

Strategies for Optimising Domestic Solid Waste
Management Systems in Urban Areas of Australia and
South Korea

by

Seung Hoon Lee



Faculty of Science
University of Technology, Sydney

A Thesis Submitted for the Degree of
Doctor of Philosophy
September 2005

CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Production Note:
Signature removed prior to publication.

Signature of Candidate

Abstract

In today's world, with rapidly developing technologies and booming population, solid waste management has become a major concern. In general, awareness of this problem could lead to the development of improved pollution control technologies and rigorous policies for solid waste handling systems and disposal, in order to minimise the environmental impacts of this waste. In addition, policy-makers need to develop and implement effective municipal solid waste management strategies, taking into account all economic, technical, and environmental objectives and factors.

As the population continues to increase in both Australia and South Korea, the need for strategies to optimise municipal solid waste systems and manage waste is becoming more urgent. It is important to understand that solid waste management is a complex task, which depends as much upon organisation and cooperation between households, communities, private enterprises and government at all levels as it does upon recycling and disposal systems. A conventional view is that either private or public management is more efficient for managing municipal solid waste systems, irrespective of the nature of the resource, or the socio-economic situation of the people. However, because many local governments lack the appropriate financial, technical and human resources, they are neither able nor willing to manage these systems.

Industrialised countries such as Australia and South Korea produce millions of tonnes of municipal solid waste every year, which deplete the world's natural resources and have negative consequences for the environment. In recognition of this problematic global trend, the question of environmental protection for the world's sustainable development through solid waste management systems has been given special attention by many countries, including Australia and South Korea. This study has sought to provide the cities of Sydney and Seoul with tools that will enable them to evaluate the environmental and economic performance of the various elements of their existing or proposed waste management systems. The tools are based on the best information publicly available at the present time, with a commitment to revise this information periodically to ensure that it is up-to-date. The tools are intended as guides only; they do not prescribe the best system for each city. The determination of the best system for a community must take into account several factors, including social and political considerations.

A survey was designed and conducted with the purpose of collecting information on the attitudes of the residents of Sydney and Seoul about municipal solid waste management, how they perceive the current programs of their respective cities in terms of collection, processing and disposal, and how they believe the waste management programs of their cities could be improved in terms of decreasing the amounts of waste generated and effectively managing the collected wastes.

The researcher applied the second version of the White model, the Integrated Municipal Waste (IMW-2) model. The application of the MSW analysis to the two different cities provided an interesting comparison of economic cost, environmental cost and disposal cost. For example, the cost of disposal is quite similar between the two cities. The result does not clearly confirm the environmental superiority of the incineration over the landfill. However, if an incineration facility is introduced in Sydney, an increase of the economic cost of the system will occur. Even though these comparisons are not 100% rigorous, this analysis is still useful for giving some estimation of future MSW management strategies.

The study has used a structured focused comparison to investigate the prevailing waste management programs of Sydney and Seoul and determine the strengths, weaknesses, opportunities and threats in each, in order to develop a waste management model that can be utilised in each city. To achieve optimal results, solid waste management programs must be based on the life-cycle philosophy, filling in the gaps to assess the economic affordability of waste systems, to evaluate the environmental effects involving a product or process, to implement ways to improve or lessen these impacts, and to call for greater public participation in the solid waste management program.

Acknowledgements

I would like to thank my supervisor, Dr Noel Merrick, Dr William Milne-Home and former supervisor, Dr Michael J Knight for their valuable ideas, suggestions, constructive discussions and guidance in preparing this thesis.

I would like to thank all the people that contributed to the completion to this thesis, especially:

Mr. David Williams (Waste Service of NSW)

Ms. Bo Karaula (North Sydney Council)

Mr. Rachael Williamson (City of Sydney)

Mr. Peter Monov (BIEC)

Mr. Sang Jin Kim (KEI)

Ms. Min Kyung Song (Ministry of Environment, Seoul)

Special thanks are due to Ms Pat Skinner who helped a lot to correct the English in this thesis and to residents who participated in the survey.

