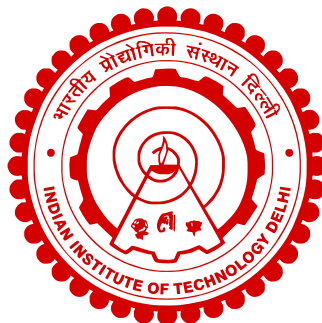


SELECT STUDIES FOCUSING ON SUSTAINABILITY IN PACKAGING SUPPLY CHAIN

GULSHAN KUMAR GAUR



**DEPARTMENT OF MANAGEMENT STUDIES
INDIAN INSTITUTE OF TECHNOLOGY DELHI**

JUNE 2026

© Indian Institute of Technology (IITD), New Delhi, 2026

SELECT STUDIES FOCUSING ON SUSTAINABILITY IN PACKAGING SUPPLY CHAIN

by

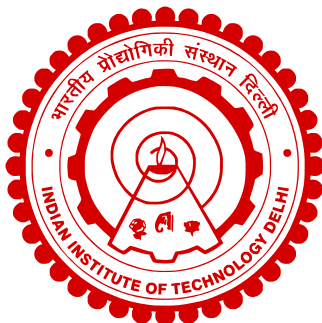
GULSHAN KUMAR GAUR

DEPARTMENT OF MANAGEMENT STUDIES

Submitted

In fulfilment of the requirements of the degree of Doctor of Philosophy

to the



INDIAN INSTITUTE OF TECHNOLOGY DELHI

JUNE 2026

CERTIFICATE

This is to certify that the thesis titled “**Select Studies Focusing on Sustainability in Packaging Supply Chain**”, being submitted by **Mr. GULSHAN KUMAR GAUR** 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 supervision and has fulfilled the requirements for the submission of this thesis, which is in accordance with the standards required for a Ph.D. degree of the institute.

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.

Prof. Jitender Madaan

Professor

Department of Management Studies

Indian Institute of Technology Delhi, India

Hauz Khas, New Delhi, 110016 India

Phone: +91-11-26596077

गुरुर्ब्रह्मा गुरुर्विष्णुः, गुरुर्देवो महेश्वरः ।
गुरुःसाक्षात् परब्रह्म, तस्मै श्रीगुरवे नमः ॥

Dedicated to my parents

Mr. HARI SINGH SHARMA & Mrs. GEETA RANI

for their blessings, unconditional love, support and encouragement.

ACKNOWLEDGEMENTS

I express my deepest gratitude to my supervisor, Prof. Jitender Madaan, Department of Management Studies (DMS), Indian Institute of Technology Delhi, for providing me the opportunity to work on this invaluable research topic and for his excellent supervision throughout the course of this work. This research has been possible due to his enthusiastic interest, valuable guidance, and insightful suggestions, supported by an exceptional foresight that consistently kept me motivated and on course. He has been a mentor to whom I remain deeply obliged for his unconditional trust, patience, and support, and for granting me the freedom to raise even trivial questions without hesitation. Above all, he has continually inculcated in me the belief to pursue the best, and his sympathetic, logical, and principled approach both to academic issues and to life will remain a long-lasting source of inspiration.

I wish to extend my sincere thanks to Head of the Department, Prof. M.P. Gupta (Chairman, SRC), Prof. Amlendu Dubey (SRC Member), and Prof. Varun Ramamohan (SRC Member, External Expert, MED) for their valuable inputs, constructive feedback, encouragement, and guidance at various stages of this research. Their insightful suggestions and critical observations helped strengthen the rigour, clarity, and overall quality of the work. I am also thankful to the Department of Management Studies (DMS), IIT Delhi, for providing an enabling academic environment and the opportunity to pursue this research. I gratefully acknowledge the Ministry of Human Resource Development (MHRD) for the fellowship and financial support that sustained my research journey. I sincerely appreciate the cooperation and support extended by the faculty members and staff of DMS, IIT Delhi, and I take this opportunity to express my heartfelt gratitude to the entire Institute fraternity for contributing, directly or indirectly, to the successful completion of this work.

I would like to sincerely acknowledge all the respondents who participated in my questionnaire survey and related discussions, particularly the domain experts and practitioners associated with sustainability initiatives across the packaging supply chain. Their experiential insights, practical perspectives, and thoughtful responses substantially enriched the empirical grounding of this research and helped align the study with real-world challenges and priorities. I also express my sincere gratitude to the editors and anonymous reviewers of the international journals for their rigorous evaluation and constructive critiques. I would like to thank the thesis examiners for their valuable comments and critical suggestions which significantly enriched the clarity, methodological rigour, quality and scholarly contribution of my work.

I would like to make a special mention of Mr. Neeraj Kumar Singh and Mr. Utkarsh Nigam, two individuals who played a deeply meaningful role in my PhD journey. Mr. Neeraj Kumar Singh is a very close friend of mine and always supported me whenever I reached out to him, offering guidance, encouragement, and help in every possible way. A heartfelt regard for Mr. Utkarsh Nigam for his constructive comments, thoughtful improvements, belief, encouragement, unconditional love and support which enhances quality as well as completion of this work. I gratefully acknowledge my seniors - Dindayal Agrawal, Ashish Dwivedi, Anchal Patil and Amit Gupta for their support, suggestions, and companionship throughout my PhD journey. I am grateful to Vikrant Giri, Sachin Yadav, Krishna Kunal, Himanshu Pandey and many others for moral support throughout my time at IIT Delhi. I feel fortunate to have been surrounded by peers who were not only academically driven but also genuinely supportive, making this journey both enriching and memorable.

I express my heartfelt regards to my grandparents, Late Chanda Devi and Late Channi Ram, whose blessings, values, and quiet strength have remained a lasting source of guidance in my life. I convey my deepest gratitude to my parents, Mr. Hari Singh Sharma and Mrs. Geeta Rani, for their unconditional support, steadfast encouragement, and the sacrifices they made to help me pursue my goals with confidence and integrity. My elder sisters Ritu Gaur, Nisha Rani, and Dev Prabha have always remained inspirational, encouraging, supportive, and advisor to me in my life. A special note of gratitude is due to my younger brother, Mr. Dinesh Kumar Gaur, for the many thoughtful discussions and for nurturing a scientific and rational approach in my thinking. His understanding, constructive guidance, moral support and consistent encouragement helped me face challenges with clarity and strive toward higher standards. My heartfelt regards to Rachna for her support throughout the course of this work. Her affection, understanding, love and strength helped me remain resilient and focused, particularly during demanding phases. I on behalf of our family consider ourselves truly fortunate to have a beautiful baby girl Pratibha in our family. Above all, I bow in humility before the Almighty Creator and Preserver with reverence and gratitude for his grace, protection, and guidance throughout this journey.

