From urban waste to sustainable value chains:
Linking sanitation and agriculture through innovative partnerships

Design options for building sustainable urban waste value chains

Prepared by the Institute for Sustainable Futures, Janathakshan and Sabaragamuwa University of Sri Lanka

March 2022

Knowledge and Linkages for an Inclusive Economy Grants Program
Australian Government Department of Foreign Affairs and Trade

This report presents design options for sustainable organic waste value chains informed by research focused on (1) waste system assessment; (2) study on social and market research of organic value chains; and (3) political economy analysis. This research was undertaken as part of Activity 4 within the project *From urban waste to sustainable value chains: Linking sanitation and agriculture through innovative partnerships*.

This applied research project in Sri Lanka connects the waste management, sanitation and agriculture sectors through the circular economy, to improve food security and environmental health. This project is a partnership between the Institute for Sustainable Futures at the University of Technology Sydney (UTS-ISF), the International Water Management Institute (IWMI), Janathakshan (GTE) Ltd, Sabaragamuwa University of Sri Lanka (SUSL) and the Sri Lankan Department of Agriculture (DoA).

The project is funded through the Knowledge and Linkages for an Inclusive Economy Grants Program by the Australian Government Department of Foreign Affairs and Trade.

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Citation

Winterford, K., Carrard, N., Davilla, F., Drechsel, P., Esham, M., Jayathilake, N., Jacobs, B., Samarakoon, D., Dominish, E. (2022). Design options for organic waste value chains. Report prepared by Institute for Sustainable Futures at the University of Technology Sydney, Janathakshan (GTE) Ltd and Sabaragamuwa University of Sri Lanka.

Acknowledgments

The authors would like to thank all the research participants, who generously gave their time as part of research and acknowledge input from key stakeholders during consultations and an on-line forum in early 2022.

This research was funded by the Australian Government Department of Foreign Affairs and Trade.

Glossary

AIs	Agriculture Inspectors
ARPAs	Agriculture Research and Production Assistants
DFAT	Department of Foreign Affairs and Trade, Australia
DFS	Dried Faecal Sludge
DS	Divisional Secretariat
IWMI	International Water Management Institute
KMC	Kaduwela Municipal Council
MC	Municipal Council
MSW	Municipal Solid Waste
SUSL	Sabaragamuwa University of Sri Lanka
UTS-ISF	Institute for Sustainable Futures, University of Technology Sydney

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Executive Summary

The project “From Urban Waste to Sustainable Value Chains: Linking Sanitation and Agriculture Through Innovative Partnerships” is funded under the **Knowledge and Linkages for an Inclusive Economy** (KLIE) Grants Program of the Australian Department of Foreign Affairs and Trade (DFAT).

This report presents the findings from the last of four project activities. This activity brought together research findings from earlier activities (i) waste supply assessment; (ii) social and market research; and (iii) political economy analysis, to identify options for building sustainable urban waste value chains.

Findings presented in this report are relevant to the study location of Kaduwela Divisional Secretariat (DS) Division of Colombo District, but based on stakeholder feedback are generalisable for the country more broadly. We have noted instances where the findings are likely to be specific only to the Kaduwela region.

Urban waste to sustainable value chains

For this project, we developed a visual summary of a circular economy system that links source materials and end-users through organic waste value chains. Our focus of interest is made up of three sectors: agriculture, sanitation, and solid waste. Our research project sought to draw linkages and connections between different parts of the value chain which are often siloed and fragmented. This ‘bringing together’ is especially relevant to this research report which focuses on options to build sustainable value chains from urban organic waste.

Summary of key research findings

This research revealed a range of design options for building sustainable urban waste value chains. These were identified through analysis of findings from previous research activities: Waste System Assessment: Kaduwela Municipal Council; Social and market research on organic waste value chains; and Political economy analysis of organic waste value chains in Sri Lanka,[1] as well as consultations with stakeholders.[2]

[1] See reference list for reports
[2] See section 2.3 for details of stakeholder consultations

Design options are presented below with further insights into actions required to support change. Actions are categorised within the three spheres of practical, political, personal, as presented above.

- Option 1: QUANTITY - Increase volume of waste treatment for compost
- Option 2: QUALITY - Improve waste collection and compost production practices
- Option 3: VALUE-ADD - Improve nutrient value of compost through addition of septage
- Option 4: MARKETING - Segmenting and marketing compost products to meet farmer needs
- Option 5: AWARENESS – EDUCATION - Education of retailers and farmers on compost use

Implications for future organic waste value chains

- Whilst action at two ends of the value chain – the segregation of waste by households and use by farmers of compost – were identified as critically important, a key area of action to build sustainable urban waste value chains is to increase utilisation of municipal waste and increase compost quality to meet standards.
- Collaborative efforts of multiple actors at community, national and sub-national levels involving both public and private sector is required to realise change.
- A broader perspective on boundaries for building sustainable urban waste value chains is required.
- Intervention is required in multiple parts of the value chain to realise change in any one part.
- A paradigm shift for how we think about 'waste' needs to occur in order to change personal behaviours and broader systems and structures that could support a circular economy of sustainable value chain.
- The role of schools and standard education curriculum may be an effective means to create attitude changes towards waste as a resource.
- Value addition / co-composting provides a practical means of strengthening nutrient value but requires further research and technical guidance.
- There are so many actors in this part of the value chain (public, private and community) and stronger coordination and cooperation is required within these vast sets of actors to enable system change.
- Exploring new business models of waste management may also be an opportunity for change.
- Applying system thinking to integrate other waste streams can also help to determining the feasibility the possible interventions for building sustainable value chains.

