

**DEVELOPMENT OF A FRAMEWORK FOR
INTEGRATED SOLID WASTE MANAGEMENT: AN
APPLICATION TO KEKIRAWA PRADESHIYA SABHA**

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Degree of Master of Science

Department of Civil Engineering

University of Moratuwa

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Thesis submitted in partial fulfillment of the requirements for the
degree of Master of Science in Environmental Engineering and Management

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August 2021

Declaration

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Name of the supervisor: Prof. M.W. Jayaweera

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Abstract

Municipal solid waste management (MSWM) has evolved into a national concern affecting every individual in Sri Lanka. Poorly managed MSW affects to health and wellbeing of people, pollutes the air, soil, and water, causes flooding, spreads diseases, harms flora and fauna, loss of money, and obstructs resource recovery. Therefore, Sri Lanka has been trying to find a long-lasting solution to MSWM, which should be environmentally, socially, and economically acceptable. Integrated Solid Waste Management (ISWM) provides a contemporary and systematic approach to MSWM. In these efforts, the paradigm shift from landfilling to MSW reduction or prevention is thought vital to be embedded. The government's new policy on "Vistas of Prosperity and Splendor" and Draft National Environmental Policy (2021) also mandates the use of ISWM for MSWM in Sri Lanka.

Embedding circular economy perspectives to ISWM further reduces the amount of MSW produced or retained globally by transforming it into resources. Therefore, the quantity of MSW disposed of at landfills is greatly reduced, and natural resources for manufacturing processes are optimized. This study focused on developing an ISWM framework for MSWM in Sri Lanka based on the circular economy perspectives and under the purview of the present administrative framework. The local needs and conditions were carefully analyzed during the study to determine the most suitable options for all aspects of MSWM, including generation, segregation, collection and transport, sorting, recovery, treatment, and final disposal of MSW. The application of the 3R concept for MSW minimization, promoting source-segregation, increasing the efficiency of collection and transport, producing value-added compost and liquid fertilizer, selling reuse and recyclable materials, pre-processing and reusing of construction and demolition waste, landfilling, and generating electricity through waste incineration were proposed under the ISWM framework developed. The value-addition to the final compost product and liquid fertilizer was considered mandatory, as the government has given priority to organic fertilizer production efforts. The proposed ISWM framework was applied to Kekirawa Pradeshiya Sabha to evaluate the long-term sustenance of the framework developed.

The present status of MSWM practices carried out by Kekirawa Pradeshiya Sabha was evaluated through a questionnaire survey, field visits, meetings with officials involved in existing MSWM practices, and a comprehensive literature survey. Based on the deficiencies identified in the current MSWM practices carried out by Kekirawa Pradeshiya Sabha, the proposed ISWM framework developed was tailor-made to overcome the deficiencies identified and improve revenue generation to Kekirawa Pradeshiya Sabha. The current collection of MSW (17%) was increased up to 50% with the provision of two garbage compactors (6-8 m³ each). The open dumping of mixed waste currently being practiced will completely be halted, and an ISWM facility was designed with a compost plant, resource center, construction and demolition waste collection yard, and controlled landfill. The expected output of value-added compost and liquid fertilizers was 3.5 MT/day and 500 L/day, respectively. The electricity generation was 0.2 MW. Only 0.3 MT/day of fly ash will be disposed of in a secure landfill out of 13.8 MT/day of total MSW collected, which accounts

for 1.3% of the total MSW generation. An economic analysis was carried out to evaluate the economic feasibility of the proposed ISMW framework for Kekirawa Pradeshiya Sabha.

The results of economic analysis manifested that the Net Present Value (NPV) was SLR 66.52 million at an interest rate of 10%. The Internal Rate of Return (IRR) was 12%. Further, reduction of greenhouse gas emissions (GHG), land value appreciation, city beautification, improving health and wellbeing of people, promoting tourist attraction, and employment opportunities are other benefits to be gained from the proposed ISWM framework. Therefore, the proposed ISWM framework appears viable from a national economic viewpoint and can be used as a role model for the MSWM by other local authorities, particularly covering agriculture-based cities of Sri Lanka.

Keywords: Municipal Solid Waste Management, Integrated Solid Waste Management, Circular Economy, Greenhouse Gases, Net Present Value, Internal Rate of Return

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List of abbreviations

\$	United States Dollar
3R	Reduce, Reuse, and Recycle
ABC	Aggregate Base Course
BC	British Columbia
BCR	Benefit-Cost Ratio
BOD	Biological Oxygen Demand
BOQ	Bill of Quantities
C:N	Carbon:Nitrogen ratio
Ca	Calcium
CBA	Cost-Benefit Analysis
CCTV	Closed-Circuit Television
CEA	Central Environmental Authority
CMC	Colombo Municipal Council
CO ₂	Carbon dioxide gas
COD	Chemical Oxygen Demand
DEWAT	Decentralized Wastewater Treatment Plant
ECBA	Extended Cost-Benefit Analysis
EIRR	Economic Internal Rate of Return
EM	Effective Microorganisms
ENPV	Economic Net Present Value
EOCC	Economic Opportunity Cost of Capital
EPL	Environmental Protection License
FAO	Food and Agriculture Organization of the United Nations

FCA	Financial Capability Assessment
FOD	First Order Decay
FV	Future Value
GHG	Green House Gases
GPS	Global Positioning System
GSM	Global System for Mobile
GWP	Global Warming Potential
H ₂ S	Hydrogen Sulfide
HDPE	High Density Polyethylene
IPCC	Intergovernmental Panel on Climate Change
ISWM	Integrated Solid Waste Management
K ₂ O	Potassium Oxide
LDPE	Low Density Polyethylene
LPG	Liquefied Petroleum Gas
MEPA	Marine Environment Protection Authority
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MT	Metric Tonnes
N	Nitrogen
NGO	Non-Governmental Organization
NH ₃	Ammonia
NH ₄ NO ₃	Ammonium Nitrate
NPV	Net Present Value
NSWMSC	National Solid Waste Management Support Center
NTU	Nephelometric Turbidity Units

O&M	Operation and Maintenance
OECD	Organization for Economic Co-operation and Development
P	Phosphorus
P ₂ O ₅	Phosphorus Pentoxide
PET	Polyethylene Terephthalate
PPP	Public-Private Partnerships
PTA	Policy Thematic Areas
PV	Present Value
PVC	Polyvinyl Chloride
SAR	Sodium Adsorption Ratio
SIM	Subscriber Identity Module
SLLDC	Sri Lanka Land Development Corporation
SLR	Sri Lankan Rupee
SLSI	Sri Lanka Standards Institute
SO ₂	Sulfur Dioxide
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TSS	Total Suspended Solids
UDA	Urban Development Authority
UNEP	United Nations Environment Programme
US AID	United States Agency for International Development
US EPA	United States Environmental Protection Agency
VAT	Value-added Tax
WMA-WP	Waste Management Authority of the Western Province