Gulshan Kumar Gaur

ABSTRACT

Packaging is a system that enables safe, effective and efficient storage, handling, transportation and marketing of products along the supply chain. Packaging is an integral part of the supply chain and the economy. Consumption and disposal of unsustainable packaging in nature create huge complex problems for our ecosystem. The rapidly growing markets, market competition and technological advancement also accelerate these issues. Therefore, the packaging industries particularly in developing economies are encountering colossal pressure to meet sustainable development goals (SDGs). Many industries are continuously using traditional packaging methods and materials in the products supply chain to fulfill consumer demand and competition. In recent years, growing packaging waste and continuously increasing consumer demand have led to severe environmental impacts that could affect the social as well as economic reputation of the enterprises.

There will be increase in packaging consumption worldwide due to rise in population, particularly in low and lower middle-income nations, which are poised for the most rapid growth. The manufacturing industries of low-income and high-income countries demonstrate different packaging requirements; for example, the motivation for sustainability and high-quality packaging in high-income regions is not the same in lower-income countries. Therefore, the packaging management of manufacturing enterprises in emerging economies like India for implementing sustainable packaging assumes great significance. In recent studies, it has been observed that the enterprises of industrialized nations are continuously adopting sustainable manufacturing and cleaner technology infrastructure in their ecosystem. However, the packaging manufacturing industries of developing countries are still lagging in adopting sustainable and environmentally friendly practices because of several hindrances. So, there is a scope to study packaging sustainability in developing countries. The present research attempts to analyze the sustainability adoption in packaging supply chain. This study was conducted in four phases and was designed into eight chapters in the thesis.

In the first phase, a research framework has been proposed for the potential critical success factors (CSFs) to sustainability that can enhance performance of packaging supply chain system (PSCS) based on feedback from industry experts and researchers. We have utilized Total Interpretive Structural Modeling (TISM) and Matrice d'Impacts Croisés Multiplication Appliquée à un Classement i.e. Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) methodology to identify the interrelationships and develop a hierarchical structure

among the identified CSFs. The TISM approach explores binary interactions between the CSFs to sustainability in PSCS and the MICMAC methodology provides the driving potential and dependence score of the CSFs. In this phase of study, a total of sixteen CSFs has been selected that can improve sustainable performance of PSCS. After that we have evaluated and analyzed these CSFs with the adopted TISM and MICMAC approaches and developed an integrated model. The proposed framework can be utilized to describe and organize the crucial CSFs and reveal the direct and indirect effects among CSF on sustainable performance of PSCS. The findings emphasized that ‘commitment of regulatory bodies’, ‘capital investment in sustainable packaging’ and ‘integrative and collaborative approach’ are the most significant CSFs that have achieved maximum driving power and minimum dependency. The proposed model could empower various packaging industries and regulatory bodies in the formulation of policies to effectively tackle the CSFs while adopting sustainability in their ecosystem.

In the second phase, a framework has been established for assessing the cause-and-effect evaluation of CSFs that will support packaging systems by assessing the impact of significant CSFs for improving their performance. This work uses the Fuzzy Decision-Making Trial and Evaluation Laboratory (Fuzzy DEMATEL) and Maximum Mean De-Entropy (MMDE) techniques to synthesize the identified CSFs to sustainability in PSCS by ranking priority. It provides a cause-and-effect relationship between CSFs and significant factors in the cause-and-effect group. Based on the results obtained from first phase, the same sixteen CSFs were analyzed, and investigated using the Fuzzy DEMATEL and MMDE approach. The analysis results show that the most influential CSFs are integrative and collaborative approach (F9), commitment of regulatory bodies (F13), continuous enhancement in packaging operations (F8) and effective pooling packaging mechanism (F5) and they fall in the cause group. The results from this study are beneficial for decision-makers in developing better strategies while focusing on significant prominence and effect CSFs to enhance the organization’s sustainable performance.

In the third phase, the framework has been established for assessing and prioritizing the key potential barriers that can disrupt the PSCS performance towards successful implementation of sustainability in their ecosystem. A total of twenty-nine (29) potential barriers were established from the literature and expert suggestions. These potential barriers are categorized into six main categories: organizational, material, financial, technological, logistical, and independent. Further, the identified potential barriers were validated through Fleiss Kappa statistics. We proposed a structured framework to analyze and prioritize the significance of the potential

barriers by utilizing a multi-criteria decision-making (MCDM) approach- specifically the Bayesian Best Worst Method (BBWM). The study also facilitates a framework representing the interrelationship among potential barriers by developing a credal ordering network diagram that reflects their confidence level while considering the probabilistic approach. The outcomes of our study emphasized that ‘high capital investment (B32)’, ‘vagueness in return liquidity (B33)’ and ‘lack of IoT-enabled infrastructure (B54)’ barriers, were the most significant, and these results can be utilized by the managers, policymakers, and executioners of the PSCS for prioritization and subsequent consideration of potential barriers. A framework for enhancement strategies to mitigate significant critical barriers was also proposed. Packaging manufacturing firms should adopt multiple strategies to reduce the impact of potential barriers and enhance the PSCS’s sustainability and effectiveness.

In the fourth phase, we have developed a comprehensive framework for measuring and evaluating policy-driven sustainable transitions in the PSCS. A system dynamics (SD) model has been developed to effectively understand the complex interactions among various factors in the packaging ecosystem. We have taken the diverse behaviour of small, medium, and large firms across different packaging materials such as conventional, recycled, bioplastics and compostables. This study can help to address critical challenges arising from growing packaging waste, regulatory pressures, and the need to balance environmental performance with firm-level viability. The results obtained under various scenarios indicate that small and medium firms play a pivotal role in accelerating systemic change towards sustainability. The model demonstrates positive outcomes by enhancing the profitability dynamics of firms, which supports long-term policymaking. Mandates and compliance enforcement can serve as necessary drivers to improve sustainability transitions by achieving economic, environmental, and social objectives. Subsidy levers targeting different firm size categories can be designed to optimize system-wide adoption performance. The model also shows that consumer awareness can be highly effective in accelerating sustainable momentum. Finally, this study helps in framing waste management policies, such as penalties on excessive waste generation and control on absolute waste volumes as output grows.