Looking to the overall question that the research sought to answer at inception, *"What are the enablers and barriers for public and private institutions in Sri Lanka to advance the implementation of sustainable and innovative value chains to improve sanitation, health and food security?"* the research has provided clear insights. Change needs to be both deeper level paradigm and attitude change towards organic municipal waste, change in systems and structures, most particularly cooperation and coordination for compost quality as foundation for more practical changes related to behaviour change and also technical innovations for waste treatment and compost production.

1. Introduction

The project “From Urban Waste to Sustainable Value Chains: Linking Sanitation and Agriculture Through Innovative Partnerships” is funded under the **Knowledge and Linkages for an Inclusive Economy** (KLIE) Grants Program of the Australian Department of Foreign Affairs and Trade (DFAT). This project seeks to answer the question: “What are the enablers and barriers for public and private institutions in Sri Lanka to advance the implementation of sustainable and innovative value chains to improve sanitation, health and food security?” The project establishes the knowledge, linkages and policy foundations for enabling local entrepreneurs and policy-makers to implement innovative value chains that determine how organic urban waste and sanitation systems can be transformed to deliver smallholder farmers with agricultural inputs. The policy impact of the project lies in identified synergies between agriculture, health and sanitation sectors to drive organic waste value chains. Through partnerships with the government, research institutes, the private sector and NGOs, as well as an innovative stakeholder engagement strategy, the project aims to establish an evidence base for driving policy dialogue, reducing policy fragmentation and promoting coordinated action.

This report presents the findings from the last of four project activities. This activity brought together research findings from earlier activities (i) waste supply assessment; (ii) social and market research; and (iii) political economy analysis, to identify options for building sustainable urban waste value chains.

Findings presented in this report are relevant to the study location of Kaduwela Divisional Secretariat (DS) Division of Colombo District, but based on stakeholder feedback are generalisable for the country more broadly. We have noted instances where the findings are likely to be specific only to the Kaduwela region.

2. Methodology

This section of the report describes the approach employed to generate research findings.

2.1 Conceptual framing

Our research employed two major conceptual frames to guide analysis and write up of research findings.

Urban waste to sustainable value chains

For this project, we developed a visual summary of a circular economy system that links source materials and end-users through organic waste value chains. Our focus of interest is made up of three sectors: agriculture, sanitation, and solid waste, which are represented in the value chain in Figure 1. Our research project sought to draw linkages and connections between different parts of the value chain which are often siloed and fragmented. This 'bringing together' is especially relevant to this research report which focuses on options to build sustainable value chains from urban organic waste. As evident through our research findings, seeing change across the whole system is necessary. The value chain is inclusive of supply of waste streams, treatment of organic waste for compost production, storage and transport of compost to retailers and customers (farmers). Ultimately this provides a benefit to food security by increasing soil health and reducing dependence on chemical fertilizers.

Figure 1: Urban waste to sustainable value chains

Systems change – actions within spheres of transformation

In order to explore how to build sustainable organic waste value chains we used system change and the concept of 'leverage points' to describe types of actions to create change. The concept of leverage points (Meadows, 1999) help to consider the breadth and depth of actions required for systems change, and are particularly helpful when considering change for circular economies which includes complex and multi-dimensional change and multiple and different actor groups.

We have employed the framework of 'three spheres of transformation' (O'Brien 2018) to present leverage points, i.e. types of actions to create change. The spheres represent the whole system and provide insights into different types of changes - broader or deeper level change often required to enable practical level change (Figure 2).

The **practical sphere**, at the core of the figure, "represents specific actions, interventions, strategies and behaviours that directly contribute to a desired outcome" (O'Brien 2018, p.155)

As noted by O'Brien whilst actions identified in the practical sphere might be easy to identify, there are often different barriers associated with political and personal spheres which thwart realisation of change in this sphere.

In the context of this research practical change relates to such actions as waste segregation and technologies for production of quality compost.

The **political sphere** represents the systems and structures that facilitate or constrain practical responses.

'Systems can be described as relationships between parts that form a larger whole, and structures describe the norms, rules, regulations, institutions, regimes and incentives that influence how systems are designed, organized and governed. Systems and structures are interpreted here as the 'political sphere' because they are often created, codified, and managed through political processes, which include collective actions and struggles that shape the spaces for responses in the practical sphere' (O'Brien, 2018, 156)

The political sphere is:

'A space where shared interests and understandings exist, but also where disagreement and dissent are expressed, which can produce tensions and conflicts. It is in the political sphere where norms are challenged, social movements are formed to address structural injustices, and where interest groups lobby to defend or transform the status quo. It is also where cooperation, collaboration and compromise can lead to new alliances and social innovations such as circular and sharing economies' (O'Brien, 2018, 156).

