LEAN INTEGRATED CARBON FINANCING MODEL FOR CONSTRUCTION INDUSTRY

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DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date: 25.02.2026

The above candidate has carried out research for the Masters thesis under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr. Tharusha Ranadewa

Signature of the Supervisor: Date:25.02.2026

DEDICATION

To my wonderful parents and brother, the silent heroes of my success…

ACKNOWLEDGEMENT

This dissertation is the result of significant dedication and remarkable support from many individuals and organisations who contributed in various ways to the completion. Indeed, many people supported and guided me on the right path, genuinely wishing for my success. I take this opportunity to express my gratitude to all of them.

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ABSTRACT

The construction industry accounts for over one-third of global greenhouse gas emissions, urging the need for sustainable construction methods. However, almost all sustainable construction methods struggle to balance financial returns with environmental benefits. Carbon financing offers a promising solution by providing financial incentives for reducing carbon emissions, making it an environmentally and economically friendly option. Despite the benefits, practical applications of carbon financing in construction are challenged by many inefficiencies, redundancies and non-value adding activities. Lean principles directly address these challenges by emphasising value maximisation for stakeholders and encouraging a culture of continuous improvement. Hence, this study aims to develop a lean-integrated carbon financing model for the construction industry. A mixed-method approach was employed, combining a questionnaire to quantify the significance of financial impact for sustainable construction, with two rounds of expert interviews to explore the sector-specific carbon financing factors and lean integration. Quantitative data were collected from 388 respondents selected through snowball sampling and analysed using random forest regression. The qualitative data were collected from 18 experts selected through purposive sampling and code-based content analysis was employed to analyse the data. The study identified that financial challenges can influence and be influenced by sustainable construction challenges. Furthermore, carbon financing was defined based on the five notions and 4 primary carbon financing methods were identifed and described. The findings also identified 22 benefits and 19 challenges specifically associated with the implementation of carbon financing in the construction sector. The study has developed a comprehensive definition of carbon financing and identified that the best carbon financing method for construction industry would be combining carbon financing methods. A lean-integrated carbon financing model was developed to identify the most suitable carbon financing method for construction projects after validating it through focus group interviews. The research concludes that integrating lean principles with carbon financing can significantly reduce carbon financing challenges and improve adoption in construction. The study contributes to the academic discourse by deriving a definition for carbon financing and identifying sector-specific carbon financing factors, including benefits, challenges, and methods. Application of random forest models for sustainable construction research and potential use of lean principles for carbon financing are also key contributions of the study.

Keywords: Carbon Financing, Construction Industry, Financial Impact, Lean Principles, Sustainable Construction

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LIST OF ABBREVIATIONS

AE	Absolute Error
AI	Artificial Intelligence
BIM	Building Information Modelling
BOQs	Bills of Quantities
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CH_4	Methene
CO_2	Carbon Dioxide
COVID-19	Coronavirus Disease 2019
CSR	Corporate Social Responsibility
ERPAs	Emission Reduction Purchase Agreements
ERU	Emission Reduction Units
ESG	Environmental, Social, and Governance
ETF	Exchange Traded Funds
ETS	Emissions Trading System
EU	European Union
EUA	European Union Allowance
FIFO	First in First out
FMCG	Fast Moving Consumer Goods
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Mode, Effects, and Criticality Analysis
GHG	Greenhouse Gas
ICPA	International Carbon Action Partnership
IoT	Internet of Things
JI	Joint Implementation
LPS	Last Planner System
MAE	Mean Absolute Error
MDI	Mean Decrease Impurity
MRV	Monitoring, Reporting, Verification
MSE	Mean Squared Error

MW	Megawatts
N_2O	Nitrous Oxide
NDC	National Determined Contributions
PDCA	Plan-Do-Check-Act
PE	Professional Engineer
PICO	Population, Intervention, Comparator, and Outcome
PPP	Public-Private Partnerships
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RBF	Results-Based Financing
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RMSE	Root Mean Squared Error
SDG	Sustainable Development Goals
SLR	Systematic Literature Review
TPM	Total Productive Maintenance
TQM	Total Quality Management
UK	United Kingdom
UNHCR	United Nations High Commissioner for Refugees
USA	United States of America
USD	United State Dollar
VSM	Value Stream Mapping