Overall, the thesis provides- i) the hierarchical structural framework for CSFs to improve sustainable performance in PSCS by utilizing TISM and MICMAC approaches, ii) the cause and effect analysis framework for CSFs in PSCS by utilizing Fuzzy DEMATEL and MMDE approach, iii) BBWM based prioritization framework for potential barriers to sustainability that can disrupts the sustainable performance in PSCS and iv) an SD framework for measuring and

evaluating policy-driven sustainable transitions in the PSCS that can aid in understanding the complex interactions among various factors in PSCS over the long run. This study has resulted in methodological and practical methods for transacting with the various aspects of enhancing sustainability. This study was carried out to fill the gaps established in the literature and attempt to address the most relevant concerns to the packaging supply chain. In conclusion, this dissertation contributed to the frame of knowledge and management as displayed in different phases of research.

सार

पैकेजिंग एक ऐसी प्रणाली है जो आपूर्ति शृंखला के विभिन्न चरणों में उत्पादों के सुरक्षित, प्रभावी तथा दक्ष भंडारण, हैंडलिंग, परिवहन और विपणन को सक्षम बनाती है। पैकेजिंग, आपूर्ति शृंखला तथा व्यापक अर्थव्यवस्था का एक अभिन्न घटक है। प्रकृति में असतत पैकेजिंग के उपयोग और उसके निपटान से हमारे पारिस्थितिकी तंत्र के समक्ष अत्यंत जटिल और गंभीर समस्याएँ उत्पन्न होती हैं। तीव्र गति से विस्तार करते बाज़ार, बढ़ती प्रतिस्पर्धा तथा तकनीकी प्रगति भी इन समस्याओं को और अधिक तीव्र बनाते हैं। अतः विशेषकर विकासशील अर्थव्यवस्थाओं में पैकेजिंग उद्योग सतत विकास लक्ष्यों (एसडीजी) को प्राप्त करने हेतु अत्यधिक दबाव का सामना कर रहे हैं। अनेक उद्योग उपभोक्ता मांग तथा प्रतिस्पर्धात्मक दबाव को पूरा करने के लिए अब भी उत्पाद आपूर्ति शृंखला में पारंपरिक पैकेजिंग विधियों और सामग्रियों का निरंतर उपयोग कर रहे हैं। हाल के वर्षों में बढ़ते पैकेजिंग अपशिष्ट और निरंतर बढ़ती उपभोक्ता मांग के परिणामस्वरूप गंभीर पर्यावरणीय प्रभाव उत्पन्न हुए हैं, जो उद्यमों की सामाजिक एवं आर्थिक प्रतिष्ठा को भी प्रभावित कर सकते हैं।

जनसंख्या वृद्धि के कारण विश्वभर में पैकेजिंग की खपत बढ़ने की संभावना है, विशेषकर निम्न तथा निम्न-मध्यम आय वाले देशों में, जहाँ सबसे तीव्र वृद्धि अपेक्षित है। निम्न-आय और उच्च-आय देशों के विनिर्माण उद्योगों की पैकेजिंग आवश्यकताएँ भिन्न होती हैं; उदाहरण के लिए, उच्च-आय क्षेत्रों में सततता और उच्च-गुणवत्ता वाली पैकेजिंग के प्रति जो प्रेरणा दिखाई देती है, वह निम्न-आय क्षेत्रों में समान रूप से नहीं पाई जाती। इसलिए, भारत जैसी उभरती अर्थव्यवस्थाओं में विनिर्माण उद्यमों द्वारा सतत पैकेजिंग के कार्यान्वयन हेतु पैकेजिंग प्रबंधन अत्यंत महत्वपूर्ण हो जाता है। हाल के अध्ययनों में यह देखा गया है कि औद्योगिक राष्ट्रों के उद्यम अपने पारिस्थितिकी तंत्र में सतत विनिर्माण और स्वच्छ प्रौद्योगिकी अवसंरचना को निरंतर अपना रहे हैं। तथापि, विकासशील देशों के पैकेजिंग विनिर्माण उद्योग कई बाधाओं के कारण सतत और पर्यावरण-अनुकूल प्रथाओं को अपनाने में अभी भी पीछे हैं। अतः विकासशील देशों में पैकेजिंग सततता के अध्ययन की पर्याप्त संभावना है। वर्तमान शोध पैकेजिंग आपूर्ति शृंखला में सततता अपनाने का विश्लेषण करने का प्रयास करता है। यह अध्ययन चार चरणों में संचालित किया गया तथा शोध-प्रबंध को आठ अध्यायों में संरचित किया गया है।

प्रथम चरण में, उद्योग विशेषज्ञों और शोधकर्ताओं से प्राप्त सुझावों के आधार पर सततता से संबंधित संभावित महत्वपूर्ण सफलता कारकों (सीएसएफ) के लिए एक शोध ढाँचा प्रस्तावित किया गया, जो पैकेजिंग आपूर्ति शृंखला तंत्र (पीएससीएस) के प्रदर्शन को उन्नत कर सकता है। चिह्नित सीएसएफ के बीच अंतर्संबंधों की पहचान करने तथा उनके मध्य पदानुक्रमिक संरचना विकसित करने के लिए टोटल

इंटरप्रिटिव स्ट्रक्चरल मॉडलिंग (टीआईएसएम) और वर्गीकरण हेतु अनुप्रयुक्त पारस्परिक-प्रभाव मैट्रिक्स गुणन (मिकमैक) पद्धति का उपयोग किया गया। टीआईएसएम दृष्टिकोण पीएससीएस में सततता से संबंधित सीएसएफ के बीच द्विआधारी अंतःक्रियाओं का अन्वेषण करता है, जबकि मिकमैक पद्धति सीएसएफ की प्रेरक क्षमता और निर्भरता स्कोर प्रदान करती है। इस चरण में कुल सोलह सीएसएफ का चयन किया गया, जो पीएससीएस के सतत प्रदर्शन को बेहतर बना सकते हैं। इसके बाद, इन सीएसएफ का टीआईएसएम और मिकमैक दृष्टिकोणों के माध्यम से मूल्यांकन एवं विश्लेषण किया गया तथा एक एकीकृत मॉडल विकसित किया गया। प्रस्तावित ढाँचा प्रमुख सीएसएफ का वर्णन और सुव्यवस्थित वर्गीकरण करने तथा पीएससीएस के सतत प्रदर्शन पर सीएसएफ के प्रत्यक्ष एवं अप्रत्यक्ष प्रभावों को उजागर करने में सहायक हो सकता है। निष्कर्षों से स्पष्ट हुआ कि 'नियामक निकायों की प्रतिबद्धता', 'सतत पैकेजिंग में पूंजी निवेश' तथा 'एकीकृत और सहयोगात्मक दृष्टिकोण' सबसे महत्वपूर्ण सीएसएफ हैं, जिनमें अधिकतम प्रेरक क्षमता और न्यूनतम निर्भरता पाई गई। प्रस्तावित मॉडल विभिन्न पैकेजिंग उद्योगों और नियामक निकायों को अपने पारिस्थितिकी तंत्र में सततता अपनाते समय इन सीएसएफ से प्रभावी ढंग से निपटने हेतु नीतियाँ तैयार करने में सक्षम बना सकता है।