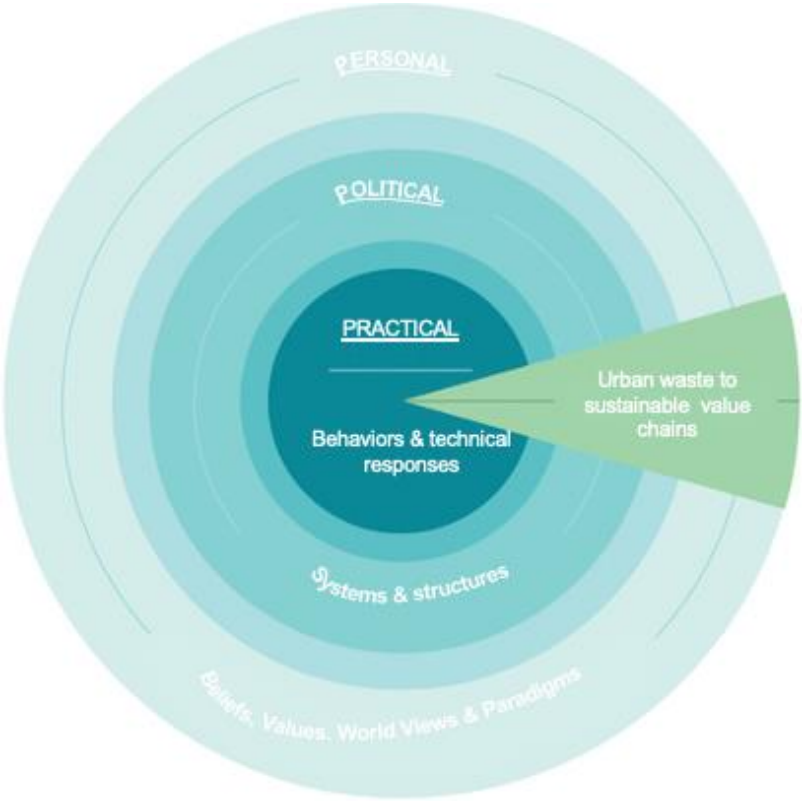
In the context of this research political change relates to such actions as setting standards for quality compost, monitoring standards as well as coordination and collaboration of different actors across the value chain such as waste management authorities and agricultural extension officers.

The **personal sphere** represents the subjective beliefs, values, worldviews and paradigms that influence how people perceive, define or constitute systems and structures, as well as their behaviours and practices.

'The personal sphere of transformation represents the subjective beliefs, values, worldviews and paradigms that influence how people perceive, define or constitute systems and structure, as well as their behaviours and practices. This sphere represents both individual and shared understandings and assumptions about the world, which influence perceptions, interpretations and constructions of reality. It also defines what is individually and collectively imaginable, desirable, viable and achievable based on different understandings of causality, levels of social consciousness and future consciousness, perceptions of agency, and assumptions about leadership' (O'Brien, 2018, 156).

In the context of this research personal change relates to such aspects as the attitudes towards compost derived from municipal waste, value addition of septage to compost and the collective interest to realise circular economies.

Figure 2: Spheres of systems change

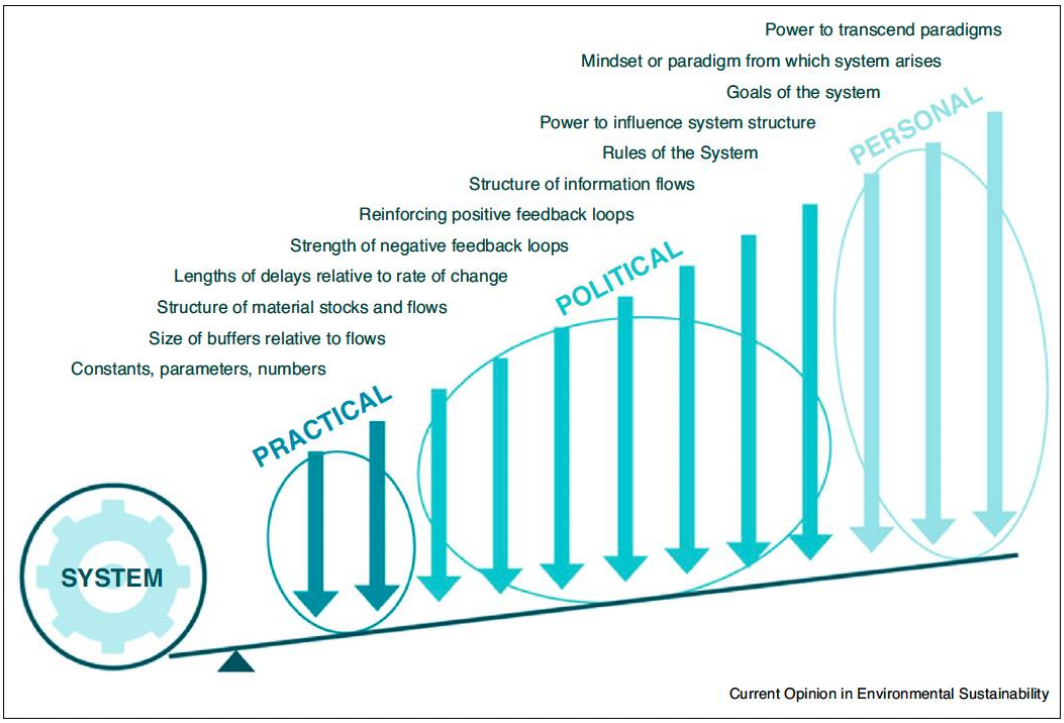


As described by O'Brien (2018) 'the there spheres correspond quite well with the 12 leverage points for systems change identified by Donella Meadows" (p.157). See Figure 3 for illustration of the alignment.

Leverage points provide a means to think about change particularly within complex systems. The idea is that to create system change, change is required at deeper system properties, such as the rules or the paradigms that shape the system, in comparison to shallower properties such as material flows or reward structures.

The research employed the three sphere categorisation as these are simpler to utilise and communicate to influence change, compared to the 12 leverage points.

Figure 3: Leverage points - practical, political and personal spheres of transformation



2.2 Analysis of earlier research

Research outputs already carried out within the project were reviewed and design options were drafted, which were then presented for discussion at stakeholder consultations. Earlier research reports identified enablers and barriers to organic waste value chains as well as recommendations to strengthen value chains. The following reports were reviewed:

Waste System Assessment: Kaduwela Municipal Council.