Moreover, my gratitude goes to all my family members and my fellow Ph.D students, John, Ramesh, Youn-Sik, David, Tony and Jeff for helping and friendly advice throughout my research.

Finally, I would like to dedicate this thesis with great respect and love to my parents, wife and my little daughter, Hyun Seo.

Table of Contents

CHAPTER 1 INTRODUCTION	1
1-1 Background	1
1-2 Objectives of the Study.....	3
1-3 Background of the Two Cities	4
1-3-1 Sydney.....	5
1-3-2 Seoul.....	6
1-4 Trends toward Municipal Solid Waste (MSW) Management.....	7
1-5 Strategy of Solid Waste Management.....	10
1-6 Research Outline.....	13
CHAPTER 2 LITERATURE REVIEW	15
2-1 Functional Elements of an MSW Management System.....	15
2-1-1 Generation.....	15
2-1-2 Collection.....	16
2-1-3 Processing.....	17
2-1-4 Disposal.....	21
2-2 Solid Waste Management Practices	22
2-2-1 Waste Management Hierarchy	22
2-2-2 Market Development Options	24
2-3 Technological Options	25
2-3-1 Mechanical Separation Technologies	25
2-3-2 Biological Treatment Technologies	26
2-3-3 Thermal Waste.....	29
2-3-4 Landfill Technologies	31
2-4 Waste Management Models.....	35
2-4-1 Economic Instruments	36
2-4-2 Life-Cycle Assessment (LCA).....	39
2-4-3 Other Evaluating Tools.....	42
2-5 Conclusion	43
CHAPTER 3 METHODOLOGY	45
3-1 Structure of the Methodology Section	45
3-1-1 Research Questions	45
3-1-2 Data Collection and Research Design.....	46

3-2 Descriptive Method.....	47
3-2-1 Research Process	48
3-2-2 Data-Gathering Tools.....	50
3-3 Case Study	50
3-3-1 Survey	50
3-3-2 Sampling Design	52
3-3-3 Respondents to the Study.....	52
3-4 Statistical Treatment	53
3-5 Analysis of Documents.....	54
3-6 Analysis of the Literature.....	54
3-7 Data-Processing.....	54
3-8 Structured Focused Comparison.....	55
3-9 Ethical Consideration for the Study.....	56
3-10 Data Analysis.....	56

CHAPTER 4 CASE STUDY: SYDNEY MSW MANAGEMENT

..... 57

4-1 Introduction.....	57
4-1-1 Socio-Demographic Profile	58
4-1-2 General View of the Environment	61
4-1-3 Knowledge of Household Waste Management	63
4-1-4 Recycling Collection and Composting	69
4-1-5 Views on New Ideas	78
4-2 Analysis	81
4-3 Statistical Analysis	85
4-3-1 Normality.....	85
4-3-2 Reliability Analysis.....	89
4-3-3 Multiple Regressions	91
4-3-4 ANOVA Analysis	93

CHAPTER 5 CASE STUDY: SEOUL MSW MANAGEMENT

..... 95

5-1 Introduction.....	95
5-1-1 Socio-Demographic Profile	95
5-1-2 General View of the Environment	99
5-1-3 Knowledge of Household Waste Management	102
5-1-4 Recycling Collection	110
5-1-5 Views about Other Systems	118

5-1-6 Food Waste.....	122
5-2 Analysis.....	125
5-3 Statistical Analysis.....	125
5-3-1 Normality.....	126
5-3-2 Reliability Analysis.....	129
5-3-3 Multiple Regressions.....	131
5-3-4 ANOVA Analysis.....	133

CHAPTER 6 STRUCTURED FOCUS COMPARISON OF THE CASE STUDIES IN SYDNEY AND SEOUL 135

6-1 Sydney.....	135
6-2 Seoul.....	140
6-3 Sydney and Seoul.....	147
6-3-1 General View of the Environment.....	147
6-3-2 Knowledge of Household Waste Management.....	147
6-3-3 Household waste management.....	148
6-3-4 Recycling Collection.....	150
6-3-5 Views on Other Systems.....	150
6-4 Conclusions.....	151