द्वितीय चरण में, सीएसएफ के कारण-परिणाम मूल्यांकन हेतु एक संरचित ढाँचा विकसित किया गया, जो प्रमुख सीएसएफ के प्रभाव का आकलन करके पैकेजिंग प्रणालियों के प्रदर्शन में सुधार हेतु मार्गदर्शन प्रदान करता है। इस अध्ययन में पीएससीएस में सततता से संबंधित चिह्नित सीएसएफ का प्राथमिकता-आधारित क्रम निर्धारण और समेकन करने के लिए फज़ी डिसीजन-मेकिंग ट्रायल एंड इवैल्यूएशन लेबोरेटरी पद्धति (फज़ी डेमेटेल) तथा मैक्सिमम मीन डी-एंट्रॉपी (एमएमडीई) तकनीकों का उपयोग किया गया। यह ढाँचा सीएसएफ के बीच कारण-परिणाम संबंध स्पष्ट करता है तथा 'कारण' और 'परिणाम' समूहों में प्रमुख कारकों की पहचान करता है। प्रथम चरण से प्राप्त परिणामों के आधार पर, उन्हीं सोलह सीएसएफ का फज़ी डेमेटेल और एमएमडीई पद्धति के माध्यम से विश्लेषण एवं परीक्षण किया गया। परिणाम दर्शाते हैं कि सर्वाधिक प्रभावशाली सीएसएफ—एकीकृत एवं सहयोगात्मक दृष्टिकोण (F9), नियामक निकायों की प्रतिबद्धता (F13), पैकेजिंग परिचालनों में सतत सुधार (F8) तथा प्रभावी पूलिंग पैकेजिंग तंत्र (F5)—'कारण' समूह में आते हैं। इस अध्ययन के निष्कर्ष निर्णय-निर्माताओं के लिए उपयोगी हैं, क्योंकि ये संगठन के सतत प्रदर्शन को सुदृढ़ करने हेतु उच्च प्रमुखता और प्रभाव वाले महत्वपूर्ण सीएसएफ पर केंद्रित बेहतर रणनीतियाँ विकसित करने में सहायक हो सकते हैं।

तृतीय चरण में, अपने पारिस्थितिकी तंत्र में सततता के सफल कार्यान्वयन की दिशा में पीएससीएस के प्रदर्शन को बाधित कर सकने वाली प्रमुख संभावित बाधाओं का आकलन तथा प्राथमिकता-निर्धारण

करने हेतु एक रूपरेखा विकसित की गई। साहित्य तथा विशेषज्ञ सुझावों के आधार पर कुल उनतीस (29) संभावित बाधाएँ चिह्नित की गईं। इन बाधाओं को छह मुख्य वर्गों में विभाजित किया गया: संगठनात्मक, सामग्री-संबंधी, वित्तीय, प्रौद्योगिकीय, परिवहन-वितरण संबंधी तथा स्वतंत्र। इसके पश्चात, चिह्नित संभावित बाधाओं का सत्यापन फ्लाइस कप्पा सांख्यिकी के माध्यम से किया गया। संभावित बाधाओं के महत्त्व का विश्लेषण और प्राथमिकता-निर्धारण करने के लिए बहु-मानदंड निर्णय-निर्माण (एमसीडीएम) दृष्टिकोण, विशेष रूप से बेज़ियन बेस्ट वर्स्ट मेथड (बीबीडब्ल्यूएम), का उपयोग करते हुए एक संरचित रूपरेखा प्रस्तावित की गई। यह अध्ययन संभावित बाधाओं के परस्पर अंतर्संबंधों को स्पष्ट करने हेतु भी एक ढाँचा प्रस्तुत करता है; इसके अंतर्गत एक क्रेडल ऑर्डरिंग नेटवर्क विकसित किया गया, जो प्रायिकात्मक दृष्टिकोण को ध्यान में रखते हुए उनके विश्वसनीयता स्तर को दर्शाता है। अध्ययन के निष्कर्षों ने रेखांकित किया कि 'उच्च पूंजी निवेश (B32)', 'रिटर्न लिक्विडिटी में अस्पष्टता (B33)' तथा 'आईओटी-सक्षम अवसंरचना का अभाव (B54)' सर्वाधिक महत्वपूर्ण बाधाएँ हैं। इन परिणामों का उपयोग पीएससीएस के प्रबंधकों, नीति-निर्माताओं तथा क्रियान्वयनकर्ताओं द्वारा संभावित बाधाओं की प्राथमिकता तय करने और आगे की रणनीतिक कार्यवाही के लिए किया जा सकता है। साथ ही, प्रमुख गंभीर बाधाओं के प्रभाव को कम करने हेतु संवर्धन रणनीतियों की एक रूपरेखा भी प्रस्तावित की गई। पैकेजिंग विनिर्माण फर्मों को संभावित बाधाओं के प्रभाव को घटाने तथा पीएससीएस की सततता और प्रभावशीलता बढ़ाने के लिए बहुविध रणनीतियाँ अपनानी चाहिए।

चतुर्थ चरण में, पीएससीएस में नीति-प्रेरित सततता उन्मुख परिवर्तन को मापने तथा मूल्यांकन करने हेतु एक समग्र रूपरेखा विकसित की गई है। पैकेजिंग पारितंत्र में विभिन्न कारकों के बीच विद्यमान जटिल पारस्परिक अंतःक्रियाओं को प्रभावी रूप से समझने के लिए एक सिस्टम डायनेमिक्स (एसडी) मॉडल विकसित किया गया है। इसमें पारंपरिक, पुनर्चक्रित, बायोप्लास्टिक्स तथा कम्पोस्टेबल जैसे विभिन्न पैकेजिंग पदार्थों के संदर्भ में लघु, मध्यम और बड़े उद्यमों के विविध व्यवहार को सम्मिलित किया गया है। यह अध्ययन बढ़ते पैकेजिंग अपशिष्ट, नियामकीय दबावों तथा पर्यावरणीय प्रदर्शन और उद्यम-स्तरीय व्यवहार्यता के बीच संतुलन की आवश्यकता से उत्पन्न महत्वपूर्ण चुनौतियों को संबोधित करने में सहायक हो सकता है। विभिन्न परिदृश्यों के अंतर्गत प्राप्त परिणाम संकेत करते हैं कि लघु और मध्यम उद्यम सततता की दिशा में प्रणालीगत परिवर्तन को तीव्र करने में निर्णायक भूमिका निभाते हैं। यह मॉडल उद्यमों की लाभप्रदता-गतिकी को सुदृढ़ करके सकारात्मक परिणाम दर्शाता है, जिससे दीर्घकालिक नीति-निर्माण को समर्थन मिलता है। अनिवार्य प्रावधान और अनुपालन प्रवर्तन आर्थिक, पर्यावरणीय तथा सामाजिक उद्देश्यों की प्राप्ति के माध्यम से सततता उन्मुख परिवर्तन को सुदृढ़ करने हेतु आवश्यक प्रेरक कारकों के रूप में कार्य कर सकते हैं। विभिन्न आकार-श्रेणियों के उद्यमों को लक्षित करने वाले सब्सिडी-