The objective of this scoping study was to identify feasible organic waste streams that may be available as potential feedstock supply for the recovery of resources such as agricultural inputs.

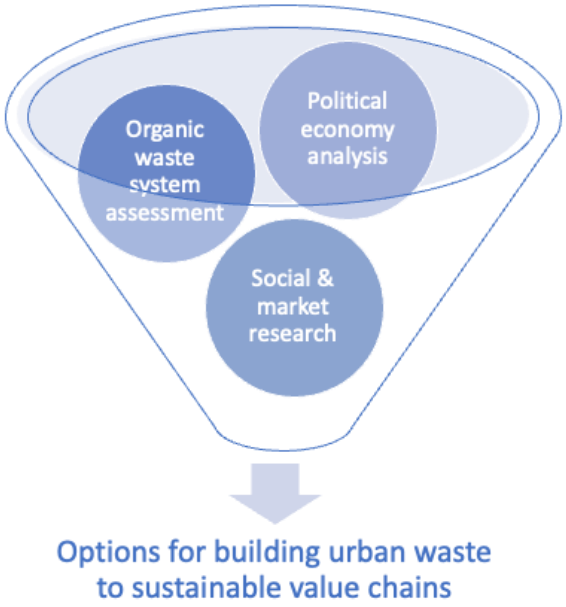
Social and market research on organic waste value chains in Sri Lanka.

The main goal of the social and market research component of the project was to identify end-user and value chain stakeholder perception of, and demand for, compost derived from municipal solid waste (MSW), including compost enhanced with faecal sludge, for food production.

Political economy analysis of organic waste value chains in Sri Lanka.

This study presented an analysis of how the current institutional and political environment can trigger new circular economy business models for innovative value chains.

Figure 4: Analysis of project research findings to inform options



The earlier research reports were reviewed and potential actions to take identified and categorised in relation to:

- different parts of the value chains
- spheres of action
- roles of different stakeholders

2.3 Stakeholder reactions to design options

Two primary forms of stakeholder consultations informed research findings presented in this report.

First, consultations were carried with individual stakeholder groups in late 2021 and early 2022. These consultations were for the purpose of getting initial reactions to proposed design options from key actors within the system. Consultations were undertaken with:

- Kaduwela Municipal Council
- Retailers
- Agricultural instructors
- Ministry of Agriculture
- The National Fertilizer Secretariat, within the State Ministry of Agriculture
- Sustainable Agriculture Research and Development Centre
- Central Environment Authority

Second, a multi stakeholder online workshop was facilitated on the 8 March 2022.

The purpose of workshop was to share research findings and validate options for action. It was attended by 36 participants representing a cross section of stakeholders from the following entities:

- Sustainable Agriculture Research and Development Centre (DoA)
- Plantation companies (Kelani valley and Kahawatta Plantations)
- Department of Local Government (Western Province)
- Western Province Waste Management Authority
- National Livestock Development Board
- National Solid Waste Management Unit, State Ministry of Provincial Councils and Local Government
- Independent researcher (Formally from Ministry of Megapolis and Western Development)
- National Water Supply and Drainage Board
- Solid Waste Management Unit, Central Environment Authority
- State Ministry of Agriculture (Fertilizer Secretariate)
- Academia (SUSL, University of Sri Jayewardenepura, South-Eastern University of Sri Lanka, Sri Lanka Information Technology Institute)
- Organic fertilizer production entities

2.4 Study area

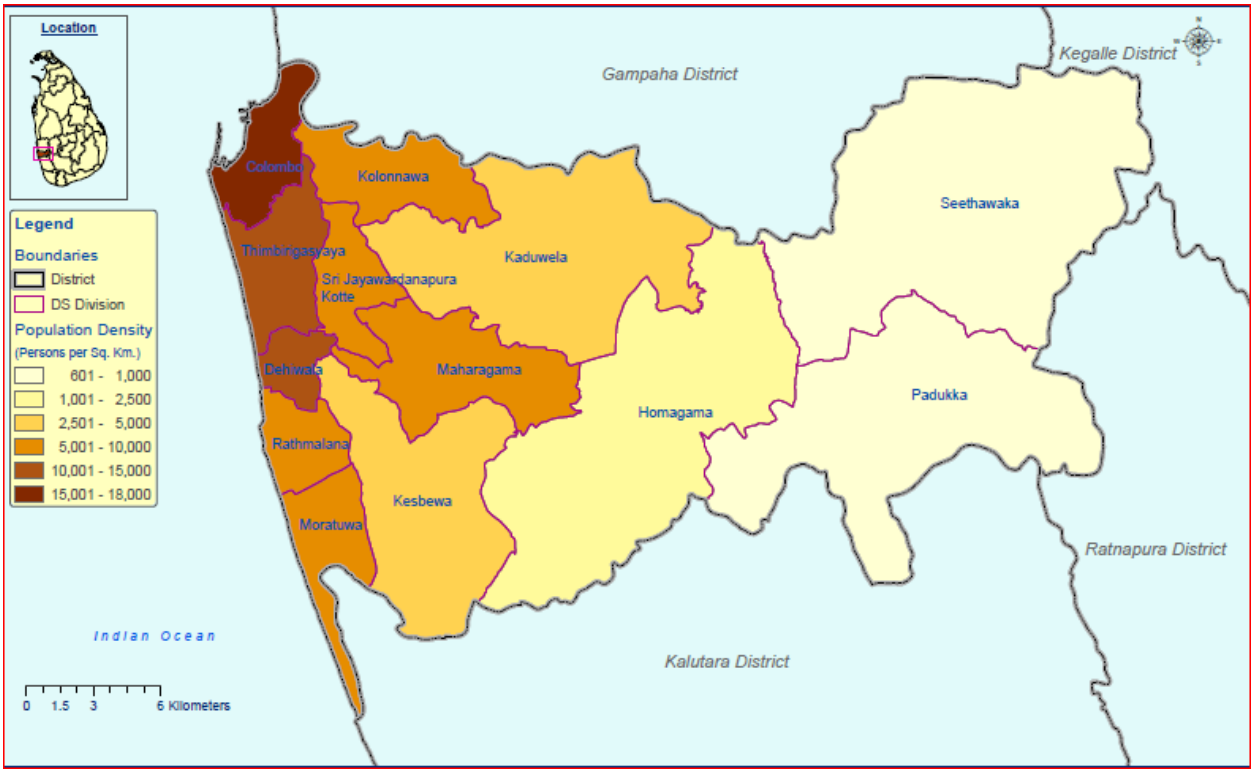
This research focused on Kaduwela DS Division administered by the Colombo Administrative District of the Western Province, though recognising the nature of agriculture food systems, the research had a broader geographical perspective to include surrounding districts of Homagama and Seethawaka[3]. The Kaduwela, Homagama and Seethawaka DS Divisions are three of the largest sized divisions, out of 13 DS divisions in Colombo District (see Figure 5).