CHAPTER 7 SOLID WASTE MANAGEMENT MODEL 154

7-1 Introduction.....	154
7-2 Waste Management Systems.....	155
7-3 Description of the Solid Waste Management Systems in Sydney and Seoul.....	156
7-4 System Boundaries.....	161
7-4-1 Recycling.....	161
7-4-2 Composting.....	162
7-4-3 Energy Recovery.....	163
7-4-4 Landfilling.....	164
7-5 Life Cycle Assessment.....	165
7-6 The Integrated Municipal Waste (IMW-2) Model.....	166
7-7 Application of Integrated Municipal Waste model.....	169
7-8 Results.....	170
7-9 Conclusions.....	177

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS. 179
8-1 Survey Results 179
8-2 Application of IMW-2 Model on Sydney and Seoul 181
8-3 Recommendations 182
REFERENCES 184

APPENDIX

- Appendix 1
- Appendix 2
- Appendix 3

List of Figures

Figure 1-1 The UR-3R Process	11
Figure 3-1 Conceptual research approach	49
Figure 4-1 Respondents According to Gender	58
Figure 4-2 Employment Status	60
Figure 4-2 Educational Attainment	61
Figure 4-4 Important Issues	63
Figure 4-5 Source of Information	65
Figure 4-6 Destination of Non-recyclable Waste	65
Figure 4-7 Most Important Household Waste Management Practice	66
Figure 4-8 Cost of Collecting and Disposing of Household Waste	67
Figure 4-9 Willingness to Recycle	72
Figure 4-10 Satisfaction with Kerbside Recycling	72
Figure 4-11 Household Responsibility	74
Figure 4-12 Recyclable Items Discarded As Waste	75
Figure 4-13 Feelings about Recycled Products	76
Figure 4-14 Composting	76
Figure 4-15 Advantages/disadvantages	77
Figure 4-16 Benefits of Composting	78
Figure 4-17 Disadvantages of Composting	78
Figure 4-18 Plastic Bags Ban	80
Figure 4-19 Public Response to Monetary Reward	80
Figure 4-20 Household Payment for Waste Collection Services	81
Figure 4-21 Multicollinearity and Singularity	87
Figure 5-1 Respondents According to Gender	96
Figure 5-2 Type of Property	96
Figure 5-3 Respondents According to the Number of Households Members	97
Figure 5-4 Proportion of Respondents According to Living Arrangement	97
Figure 5-5 Proportion of Respondents According to Employment Status	98
Figure 5-6 Proportion of Respondents According to Educational Attainment	98
Figure 5-7 Sources of Information	105
Figure 5-8 Importance of Household Waste at Home	105

Figure 5-9 Performance in Separating Household Waste106

Figure 5-10 Respondents' Perceived Cost of Waste Council Services106

Figure 5-11 Level of Satisfaction with the Council's Waste Services107

Figure 5-12 Respondents' Satisfaction with the Volume-Based Waste Charge System119

Figure 5-13 Discontinuation of free plastic bag use in shops121

Figure 5-14 Monetary reward for returning aluminium cans/containers/milk/juice cartons 121