आधारित नीतिगत उपाय इस प्रकार संरचित किए जा सकते हैं कि प्रणाली-स्तर पर अपनाने के समग्र प्रदर्शन का अनुकूलन हो सके। मॉडल यह भी दर्शाता है कि उपभोक्ता जागरूकता सततता उन्मुख गति को तीव्र करने में अत्यंत प्रभावी हो सकती है। अंततः, यह अध्ययन अत्यधिक अपशिष्ट उत्पादन पर दंड तथा उत्पादन वृद्धि के साथ कुल अपशिष्ट मात्रा पर नियंत्रण जैसे अपशिष्ट प्रबंधन नीतियों के निर्माण में सहायता करता है।

समग्र रूप से, यह शोध-प्रबंध निम्नलिखित योगदान प्रस्तुत करता है: i) टीआईएसएम और मिकमैक दृष्टिकोणों का उपयोग करते हुए पीएससीएस में सतत प्रदर्शन को बेहतर बनाने हेतु सीएसएफ का पदानुक्रमिक संरचनात्मक ढाँचा; ii) फज़ी डेमेटेल और एमएमडीई दृष्टिकोणों का उपयोग करते हुए पीएससीएस में सीएसएफ के कारण-परिणाम विश्लेषण का ढाँचा; iii) पीएससीएस के सतत प्रदर्शन को बाधित कर सकने वाली सततता-संबंधी संभावित बाधाओं के लिए बीबीडब्ल्यूएम-आधारित प्राथमिकता-निर्धारण ढाँचा; तथा iv) पीएससीएस में नीति-प्रेरित सततता उन्मुख परिवर्तन को मापने और मूल्यांकन करने हेतु एसडी ढाँचा, जो दीर्घावधि में पीएससीएस के विभिन्न कारकों के बीच जटिल अंतःक्रियाओं को समझने में सहायक हो सकता है। यह अध्ययन सततता को सुदृढ़ करने से जुड़े विभिन्न पहलुओं से प्रभावी ढंग से निपटने हेतु कार्यविधिगत तथा व्यावहारिक उपाय प्रस्तुत करता है। इसे साहित्य में चिह्नित शोध-अंतरालों को भरने तथा पैकेजिंग आपूर्ति शृंखला से संबंधित सर्वाधिक प्रासंगिक चिंताओं को संबोधित करने के उद्देश्य से किया गया। निष्कर्षतः, यह शोध-प्रबंध अनुसंधान के विभिन्न चरणों के माध्यम से ज्ञान-विस्तार तथा प्रबंधन-व्यवहार के क्षेत्र में महत्वपूर्ण योगदान देता है।

TABLE OF CONTENTS

Certificate	ii
Acknowledgements	iv-v
Abstract.....	vi-xiii
Table of Contents	xiv-xx
List of Figures.....	xxi--xxiii
List of Tables	xxiv-xxv
List of Abbreviations	xxvi-xxvii
1. Introduction.....	
1.1. Background of the Study	1-2
1.2. Packaging Supply Chain: An Overview	3-4
1.3. Sustainability in Packaging Supply Chain Systems	4-6
1.4. Challenges to Enhance Sustainability in PSCS	6-8
1.5. Need for the Study and Problem Statement	8-10
1.6. Objectives of the Study	10
1.7. Brief Outlines of the Methodologies	11
1.8. Organization of the Thesis	12-14
2. Literature Review	
2.1. Introduction	15
2.2. Status of Studies for Sustainability Focused PSCS Literature	15-20
2.2.1. Review Protocol and Selection of Studies for Sustainability Focused PSCS ...	15-16
2.2.2. Temporal Evolution in Sustainability Focused PSCS Literature	17
2.2.3. Distribution of Journals in Sustainability Focused PSCS Literature	17-18
2.2.4. Country-Wise Contribution in Sustainability Focused PSCS Literature	18-19
2.2.5. Co-occurrences of Keywords in Sustainability Focused PSCS Literature	19-20
2.3. Review on Sustainability Issues Deliberated in PSCS Across Various Themes	20-30
2.3.1. Sustainability as a Strategic Pillar in PSCS.....	20-21

2.3.2. Studies Focusing Circular Economy, Regulatory Policy, Extended Producer Responsibility and Innovation in PSCS	22-23
2.3.3. Studies Focusing Packaging Design, Material Choice and Life-Cycle Assessment in the Selected Literature of PSCS.....	23-24
2.3.4. Studies Focusing Reusable and Returnable Packaging Systems in the Selected Literature of PSCS	24-25
2.3.5. Studies Focusing Packaging Waste, Collection and Recycling Networks in PSCS	25
2.3.6. Studies Highlighting Behavioural and Organizational Aspects in PSCS.....	25-26
2.3.7. Studies Focusing on Sectoral and Contextual Specificities in PSCS	26
2.3.8. Methods, Analytical Tools and Techniques in the PSCS Literature	26-28
2.3.9. Studies Focusing on Implementing Digitalization, AI and Smart/Intelligent Packaging in PSCS	28-30
2.4. Literature Addressing the Need for Sustainability Integration in PSCS of Emerging Economies.....	30-35
2.5. Literature Addressing the Need for System Dynamics Modelling for Sustainable Transition in PSCS	35-38
2.6. Research Gaps Identified in Literature Review for PSCS	38-39
2.7. Research Questions	39
2.7. Chapter Summary.....	39
3. Research Design	
3.1. Introduction	40
3.2. Research Questions	40-41
3.3. Research Objectives	41-43
3.4. Scope of the Thesis	43-44
3.5. Research Methodology.....	44-70
3.5.1. Confirmation of Selected CSFs Using Fleiss Kappa Statistics	45-47
3.5.2. Total Interpretive Structural Modelling (TISM) Method.....	47-51