The total population of the DS Divisions is approximately 260,000 in Kaduwela, 264,000 in Homagama and 121,000 in Seethawaka.[4] The three DS divisions are situated in the Kelani River flood plain and fall under the wet lowland agro ecological zone which receives over 1500 mm of annual rain fall.

These three districts have lower population density and higher levels of agriculture compared to other DS Divisions in the District. They are considered peri-urban areas, however they are rapidly becoming urbanised with new residents moving from more rural districts. The area also has a high number of people who travel to the Colombo city area during day for work.

[3] Social and market research for this project included the three districts of Homagama, Seethawaka and Kaduwela
[4] Resource Profile 2017 – Kaduwela Divisional Secretariat, Resource Profile 2017 – Homagama Divisional Secretariat, Divisional Secretariat Seethawaka – website

Figure 5: Study area map



(Source: Population Atlas of Sri Lanka 2012, Department of census and statistics, Ministry of Finance and Planning)

Home gardening is the most common type of farming across the three DS Divisions based on the number of farmers. In terms of farming industry, Seethawaka has a high number of plantations, whereas Homagama is dominated by paddy farming. Kaduwela also has a high number of poultry farmers.

In addition to agriculture, Kaduwela and Seethawaka have industries such as beverage and garment manufacturing, while Homagama is planned to be developed as an education hub.

3. Findings

3.1 Options for building sustainable urban waste value chains

This research revealed a range of design options for building sustainable urban waste value chains. These were identified through analysis of findings from previous research activities: Waste System Assessment: Kaduwela Municipal Council; Social and market research on organic waste value chains; and Political economy analysis of organic waste value chains in Sri Lanka,[5] as well as consultations with stakeholders.[6]

Design options are presented below with further insights into actions required to support change. Actions are categorised within the three spheres of practical, political, personal, as presented above.

- Option 1: QUANTITY - Increase volume of waste treatment for compost
- Option 2: QUALITY - Improve waste collection and compost production practices
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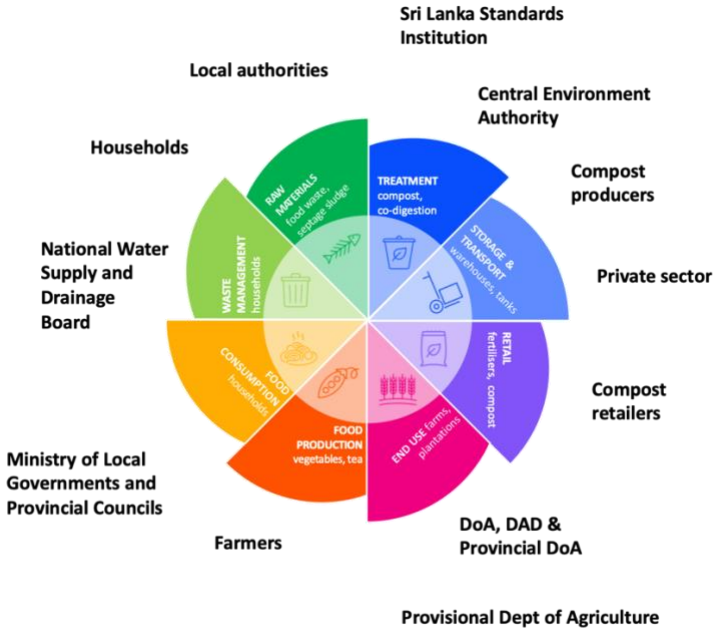
- Option 4: MARKETING - Segmenting and marketing compost products to meet farmer needs
- Option 5: AWARENESS – EDUCATION - Education of retailers and farmers on compost use

Whilst each option is presented separately it is important to recognise that they are linked across the value chain. Each of the separate value chains is inclusive of roles and responsibilities of a range of different stakeholders. Key actors include those listed in Figure 6.

