
RMSE	Root Mean Square Error
MAPE	Moving Average Percentage Error
SEIR	Susceptible-Exposed-Infected-Recovered
ICU	Intensive Care Unit
HCW	Health Care Workers

LIST OF ANNEXURES

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