3.5.3. Description of MICMAC Method	51-52
3.5.4. Description of Fuzzy DEMATEL Methodology for Identification and Prioritizing Significant CSFs to Sustainability in PSCS	52-59
3.5.5. Maximum Mean de-Entropy Algorithm (MMDE)	59-61
3.5.6. Bayesian Best-Worst Method (BBWM)	61-69
3.5.7. Role of System Dynamics Modelling in Sustainable Transition in PSCS	69-70
3.6. Chapter Summary	70
4. Sustainability Focused Decision Modeling Framework for Improving Performance of Packaging Supply Chain System	
4.1. Introduction	71-72
4.2. Theoretical Background to Identifying Critical Success Factors (CSFs) in PSCS ..	72-77
4.2.1. Identification of Critical Success Factors (CSFs) to Sustainability in PSCS	73-77
4.3. Methodology Framework for the Research Study	78-79
4.4. Application of the Proposed Research Framework for Evaluating CSFs in PSCS	79-99
4.4.1. Confirmation of CSFs of PSCS that Enhances Sustainability	79-80
4.4.2. Data Collection and Sampling Design for Finalized CSFs	80-82
4.4.3. Development of TISM-based Decision Modelling Framework.....	82-99
4.4.4 MICMAC Analysis for the Selected CSFs to Sustainability	99-101
4.5. Results and Discussion of TISM-MICMAC Analysis.....	101-105
4.6. Implications of the Chapter	105-106
4.6.1. Theoretical Implications.....	105-106
4.6.2. Managerial Implications.....	106
4.7. Chapter Summary.....	107
5. Cause and Effect Analysis of Critical Success Factors to Sustainability for Enhancing Performance of PSCS	
5.1. Introduction	108-111
5.2. Research Methodology.....	111-112

5.3. Proposed Framework for Enhancing Sustainability in PSCS with DEMATEL and MMDE Method.....	112-113
5.4. Application of the Proposed Framework for Our Study	113-125
5.4.1. Identification of the CSFs to Sustainability in PSCS and Data Collection ...	113-114
5.4.2. Analysis of the Identified CSFs in PSCS with the Fuzzy DEMATEL	114-119
5.4.3. Application of MMDE Algorithm.....	119-125
5.5. Results and Discussion.....	125-131
5.5.1. Results for Identified Cause and Effect Categories for CSFs	126-127
5.5.2. Results for Scenario Analysis Conducted for CSFs.....	128-129
5.6. Implications of the Chapter	130-131
5.7. Chapter Summary.....	131
6. Prioritization of Potential Barriers to Sustainability that Disrupts Performance of Packaging Supply Chain System	
6.1. Introduction	133-136
6.2. Relevant Issues Addressed for Sustainability Improvement in PSCS	136-137
6.3. Identification of Barriers that Disrupts Sustainable Performance in PSCS from the Recent Studies and Experts Inputs.....	137-146
6.4. Methodological Framework Developed for Identification and Analyzing the Barriers to Sustainability in PSCS	146-147
6.5. Analysis Results and Discussions for the Potential Barriers to Sustainability in PSCS	148-163
6.5.1. Procedure for Data Collection, Profile of the DMs and Fleiss Kappa Results	148-149
6.5.2. Discussion of Data Collected for Potential Barriers to Sustainability in PSCS	150-151
6.5.3. Discussion of Credal Ranking Obtained by Main and Sub-Barriers of PSCS	151-157
6.5.4. Discussion of Prioritization Rank Obtained by Barriers to Sustainability in PSCS	157-161

6.5.5 Strategies Suggested to Mitigate the Impact of Significant Barriers to PSCS	161-163
6.6. Implications of the Chapter	163-164
6.7. Chapter Summary	164
7. A Systems Dynamic Modelling Approach to Measure Decision Effectiveness in Packaging Supply Chain System	
7.1. Introduction	165-167
7.2. Framed Research Objectives (ROs) for SD Model to Enhance Sustainability in PSCS	167-168
7.3. Scope for the Current Study-SD Modelling for Sustainable Transition in PSCS	168
7.4. Methodological Foundation of the Proposed SD Model for Enhancing Sustainable Transition in PSCS	169-171
7.4.1. Model Validation Requirements of the Proposed SD Model for Sustainable Transition in PSCS	169-170
7.4.2. Data Collection of the Proposed SD Model for Sustainable Transition in PSCS	170
7.4.3. Model Assumptions of the Proposed SD Model for Sustainable Transition in PSCS	170-171
7.5. Proposed SD Modelling Framework for Sustainable Transition in PSCS	171-184
7.5.1. Notation and Index Sets Used in the Proposed SD Model for Enhancing Sustainable Transition in PSCS	172-173
7.5.2. Firm-wise Adoption Behaviour SFD of the Proposed SD Model for Enhancing Sustainable Transition in PSCS	173-175
7.5.3. Material-wise Adoption Behaviour SFD of the Proposed SD Model for Enhancing Sustainable Transition in PSCS	175-177
7.5.4. Compliance Dynamics in Proposed SD Model for Sustainable Enhancing Transition in PSCS	177-178
7.5.5. SFD for Budget Allocation and Subsidy Distribution in Proposed SD Model for Enhancing Sustainable Transition in PSCS	178-179

7.5.6. SFD for Packaging Waste in Proposed SD Model for Enhancing Sustainable Transition in PSCS.....	180-181
7.5.7. SFD for Consumer Awareness in Proposed SD Model for Enhancing Sustainable Transition in PSCS.....	181-182
7.5.8. SFD for Economic-Cost Dynamics in Proposed SD Model for Enhancing Sustainable Transition in PSCS	183-184
7.6. Scenario Design for the Proposed SD Model for Sustainable Transition in PSCS	184-188
7.6.1. Simulation Setup of the Proposed SD Model for Sustainable Transition in PSCS	188
7.7. Results and Discussion of the Proposed SD Model for Sustainable Transition in PSCS	188-198
7.7.1. Results Obtained for Firm-Wise Adoption Behaviour of the Proposed SD Model for Enhancing Sustainable Transition in PSCS	188-190
7.7.2. Results Obtained for Material-Wise Adoption Behaviour of the Proposed SD Model for Enhancing Sustainable Transition in PSCS	190-192
7.7.3. Packaging Waste Generation Results of the Proposed SD Model for Enhancing Sustainable Transition in PSCS	192-194
7.7.4. Subsidies Expenditure Results of the Proposed SD Model for Enhancing Sustainable Transition in PSCS	194
7.7.5. Firm Profitability Results of the Proposed SD Model for Enhancing Sustainable Transition in PSCS.....	194-196
7.7.6. Compliance Level Results of the Proposed SD Model for Enhancing Sustainable Transition in PSCS.....	196-197
7.7.7. Simulation Results of Consumer Awareness in the Proposed SD Model for Enhancing Sustainable Transition in PSCS	197-198
7.8. Implications of the Chapter	198-199
7.9. Chapter Summary.....	199
8. Conclusions and Scope for Future Research.....	
8.1. Introduction	200