Figure 6: Actors that influence or inform an organic waste value chain



[5] See reference list for reports
[6] See section 2.3 for details of stakeholder consultations

Whilst options emphasise a particular part of the value chain, they also require and assume change in other parts of the value chain. For example, Option 2 is important for the enabling of Options 1 and 5. A focus on education and awareness raising to retailers and farmers in Option 5 assumes that changes in other parts of the value chain have achieved quality compost standards and trusted monitoring and compliance of quality (Option 2). Increasing the volume of biodegradable waste and utilisation of compost (Option 1) will have a greater impact if improvements in waste treatment practices are improved (Option 2), which will increase the market for compost products. As illustrated below, there are many further linkages between the five options within the value chain.

Design Option 1: QUANTITY - Increase volume of waste treatment for compost

This design option has a focus on increasing the volume of waste treated for compost production – but recognises that the increased use of municipal waste for compost cannot be realised without improvements in other parts of the value chain, such as improvements in source separation and an increased market for compost products.

Expected system change:

- Reduced waste going to landfill, reducing negative environmental impacts
- Increased utilisation of municipal solid waste
- Increased revenue from compost sales
- Reduced costs of sending waste to landfill or private operators (if instead used for compost production)
- Improved food security from increased agriculture yields, improved soil health and reduced dependence on chemical fertilisers

Key activities associated with this option are provided below.

An illustrative example of this option relevant to Kaduwela Municipal Council might be the increased utilisation of waste collected by the council for compost production. The waste assessment study carried out under this research identified that approximately 60% of the collected biodegradable waste (25 tonnes / day), about 10 tonnes, is processed as compost at the waste recycling center. The rest of the organic waste and almost all of the non-biodegradable waste (25 tonnes / day) is transported by private operators to produce compost or be landfilled on private lands, for which the council pays a tipping fees of LKR 166,500 (USD 850) per day. Increased utilisation of municipal waste for compost production could provide an important and critical revenue stream for the council.

However, the recent communications with Kaduwela MC revealed that the current arrangement is such that the MC has agreements with Sri Lanka Land reclamation and development corporation (SLRDC) (to dispose mostly biodegradable waste at Kerawalapitiya landfill), Western Power- a private entity (to direct non-biodegradable waste to a waste to energy plant at Karadiyana), INSEE- a private entity (to co-process non-biodegradable waste as an alternative fuel) and another private operator (to dispose non-biodegradable waste). These strategies have helped MC reducing the cost of waste disposal to a certain extent, particularly non-biodegradable waste. However, the volume of organic waste processed at the waste recycling center remains the same. Strategies need to be identified to increase the volume of organic waste treated to produce compost. The country currently has a high demand for compost and local authorities can benefit from this opportunity to bring in more revenues.

Space limitations are a major challenge Kaduwla MC has encountered in increasing volumes of compost production. The MC is exploring technological advancements to the current composting practices to enable them to process more organic waste. The current practice is the conventional windrow composting with piles created and rolled using a bakcho loader, and it takes 4-5 months to produce compost. If advanced technologies can be used to improve the composting speed (through pre crushing of waste) and further mechanise the piling and turning process, then more volumes of waste can be converted in to compost using the same space and time. Kaduwela MC needs to develop a detailed cost benefit analysis on making the process more mechanised and there by understanding and justifying the investment needs for such a process.

Design Option 2: QUALITY – Improved waste collection and compost production practices

This design option focuses on improvements in waste treatment processes to improve compost quality and reduce contamination. The design option assumes improvements in other stages of the value chain.

Expected system change:

- Improved quality of compost products
- Higher-value utilization of municipal solid waste, as higher quality compost products will be more likely to be used in agriculture
- Increased market demand and new customers who are seeking a higher quality product
- Increased revenue from compost sales (higher quality compost may have a higher sale price)
- Improved food security from increased agriculture yields, improved soil health and reduced dependence on chemical fertilisers

Key activities associated with this option are provided below.

For example, the waste supply assessment undertaken in this project revealed that improvements can be made to the current waste treatment practices at Kaduwela MC to ensure effective composting and thereby to make the compost quality consistent. It is of paramount importance to have high quality feed stocks without contaminations to produce high quality compost. Improved waste segregation is a key to obtain high quality organic waste materials. A common observation of the compost plant at Kaduwela MC was the compost piles contaminated with significant volumes of polythene/plastics. This could potentially hinder the degradation process of organic waste. Kaduwela MC highlighted poor source segregation as a key challenge they are facing.

In addition to the improved source segregation, maintaining optimum conditions for composting (including optimum temperature, moisture content, C:N ratios etc.), regular turning, providing adequate training to the staff are some of the measures that can be taken to improve and maintain the quality of compost. The social and market research study under this project revealed that many farmers are concerned about current compost quality but there is a high farmer demand for compost if quality can be assured. Another important aspect from the research findings was the need for producing customized compost products for different crops. Strategies should be developed to explore this by making improvements to the current composting processes such as value addition to compost during or after the production process.

Design Option 3: VALUE-ADD – Improving nutrient value of compost through addition of septage

This design option focuses on improving compost nutrient value by adding septage to compost production (co-composting with dried septage sludge). The design option is inclusive of transformation in other parts of the system beyond compost production.

Expected system change:

- Increased utilization of (waste) faecal sludge
- Potential for reduced costs of septage management for desludging operators
- Increased nutrient value of compost
- Increased market demand and new customers who are seeking a compost with higher nutrient value
- Improved food security from increased agriculture yields, improved soil health and reduced dependence on chemical fertilisers

Key activities associated with this option are provided below.

Having recognized the quality of compost is a key factor when it comes to the sales of compost, Kaduwela MC is exploring options to improve the quality of their compost product. Value addition to compost by co-composting with dried septage sludge and pelletizing could increase the marketability of the product and bring in more revenue. However, current infrastructure facilities at the waste recycling center of Kaduwela are not adequate to practice co-composting as an immediate strategy. This can be an option to explore with the participation of private sector after investigating the feasibility. In Sri Lanka co-compost is already being practiced by some of the LAs such as Balangoda and proved to be a successful strategy in increasing the sale of compost. Increasing the knowledge and capacities of Kaduwela MC staff on co composting techniques is essential to initiate this process. Coordinating with the treatment centres of National Water Supply and Drainage Board (NWS&DB) and commencing co composting as a value adding strategy through already tested and verified septage sludge will help to avoid large investments up front.

Design Option 4: MARKETING - Segmenting and marketing compost products to farmer needs

This design option focuses on producing quality compost products to farmers, recognising that different farmer groups have different needs and preferences for compost.

This design option, like others, assumes changes in other parts of the value chain, most particularly in the waste management and treatment, as compost quality is a priority to be able to market compost to farmers.

Expected system change:

- Range of different compost products fit-for-purpose for different farming
- Increased farmer demand for compost by catering to different farmer needs and preferences
- Increased availability and accessibility of compost (transport and price)
- Increased revenue from compost sales
- Improved food security from increased agriculture yields, improved soil health and reduced dependence on chemical fertilisers

Key activities associated with this option are provided below.

Marketing of compost remains largely under explored and marketing approaches are rarely applied. It is a prerequisite for market orientation to consider composting as a business operation. For market orientation, it is critical to understand the customer base around the composting facility by learning what the customers need, what products they are currently using and the prices that they are paying and willing to pay. It will be useful for KMC to use the outcomes of the social and market survey to understand customer requirements, preferences, and demand for compost. The survey revealed different farmers prefer compost in different forms (e.g. paddy farmers preferred the pellet format) and with different nutrient and soil enrichment content added (e.g. paddy husk ash or coco peat) indicating the need for market segmentation. Creating a trademark for KMC compost would be a good marketing strategy. The KMC needs capacity building on marketing approaches for composting especially to develop a marketing plan and linkages with value chain actors. Interventions in the other value chain nodes are critical for the success of the marketing strategy.

Design Option 5: AWARENESS– EDUCATION - Education to farmers on compost use

This design option is focused on increasing demand and effective use of compost.

Like other design options noted above, it is assumed that changes in other parts of the value chain will also be strengthened.

Expected system change:

- Increased farmer awareness about compost value and use
- Increased farmer demand for compost
- Increased farmer practice of compost
- Improved food security from increased agriculture yields, improved soil health and reduced dependence on chemical fertilisers

- Educate producers about the value and use of compost
- Educate retailers about the value and use of compost
- Educate farmers and the broad community about the value of compost and co-compost, building from existing understanding
- Conduct awareness campaigns targeted to specific farmer needs and expectations
- Develop and promote recommendations on how to use compost for different farming systems
- Use existing farmer networks to promote compost use through peer recommendations and sharing of information
- Promote compost with the promotion of traditional crop varieties
- Demonstrate compost use and benefits to farmers (e.g. through on-farm trials for specific farming systems, providing free samples of farmers to test, opportunities for farmers to learn from each other)
- Government support could help to promote compost use, including support for demonstrations and developing recommendations on compost use, as well as increasing the technical knowledge of extension officers and supporting standards development and certification.

An illustrative example of this option relevant to Kadewala MC might be targeted education to compost retailers in the area on the composition of compost products, nutrient value and use for particular soil types and farming practices. Our research identified that retailers often were not aware of the nutrient value of compost. Furthermore they were not educated to provide guidance to farmers on how to use compost. This was in contrast to their knowledge on chemical fertilisers and their confidence to provide guidance to farmers.

Another proposal identified through our research to realise education to farmers on compost use is the set-up of compost trials. Live compost use as part of dedicated trials would show the results to farmers and also enable farmers and retailers to learn from each other. As part of trials, farmers could be provided free compost samples. Through the trial, farmers and retailers will gain insights from each other and can also be encouraged to share their new knowledge with other farmers.

Another practical way that farmers and retailers could be better educated on compost use is through strengthened role of government services. Whilst the Department of Agriculture support education of farming practices, more could be done to strengthen the capacity of these services to educate farmers on compost use.

3.2 Types of actions to deliver options for building sustainable urban waste value chains

Actions to deliver options are summarised in relation to three categories of personal, political and practical. As is evident from the detailed description of options described above there is strong synergies of actions related to one option with other options. Therefore a summary against the three types of actions is very helpful.

PERONSAL - Beliefs, Values. World Views & Paradigms

- Value waste as resource to help households understand purpose of waste segregation
- Use the word ‘resource’ as an alternative organic waste
- Shift negative perception of use of biodegradable municipal solid waste and septage in compost production

POLITICAL – systems and structures

- Facilitate information exchange between local government areas in regards to their needs for waste treatment / compost production
- Promote quality standards and certification of compost
- Strengthen capability for certification and monitoring of quality of compost products
- Government support to promote and incentivise financial viability for compost production and use

PRACTICAL - Behaviors & technical responses

Behaviours:

- Improved household segregation of waste
- Training to improve processes including segregation of waste and reduction of contamination by Municipal Council to ensure quality compost production
- Increased knowledge of compost use, quality, ingredients and value by producers, retailers and farmers
- Increased demand for and use of compost by farmers

Technical responses:

- Produce a variety of compost products
- Improve record keeping on waste generation and management
- Expand land area for waste treatment and compost production
- Technology improvements to increase volumes and speed of compost production
- Training for to increase staff technical expertise and skills to ensure quality compost production and reduce contamination
- New transport and purchasing options to reduce costs

4. Implications for building sustainable urban waste value chains

This final section suggests a range of implications for building sustainable urban waste value chains. Insights have been drawn from across all research phases, within the transdisciplinary research team and from participants who attended our on-line research findings forum in March 2022. Implications relevant to the Kaduwela Municipal Council as the case study focus for this research are presented first, followed by insights we consider to be transferrable and that are likely to be relevant to other parts of Sri Lanka.

Implications for Kaduwela Municipal Council

The research identified key sets of actions to build urban waste to sustainable value chains in the Kaduwela Municipal Council which have been presented in this report. Each of the five options identified above are applicable to the Kaduwela area.

Whilst action at two ends of the value chain – the segregation of waste by households and use by farmers of compost – were identified as critically important, a key area of action to build sustainable urban waste value chains is to **increase utilisation of municipal waste and increase compost quality to meet standards.** Improving and expanding production processes and the marketing and communication of quality compost products is essential for trust in reliability of products for farmers and consumers.

It's also important to recognise that any changes by the Kaduwela Municipal Council alone will not effectively build sustainable urban waste value chains. Changes in the personal and political spheres are especially difficult for the council to shift since they relate to attitudes, systems and structures and coordination mechanisms of multiple government agencies at national and sub-national levels. **Collaborative efforts of multiple actors at community, national and sub-national levels involving both public and private sector is required to realise change**.

Implications for building urban waste to sustainable value chains in Sri Lanka

Whilst this research focused on the location of Kaduwela Municipal Council as a case study – research findings are relevant to other parts of Sri Lanka. Similar experiences between Kaduwela Municipal Council and other municipal councils are known to the research team and were also described by stakeholders during research consultations.

- It's also important to recognise that food system boundaries and geographic boundaries for urban waste to sustainable value chains don't fit neatly within government and governance boundaries such as municipal governments. **A broader perspective on boundaries for building sustainable urban waste value chains is required**. An illustration of this insight is that our social and market research extended beyond the Kaduwela council boundary to other surrounding councils.
- **Intervention is required in multiple parts of the value chain to realise change in any one part.** For example, increased awareness and education about use of compost requires improvements in quality.
- **A paradigm shift for how we think about 'waste' needs to occur** in order to change personal behaviours and broader systems and structures that could support a circular economy of sustainable value chain. This deeper level change is required as a foundation for more practical level changes.
- The **role of schools and standard education curriculum may be an effective means to create attitude changes** towards waste as a resource. Education of new generations can support attitude and behaviour change.

- **Value addition / co-composting provides a practical means of strengthening nutrient value but requires further research and technical guidance.** There are mixed views about use of septage for compost from farmers and retailers. Further research and education may shift practice.
- There are a whole set of actors and actions relevant to strengthening quality of compost production, monitoring and compliance and then transparency and trust of quality standards. There are so many actors in this part of the value chain (public, private and community) and **stronger coordination and cooperation is required within these vast sets of actors to enable system change**.
- Exploring new business models of waste management may also be an opportunity for change. Applying system thinking to integrate other waste streams can also help to determining the feasibility the possible interventions for building sustainable value chains .

Looking to the overall question that the research sought to answer at inception, *"What are the enablers and barriers for public and private institutions in Sri Lanka to advance the implementation of sustainable and innovative value chains to improve sanitation, health and food security?"* the research has provided clear insights. Change needs to be both deeper level paradigm and attitude change towards organic municipal waste, change in systems and structures, most particularly cooperation and coordination for compost quality as foundation for more practical changes related to behaviour change and also technical innovations for waste treatment and compost production.

5. References

Davila, F., Esham, M. Jayathilake, N. (2022). *Political economy analysis of organic waste value chains in Sri Lanka.* Report prepared for the Australian Department of Foreign Affairs and Trade. Colombo, Sri Lanka.

Dominish, E., Hettiarachchi, K., Samarakoon, D., Esham, M., Winterford, K. and Jacobs, B., (2020). *Social and market research on organic waste value chains in Sri Lanka*. Report prepared by Institute for Sustainable Futures at the University of Technology Sydney, Janathakshan (GTE) Ltd and Sabaragamuwa University of Sri Lanka.

Dominish, E., Hettiarachchi, K., Samarakoon, D., Esham, M., Winterford, K. and Jacobs, B., (2021). *Research Summary: Social and market research on organic waste value chains in Sri Lanka*, From Urban Waste to Sustainable Value Chains: Linking Sanitation and Agriculture Through Innovative Partnerships project

Jayathilake, N.; Drechsel, P.; Dominish, E.; Carrard, N. (2021). *Fact Sheet: Opportunities for Improving Organic Waste Systems: Kaduwela Case Study*, From Urban Waste to Sustainable Value Chains: Linking Sanitation and Agriculture Through Innovative Partnerships project

Jayathilake N., Drechsel P., Dominish E., Carrard N. (2021). *Organic Waste System Assessment: Kaduwela Municipal Counci*l. Report prepared by the International Water Management Institute.

Meadows, D. (1999). *Leverage points: places to intervene in a system*. The Sustainability Institute, Hartland

O'Brien, K. (2018). 'Is the 1.5 _C target possible? Exploring the three spheres of transformation', *Current Opinion in Environmental Sustainability*, 31, p.153-160