Figure 5-15 Multicollinearity and Singularity 128

Figure 6-1 Waste Management Facilities in Sydney136

Figure 7-1 Trends of Sydney Municipal Waste per person per year (Kg)161

Figure 7-2 System Boundary for Recycling162

Figure 7-3 System Boundary for Composting163

Figure 7-4 System Boundary for the Production of Energy from Waste164

Figure 7-5 Waste Management Systems(Landfill)166

Figure 7-6 Components of Integrated Waste Management System168

Figure 7-7 Detailed Structure of Integrated Waste Management System168

Figure 7-8 Breakdown of MSW of Seoul170

Figure 7-9 Breakdown of MSW of Sydney170

List of Tables

Table 2-1 Situation of Collection and Recycling of Main Recyclable Materials 2001	19
Table 2-2 Input Wastes and Output Products by Waste Technology Type	34
Table 4-1 Number of People in the Household	59
Table 4-2 Description of Household	60
Table 4-3 Type of Property	60
Table 4-4. Environmental Concern	61
Table 4-5 Helping the Environment	62
Table 4-6 Environmental Involvement	62
Table 4-7 Importance of Household Waste Management	63
Table 4-8 Reducing Household Waste at Home	64
Table 4-9 Practices to Reduce Household Waste	64
Table 4-10 Interest in Household Waste Management	65
Table 4-11 Evaluation of Performance	67
Table 4-12 Satisfaction about Services	68
Table 4-13 Reluctance to Commit to Waste Management Practices	69
Table 4-14 Areas for Improvement	69
Table 4-15 Items for Kerbside Recycling Collection	70
Table 4-16 Frequency of Using Kerbside Recycling Service	70
Table 4-17 Feelings about Recycling	71
Table 4-18 Reluctance to Recycle	71
Table 4-19 Improving Kerbside Recycling Arrangements	73
Table 4-20 Motivations for Recycling	74
Table 4-21 Reasons for not Composting	77
Table 4-22 Volume-based Waste Charge System	79
Table 4-23 Household Waste Management Schemes	79
Table 4-24 Descriptive statistics	85
Table 4-25 Correlations	89
Table 4-26 Item-Total Statistics	90
Table 4-27 Reliability Statistics	91
Table 4-28 Model Summary	92
Table 4-29 Coefficients	92

Table 4-30 ANOVA 93

Table 5-1 Environmental Concern of the Respondents 99

Table 5-2 Helping the Environment 100

Table 5-3 Willingness to Help Protect the Environment100

Table 5-4 Issues Considered as Important by Respondents101

Table 5-5 Importance of Household Waste Management for the Preservation of the Environment and Natural Resources102

Table 5-6 Destination of Non-recyclable Waste103

Table 5-7 Most Important Household Waste Management Practice103

Table 5-8 Interest in Learning More about Managing Household Waste Management104

Table 5-9 Current Household Management Practices of the Respondents108

Table 5-10 Reluctant to Commit to Household Waste Collection Service109

Table 5-11 Suggestions as to How the Household Waste Management could be more effectively improved.110

Table 5-12 Items that the Respondents Do Not Separate for Recycling Collection111

Table 5-13 Frequency of Respondents’ Usage of the Recycling Services112

Table 5-14 Attitudes Towards Recycling112

Table 5-15 Reasons Why Respondents Are Less Committed to Recycling113

Table 5-16 Willingness to Increase Recycling Efforts114

Table 5-17 Items that respondents think they could have recycled but have thrown away ..114

Table 5-18 Respondents’ Satisfaction with the Recycling Services 115

Table 5-19 Improving Recycling Arrangements115

Table 5-20 Person in the Household Responsible for Recycling116

Table 5-21 Factors that influence the respondents to recycle117

Table 5-22 Feelings about recycled as compared to non-recycled products118

Table 5-23 Activities that would be prepared in the respondents’ area119

Table 5-24 Preference for Household Payment for Waste Collection Services122

Table 5-25 Managing Food/Organic Waste Generated at Home123

Table 5-26 Reasons for Not Separating Food/Organic Waste from Normal Household Waste123

Table 5-27 Advantages of Food Collection124

Table 5-28 Disadvantages of Food Collection124

Table 5-29 Descriptive Statistics126

Table 5-30 Correlations129

Table 5-31 Item—Total Statistics	130
Table 5-32 Reliability Statistics	131
Table 5-33 Model Summary	132
Table 5-34 Coefficients	133
Table 5-35 ANOVA	133
Table 7-1 Trends in Seoul’s Waste Generation	158
Table 7-2 Trends in Seoul’s Food Waste Generation	158
Table 7-3 Composition of Solid Waste in Major Municipal Centres	160
Table 7-4 Results of Seoul and Sydney MSW Systems Analysis with the Application of IMW-2	171
Table 7-5 Cost of Living	172
Table 7-6 Comparison of Sydney and Seoul MSW disposal system	176

List of Pictures

Picture 6-1 Waste Collection in Sydney	139
Picture 6-2 Recycling Materials Guidelines in Sydney	140
Picture 6-3 Standardised Waste Bags in Seoul	143
Pictures 6-4 Waste Collection in Seoul	144