8.2. Summary of Research	200-202
8.3. Revisiting Research Questions and Objectives	203-208
8.3.1. Research Questions Revisited	203-205
8.3.2. Research Objectives Revisited	205-208
8.4. Major Findings	209-211
8.5. Research Contribution of the Thesis	212-214
8.6. Implications of the Thesis	215-217
8.7. Sustaining Research Deliverables in a Dynamic Environment	217
8.8. Limitations and Scope for Future Research	218-219
8.8. Chapter Summary	219
References	220-250
Appendix 5.1	251-252
Appendix 5.2	253
Appendix 6.1	254
Appendix 6.2	255
Appendix 6.3	256
Appendix 6.4	257
Appendix 6.5	258
Appendix 6.6	259
Appendix 6.7	260
Appendix 6.8	261
List of Publications Based on Present Research Work	262-263
Brief CV of Researcher	264

LIST OF FIGURES

Figure 1.1. A Typical Design Framework for Packaging Supply Chain System	3
Figure 1.2. Projection of Plastic waste from 2020 to 2060.....	6
Figure 1.3. Optimum Level Packaging	8
Figure 1.4. Position of Research Focus in Packaging Supply Chain System	10
Figure 1.5. Chapter-Wise Flow Structure of the Thesis	13
Figure 2.1. Number of Papers on Sustainability in PSCS in International Journals.....	17
Figure 2.2. Articles Published by Different Journals (Top 10 Journals)	18
Figure 2.3. Distribution of Studies According to Country Wise in PSCS Literature	18
Figure 2.4. Mapping on Co-occurrences of Keywords Related to Sustainability in PSCS	19
Figure 2.5. Density Visualization on Co-occurrences of Keywords Related to Sustainability in PSCS	20
Figure 3.1. Visualization of Research Design for Sustainability Focused PSCS	42
Figure 3.2. A Flowchart to Demonstrate the Combined TISM and MICMAC methodology.	46
Figure 3.3. Flowchart for Combined Fuzzy DEMATEL and MMDE Approach in PSCS	53
Figure 3.4. A Flowchart for Evaluating Potential Barriers to Sustainability in PSCS	62
Figure 3.5. A Visual Representation of Stock and Flow Diagram	70
Figure 4.1. Methodology Framework for CSFs Evaluation with TISM and MICMAC	78
Figure 4.2. Developed ISM Model to Reflect Relationships Among CSFs	90
Figure 4.3. TISM Model Reflecting Relationships between CSFs to Sustainability in PSCS	94
Figure 4.4. Final TISM Model After Statistical Validation of Each Link Between CSFs	99
Figure 4.5. MICMAC Analysis of CSFs to Sustainability in PSCS	101
Figure 5.1. Proposed Framework for Cause-and-Effect Analysis of CSFs	112
Figure 5.2. Cause and Effect Diagram of CSFs with Intensity of Impact	119
Figure 5.3. Mean De Entropy Values for Dispatch Node Sets Plot.....	120
Figure 5.4. Mean De Entropy Values for Receive Node Sets Plot	121

Figure 5.5. Impact relationship Map for CSFs of PSCS.....	124
Figure 5.6. Dynamics of Cause-and-Effect Nature of CSFs using Sensitivity Analysis.....	128
Figure 6.1. A Research Methodology Framework to Evaluate Potential Barriers to Sustainability in PSCS	147
Figure 6.2. Categorization of Barriers into Main Groups with Experts’ Inputs	149
Figure 6.3. Credal Ranking Diagram for Main Barriers of PSCS.	152
Figure 6.4. Visualization of Credal Ranking for the Organizational Barriers in PSCS.....	153
Figure 6.5. Visualization of Credal Ranking for the Material Barriers	153
Figure 6.6. Visualization of Credal Ranking for the Financial Barriers.....	154
Figure 6.7. Visualization of Credal Ranking for the Logistical Barriers.....	155
Figure 6.8. Visualization of Credal Ranking for the Technological Barriers.....	156
Figure 6.9. Visualization of Credal Ranking for the Independent Barriers	156
Figure 6.10. Comparative Analysis of BWM and BBWM for Prioritization of Barriers.....	161
Figure 7.1. Causal Loop Diagram (CLD) for the Sustainable Packaging Transition in PSCS	171
Figure 7.2 (a). Stock and Flow Diagram (SFD) for Adoption Behaviour of Large Firms	174
Figure 7.2 (b). Stock and Flow Diagram (SFD) for Adoption Behaviour of Medium Firms	174
Figure 7.2 (c). Stock and Flow Diagram (SFD) for Adoption Behaviour of Small Firms	175
Figure 7.3 (a). SFD for Adoption Behaviour of Firms in Case of Recycled Material.....	176
Figure 7.3 (b). SFD for Adoption Behaviour of Firms in Case of Bioplastics Material	176
Figure 7.3 (c). SFD for Adoption Behaviour of Firms in Case of Compostables Material...	177
Figure 7.4. SFD for Compliance Dynamics with Mandated Packaging Target in PSCS.....	178
Figure 7.5. SFD of the Government Budget and Subsidy-Disbursement Module	179
Figure 7.6 (a). SFD for Packaging Waste by Large Size Firms	180
Figure 7.6 (b). SFD for Packaging Waste by Medium Size Firms	181
Figure 7.6 (c). SFD for Packaging Waste by Small Size Firms	181
Figure 7.7. SFD for Consumer Awareness	182
Figure 7.8 (a). SFD for Revenue Cost Dynamics for Large Firms.....	183

Figure 7.8 (b). SFD for Revenue Cost Dynamics for Medium Firms	183
Figure 7.8 (c). SFD for Economic Cost Dynamics for Smaller Firms	184
Figure 7.9 (a). Results for Large Size Firms for Adoption of Sustainable Alternatives.....	188
Figure 7.9 (b). Results for Medium Size Firms for Adoption of Sustainable Alternatives ...	189
Figure 7.9 (c). Results for Small Size Firms for Adoption of Sustainable Alternatives.....	189
Figure 7.10 (a). Simulation Results for Recycled Packaging Adoption in PSCS.....	190
Figure 7.10 (b). Simulation Results for Bioplastics Packaging Adoption in PSCS	191
Figure 7.10 (c). Simulation Results for Compostable Packaging Adoption in PSCS	191
Figure 7.11 (a). Simulation Results for Packaging Waste Generation for Large Size Firms	192
Figure 7.11 (b). Simulation Results for Packaging Waste Generation for Medium Size Firms	193
Figure 7.11 (c). Simulation Results for Packaging Waste Generation for Small Size Firms	193
Figure 7.12. Simulation Results for Cumulative subsidies for All Firms in PSCS	194
Figure 7.13(a). Simulation Results for Cumulative Profit in Large Firms Across All Scenarios	195
Figure 7.13(b). Simulation Results for Cumulative Profit in Medium Firms Across All Scenarios	195
Figure 7.13(c): Simulation Results for Cumulative Profit in Small Firms Across All Scenarios	196
Figure 7.14. Simulation Results for Compliance Level Across All Scenarios.....	197
Figure 7.15. Simulation Results for Consumer Awareness Across All Scenarios	197

LIST OF TABLES

Table 2.1. Summary of Recent Studies on Sustainability Related Issues in PSCS	32-35
Table 2.2. Brief Overview of Recent Studies on SD Modelling in PSCS	36-37
Table 3.1. Research Objectives (ROs) and Proposed Methodologies for the Thesis	43
Table 3.2. Triangular Fuzzy Numbers (TFNs) Scale.....	56
Table 4.1. List of CSFs to Sustainability in PSCS, their Description and Related References	74-77
Table 4.2. Cumulative Survey Responses for Confirmation of CSFs	79
Table 4.3. A Brief Overview of Experts' Profile.....	81
Table 4.4. SSIM for CSFs to sustainability in PSCS	82
Table 4.5. IRM for CSFs of PSCS Appropriate to Sustainability	83
Table 4.6. FRM for CSFs of PSCS Appropriate to Sustainability.....	84
Table 4.7. Iteration 1 for CSFs in PSCS Appropriate to Sustainability.....	85
Table 4.8. Iteration 2 for CSFs in PSCS Appropriate to Sustainability.....	86
Table 4.9. Iteration 3 for CSFs in PSCS Appropriate to Sustainability.....	87
Table 4.10. Iteration 4 for CSFs in PSCS Appropriate to Sustainability.....	88
Table 4.11. Iteration 5 for CSFs in PSCS Appropriate to Sustainability.....	88
Table 4.12. Iteration 6 for CSFs in PSCS Appropriate to Sustainability.....	89
Table 4.13. Interpretation Matrix for CSFs to Enhance Sustainable Performance.....	91-93
Table 4.14. Results of Hypothesis Testing for Validation of Links Among CSFs in PSCS	96-98
Table 4.15. Dependence Power (P_{DP}) and Driving power (P_{DR}) of CSFs of PSCS	100
Table 5.1. Average Initial Direct Relation Matrix (D) for the CSFs in PSCS.....	115
Table 5.2. Normalized Direct Relation Matrix (S) for the CSFs to Sustainability in PSCS .	116
Table 5.3. Total Interrelationship Matrix (T) for the CSFs to Sustainability in PSCS.....	117
Table 5.4. CSFs Ranking and Causal Effect Nature Based on Significance	118
Table 5.5. Dispatch Node Sets Results	120

Table 5.6. Receive Node Sets Results	121
Table 5.7. Obtained Threshold Value (α) Results	122
Table 5.8. Impact Relationship Matrix (G) for obtained threshold value.....	123
Table 5.9. Weight Assigned to each Expert for Scenario Analysis	128
Table 5.10. Cause and effect Nature of CSFs with Different Scenarios.....	129
Table 6.1. A Brief Description of Barriers to Sustainability in PSCS	140-145
Table 6.2. Computation of Fleiss Kappa Statistics for Inter-Rater Agreement for DMs	149
Table 6.3. Best to Others Pairwise Comparison Matrix for Main Barriers of PSCS.....	150
Table 6.4. Others to Worst Pairwise Comparison Matrix for Main Barriers in PSCS	151
Table 6.5. BBWM Results Obtained for Prioritization of Barriers to Sustainability in PSCS	158
Table 6.7. Strategies for Mitigating the Impact of Significant Barriers in PSCS	162-163
Table 7.1. Notation and Index Set for the Parameters Used in SD model of PSCS	172-173
Table 7.2. Scenario Settings for Baseline and S1–S5 for PSCS Sustainable Transition	186-187
Table 8.1. Revisiting the Research Objectives of the Thesis.....	208
Table 8.2. Result Contribution of the Thesis	212-214

LIST OF ABBREVIATIONS

Abbreviations	Stands for
AHP	Analytic Hierarchy Process
AI	Artificial Intelligence
ANP	Analytic Network Process
BBWM	Bayesian Best Worst Method
BWM	Best Worst Method
CLD	Causal Loop Diagram
CLSC	Closed Loop Supply Chain
CPCB	Central Pollution Control Board
CSF	Critical Success Factor
DEMATEL	Decision-Making Trial and Evaluation Laboratory
DM	Decision Makers
EOL	End of Life
EPR	Extended Producer Responsibility
EU	European Union
FMCG	Fast Moving Consumer Goods
FRM	Final Reachability Matrix
IoT	Internet of Things
IRM	Initial Reachability Matrix
ISM	Interpretive Structural Modelling
LCA	Life-Cycle Assessment
MCDM	Multi-Criteria Decision-Making
MDE	Mean De-Entropy
MFA	Material Flow Analysis
MICMAC	Matrice d'Impacts Croisés Multiplication Appliquée à un Classement (Cross-Impact Matrix Multiplication Applied to Classification)
ML	Machine Learning
MMDE	Maximum Mean De-Entropy
PPWD	Packaging and Packaging Waste Directive
PSCS	Packaging Supply Chain System

RO	Research Objective
RTI	Returnable Transport Items
RTP	Returnable Transport Packaging
SC	Supply Chain
SD	System Dynamics
SDG	Sustainable Development Goal
SEM	Structural Equation Modelling
SFD	Stock and Flow Diagram
SME	Small Medium Enterprises
SSIM	Structural Self-Interaction Matrix
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TFN	Triangular Fuzzy Numbers
TISM	Total Interpretive Structural Modelling
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution