Factors Affecting Sustainability of Municipal Solid Waste Composting Projects in Sri Lanka

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Abstract
During the past decades, many composting projects have been implemented with the assistance from various donor agencies to address the municipal solid waste problem in urban areas. However, very few of these projects are sustainable and most are reported as failures, some are closed down and existing few are also operating under the heavy subsidies from the government and Local Authorities (LAs). As a solution for the organic fraction of the municipal solid waste, an initiative called "Pilisaru" project started in 2008 by the Central Environmental Authority (CEA) to develop the infrastructures of LAs for a better SWM system mainly focusing composting as the main viable treatment for organic fraction. Initial assessment of this new initiative also reported many failures. Therefore, this study is designed to identify the main factors that affect for the sustainability of compost plants based on MSW. The main methodology of this research is sample survey of 5 to 10% compost plants operating under LAs throughout Sri Lanka. To supplement this, literature review and various interviews carried out with many Apex, policy and regulatory bodies. This study found that most of LAs do not have expertise to design, implement and manage to develop an integrated SWM system with the required expertise to operate plants for the required standard. Therefore, it is recommended to have continuous capacity building programmes for various stakeholders, develop awareness programs, marketing, technical and financial management assistance for various stakeholders in SW value chain. Furthermore, it is better to take steps to streamline the SWM policies and implement good SWM practices for the community, especially on waste collection with separation, collaboration with private and public partnership is vital for successful composting projects in this sector.

Key words: Solid Waste Management, Composting, Smart Agriculture, Value Chain, Technology Management.

Introduction
Composting is a growing solution to solid waste management. According to the US Environmental Protection Agency (EPA), the amount of waste that has been diverted from landfill disposal through composting has quadrupled since 1990, from 2% of total MSW to 8.4%. In fact, 62% of all yard trimmings are composted in more than 3,500 municipal yard trimming composting programs in the US and 23 states ban at least some organics disposal in landfills, mostly leaves, grass and other yard debris. In Sri Lanka, Municipal Councils, Provincial councils and Ministry of Local Governments have funded limited compost plants in small and medium scales. Also lead international agencies like KOICA, World Bank, ADB, JICA, UNIDO, ILO, WHO, GIZ, UNEP etc. have funded numerous composting projects in various parts of Sri Lanka (Ref). In most cases the capital investment was a grant while operation and maintenance (O&M) costs were subsidized for an agreed project period. Once the subsidized period was over, the Local Authorities (LAs) has to keep the plant without operation due to unavailability of funds for O&M. As a result, most of the plants have been abandoned after the subsidized period. In 2008 with the national vision, a national SWM project called 'Pilisaru' was initiated with US$ 40 million public funds from the national treasury with the prime objective of promoting composting. By 2013, 115 compost plants had been established under the 'Pilisaru' Project (CEA,2013) and without having a detail evaluation study of the existing plants, Government extended the Pilisaru project Phase 2 for further 5 years until 2018. The Pilisaru project provides the capital cost as a grant to the LAs or public institutes and the O&M cost should be borne by the relevant public institute. This capital grant includes buildings, access roads, services, equipment and in addition, training to workers. Except few plants for public institutions, all other plants are owned by the LAs as the grant is limited to public institutes.

There are no extra subsidies for the composting industry in Sri Lanka except the above said capital grant. However, cluster (large scale) compost plants receive O&M costs for one year from the project and after

that period LAs should provide the O&M. The main objective of the 'Pilisaru' project was to develop the LA's infrastructures for a better SWM system mainly focusing composting as the main viable venture but the initial assessment reported many failures. Therefore, this study is designed to identify the main factors that affect the sustainability of compost plants based on MSW.

Methodology

The main methodology of this research is sample survey of 5 out of 115 composting plants operating under LAs throughout Sri Lanka by using a random sampling combined with cluster sampling in 5 Districts.

Compost Plant Institute	Year Funded	Institution Type	Scale	Waste Quantity (Tons/Day)	Expected Compost (Tons/Day)	District		Province
Balangoda Urban Council (BUC)	2008	Local Authority	Medium-scale	20	4	Ratnapura		Sabaragamuwa
Kaduwela Municipal Council (KMC)	2008	Local Authority	Small-scale	5	1	Colombo		Western
Kalutara PS (& Kalutara PS, Panadura PS, Panadura UC)	2011	Local Authority	Cluster Large-scale for 4 LAs	38	7.6	Kalutara		Western
Wariyapola Pradesa Saba (WPS)	2010	Local Authority	Small-scale	2	0.4	Kurunegala		Northwestern
Weligama Urban Council (WUC)	2008	Local Authority	Medium-scale	12	2.4	Matara		Southern

To supplement this, literature review and various interviews carried out with many Apex, policy and regulatory bodies. Further, an **observation survey** of 2 full week observation on segregated waste collection mechanism was conducted in Soysapura Housing Scheme, Moratuwa and a **perception survey** with 10 customers in 3 days' interval on the increasing demand (consumption) of organic food, mainly on vegetables & fruits was conducted at Cargill's Super Market, Union Place (Colombo 2), to validate the opportunity and the potential market of composting venture.

Common factors affecting sustainability of sample MSW composting projects

1. Owner/Partnership Modality

Plant	Own Local Authority	Managed by	Modality
Balangoda	BUC	BUC	Public (BUC)
Kaduwela	KMC	KMC	Public (KMC)
Kalutara	Cluster ownership: Kalutara UC, Kalutara PS and Panadura PS	Waste Management Authority of the Western Province (WMA-WP)	Public (WMA-WP)
Wariyapola	WPS	WPS	Public (KMC)
Weligama	WUC	WUC	Public (WUC)

Majority of the compost plants are managed by the respective LAs and they have a Public ownership. However, the Balangoda compost plant was piloted as a public private partnership (PPP) model but couldn't succeed for a long.

2. Technology Performance

In Sri Lanka, all compost plants including this 5 sample used the turning windrow composting system as a common and viable technology. The size of the piles, dry beds, number of machineries (bob cats, tractors, loaders and other mechanical accessories) use from collection to compost output vary with the scale of the compost plant, plant capacity and population size (amount of waste generation). Having appropriate technology and technical competence in place is very important for any composting initiative otherwise it will fail as in the case of 'Teshi' compost plant in Accra, Ghana is sophisticated to be maintained a sustainable manner (Cofie et al.,2003).

3. Financial Performance

Compost Plant	Break Even Point (BEP)	Input	Main Output	By Product
Balangoda	100%	MSW, faecal sludge, fish & slaughter house waste	High nutrient compost	Providing Waste Management course to neighbouring LAs.
Kaduwela	3%	Only MSW	Compost	N/A
Kalutara/ Phorawatta	66%	Mixed waste	High quality soil conditioner	N/A
Wariyapola	5%	MSW with Salvenia & banana leaves	High nutrient enrich compost	N/A
Weligama	106%	Mixed waste	Variety of compost	Practical demonstration site on compost use Fruit juice stall/restaurant Sale of seed/plant/vegetable/fruit/livestock Recyclable (plastic/glass) product sale outlet

Since all the compost plants are subsidized, the profitability has never seen. So this analysis was done to assess whether they could generate income to cover up the O&M cost. The Break Even Point (BEP) was calculated by dividing the Total Sales income by O&M (Overheads or Operational cost recovery) cost. Balangoda LA shows the 100% O&M recovery, but with the diversified by products and marketing strategies, Weligama LA shows 6% profitable margin.

4. Objective of the Compost Plant

Compost Plant	Purpose	Main Output	By Product
Balangoda	Alternative Dumping	High nutrient compost	Providing Waste Management course to neighbouring LAs.
Kaduwela	High transportation/ landfilling fee	Compost	N/A
Kalutara	Not specific, but composting	High quality soil conditioner	N/A
Wariyapola	Not specific, but composting	High nutrient enrich compost	N/A
Weligama	Not specific, but composting	Variety of compost	Practical demonstration site on compost use Fruit juice stall/restaurant Sale of seed/plant/vegetable/fruit/livestock Recyclable (plastic/glass) product sale outlet

Since Pilisaru is a Government funded project, the purpose of establishing a compost plant is to overcome the waste dumping in the country, therefore sustainability of the project was not the key objective while these plants were planned, however each plant shows a different scenario (model) which ensure a potential business venture in future as per the output and by products value chain.

5. Social & cultural impacts:

Most of the composting sites are not far away from households, so it is important to maintain aerobic conditions due to bad odour and fly nuisance, especially on turning compost piles at intervals to maintain moisture; keep the compost site clean, and removal of mixed waste, waste drainage, leature control etc. Observation shows an average level of satisfaction but annual medical clinic visit for workers and regular health checks are practiced.

6. Present & Potential Target Market Segment

Compost Plant	Segmented target customers (at present)
Balangoda UC	Government projects, Plantations, households and farmers (farmers from Eastern coast)
Kaduwela MC	Home gardens, Divi Neguma program, DS office, garden designers, small scale farmers
Kalutara UC	Tea/ Cinnamon (60%) & home gardening (40%)
Wariyapola PS	Farmers (vegetables, water melon, papaya and coconut)
Weligama UC	Home gardening 60%, tea plantation 30%, balance used at the farm and landscaping.

According to the findings from the 5 compost plants and considering the needs of the country towards economic development, following target sectors and customer market segments leads an opportunity.

Target Sector	Customer segmentation (Potential)
Plantation sector	Mainly the tea, rubber and coconut along with others like papaya and banana etc. which create a huge potential market for compost
Landscape	Low quality compost can be used in landscaping projects and urban development activities, especially town/city beautification projects. There is huge market potential in the town and rural areas for household level and eco-tourism hotel landscaping which creates a natural environment
Organic food farming	Perception study shows that the public tend to consume more organic products which reflect on a potential demand for organic fertilizer. Also organic food export market is fairly established.
Home gardening/ flora culture	Urban household use of compost in home gardening seems to be one of the promising consumer segments, even housing complex inmates too using pot farming in their tiny space.
Government programmes	Govt. projects such as 'Divi Neaguma' and 'Pura Neaguma' creates another bigger potential.

7. Legal & political performance:

Relevant stakeholders should engage in the formulation and implementation of policies and develop projects that could serve as role models in composting. This would likewise enhance collaboration between the various governmental agencies concerned (environment, agriculture, sanitation, renewable energy) to better drive composting agenda in the country. In Ghana and Sri Lanka efforts were made to enhance environmental sanitation policy that enables recovery of additional input materials for co-composting as part of new waste management strategy (Reference). In India a new legal prescription now requires to jointly sell chemical fertilizer together with compost or organic fertilizer in order to increase organic matter in soils (Fertilizer Control Amendment of India, 2013).

8. More findings support as an opportunity for the innovative compost venture in Sri Lanka

a. Perception against agro chemical fertilizer: High subsidies on chemical fertilizer have created environmental and health issues which created Chronic kidney disease (CKDu) among the farming communities in the North Central province. This negative perception on agro-chemicals will be an opportunity.
b. Suitable soil conditioner: Our agricultural soil has low organic matter content 1 to 2%, whereas the organic matter content in a typical agricultural topsoil is expected to be around 5% (DoA, 2014; MENR, 2007). In such cases compost can play a vital role.
c. High nutrient co-compost: Septage has high nutrient value, hence MSW co-composting with septage will produce high nutrient fertilizer, which has high market demand (Rouse et al.,2008). It was found that 18% of the total collected untreated septage by septic trucks has been used in agriculture as a nutrient resource as of 2013 (IRRI, 2014).
d. Perception towards organic foods: Organic farming is not widespread in Sri Lanka, although a growing interest for organic products exists in middle-high income societies.
e. Easy access of compost & less transport cost: Most of the compost plants are not far, in rural/semi-urban areas.
f. Phosphate enriched compost: Local rock phosphate is insoluble and the using organic acid produced during composting would be able to convert phosphate to soluble form to produce phospho-compost.
g. Need of organic fertilizer for Plantation sector: The plantation sector has high buying power and could afford additional contributions to improve soil properties. There are 15,215 hectares of land under organic farming with a share of total agricultural land of 0.65% and the presence of around 3,300 organic farms such as tea, coconut, vegetables, fruits and spices (MENR, 2004).

Specific factors affecting sustainability of sample MSW composting projects;

A. Balangoda

1. The value addition strategy (blending technique) in 4 ways, 1.Animal wastes are buried in the middle of the pile; 2.half burnt rice husk is incorporated; 3.rock phosphate is added to increase the Phosphorous content; and 4.blended with dried faecal sludge.
2. Integrated waste management in Balangoda consists of a MSW compost plant, septage treatment plant, plastic pelletizer and an open dump site.

3. BUC use two different pricing for two different products, MSW compost and dry faecal sludge blend (15% DFS) compost (40% more than MSW compost)
4. Farmers in the Eastern part of the country are the main consumer segment. Compost is preferred for the sandy soil in the eastern part of the country where application of synthetic fertilizer is not very effective.
5. Frequent laboratory testing of using commercial fertilizer is conducted to confirm the quality of the compost product and increase confidence among farmers. Quality control protocol too communicated to the customers.
6. Interest of the political authority and the officer in charge is a highlighted fact.
7. Sales outlets through agents are the channels of sale in far off locations.
8. Multi-tasking workers (for e.g. supervisor works as the bob cat driver, etc).
9. Safety of the compost blending with dry faecal sludge still to be determined.

B. Kaduwela

1. 20% of the land in the area is agricultural lands which could be a consumer segment.
2. Educated and high income households make it easier to introduce waste segregation, home composting, etc. and could be a potential consumer segment for compost.
3. High land value due to high demand has created difficulties to identify a sufficient land area for low return project like composting.
4. Focused regulations has made source segregation practical.

C. Kaluthara

1. Skilled/trained staff members including a marketing expert are satisfied with staff welfare such as free medical insurance, regular medical checkups and annual bonus.
2. Plant acts as a training center for new plants and provide comprehensive training for all plant workers.
3. High quality soil conditioner has high value in selected markets.
4. Strong quality control and monitoring mechanism.

D. Wariyapola

1. Conduct awareness program for school children on SWM and provide free compost.
2. WPS cleans the lakes and tanks indirectly since water hyacinth in use as a raw material for making compost.
3. WPS is situated in the middle of coconut plantations and vegetable farms which are potential customer segments.
4. No proper quality control and confirmation and hence it is difficult to access high end markets such as plantation industries and without proper nutrient enhancement it is hard to attract farmers.

E. Weligama

1. Waste disposal is reduced by 70% due to composting and recycling of waste.
2. Plant provides free training courses on composting for other LAs and the demonstration farm acts as the indicator of compost quality which generates an additional income for the project.
3. WUC producing high value proposition outputs instead of soil conditioner, the high nutrient co-compost is enriched and co-composting blend with faecal sludge and high value animal feed waste, instead of raw material for compost.
4. High level of political commitment is a key to success.
5. No source segregation is practiced yet, but project is still a success.

1. Observation survey on segregated collection process

Moratuwa LA supplied green bins to all households (HH) in the Soysapura Housing Scheme to collect bio degradable waste. The awareness done through all HH with printed leaflets and group meetings. LA collects bio degradable waste daily expect on Wednesday & Sunday are other recyclable items like paper, plastic and glass are collected on those two days. Daily collection starts at 05.00 am and completes by 11.00 am. Waste accepted only in the given green bins and not in polythine bags and collected daily on time. Any delays, holiday or vehicle service are informed to the HH in advance and alternatives are

arranged. Moratuwa Municipality collects around 100 metric tons of garbage and 50 metric tons are recycled and/or composting. The observation survey ensued the discipline of HH and LA waste collectors in a satisfactory manner. To validate it, The Director Engineering of Solid Waste Management of Colombo Municipal Council (CMC), said according to the Cabinet decision, everyone needs to support the programme in order to eradicate the garbage problem which had affected the Colombo District for a long time and legal action would be taken against those who do not support the government's programme on waste segregation (Daily News, 27 Oct 2016). This is a very positive sign of segregated waste input for compost which accelerate the composting process with cost efficiency.

2. Perception survey towards increased demand on organic foods/vegetables

As a Corporate Social Responsibility (CSR) project, most of the leading Super Markets buys vegetables from small hold farmers from rural areas, especially encouraging to produce and supply organic vegetables for which there is an increased demand. The 90% of the perception survey result ensured the customers are keen to buy organic foods, even willing to pay more value since it is natural and have zero side effects. Further, one customer (Assistant Manager of Jetwing Hotel) confirmed that they buy more local fruits than imported fruits like apples, grapes, orange etc. to promote ecotourism, which is a niche but fast growing high end market. All these ensured the need of compost.

Conclusions

This study found that most of LAs do not have expertise to design, implement and manage to develop an integrated SWM compost system with the required expertise to operate plants for the required standard with sustainability. The followings to be consider for study on sustainable compost model and to integrate with SWM system design.

- Resource recovery from waste is one of the key priorities of the government of Sri Lanka.
- Many composting initiatives of the Pilisaru project face difficulties in marketing of compost.
- Less subsidized crop types can be potential consumer segments.
- Plantation sector has a high interest in compost due to attention in maintaining soil properties and due to high demand and high price for organic products in the international market.
- Provincial councils can play a more active role in waste management, Western Provincial Council is a role model.
- Political commitment is a key factor in the success of the compost plant.
- Financial success of the compost plant seems depend on few key facts;
  - Nutrient value: Nutrient enhancement of the product if the targeted consumer segment is farmers. Faecal sludge seems to be a great nutrient resource and can be composted with MSW via co-composting.
  - Product quality: High quality compost with quality confirmation is needed to promote compost in the plantation sector. In this case nutrient enhancement may not be a need and willingness to pay seems high.
  - High value products: Instead of compost, marketing of high value products from compost is a successful strategy (e.g. fruits, plants, especially on organic products for local & international markets).

Therefore, it is recommended to have continuous capacity building programmes for various stakeholders, developing awareness programs, marketing, technical and financial management assistance for various stakeholders in SW value chain. Furthermore, it is better to take steps to streamline the SWM policies and implement good SWM practices for the community, especially on waste collection with separation, collaboration with private and public partnership is vital for successful composting projects in this sector. This study will continue to research the key sustainable factors such as key partners; key activities; key resources; value propositions; customer relationship; channels; customer segments; cost structure; revenue streams; national legal policies and environments/social/health impacts to derive an innovative business model for Sri Lanka.

REFERENCES

- CEA (Central Environmental Authority: Pilisaru Project). 2013. Compost plant database. Colombo, Sri Lanka: Central Environmental Authority
- Cofie, O. (Ed.) 2003. Co-composting of faecal sludge and solid waste for urban and peri-urban agriculture in Kumasi, Ghana. Daily Mirror, 27th October 2016, page 6
- Final report of a pilot project implemented by the International Water Management Institute (IWMI) in collaboration with the Kumasi Metropolitan Assembly (KMA) and Kwame Nkrumah University of Science & Technology (KNUST); Department of Water & Sanitation in Developing Countries (SANDEC) at the Swiss Federal Institute of Aquatic Science & Technology (EAWAG). 124p.
- IRRI (International Rice Research Institute). 2014. Nutrient calculator. Available at http://www.knowledgebank.irri.org/ericeproduction/IV.3_Nutrient_calculator.htm (accessed on April 24, 2014).
- MENR (Ministry of Environment and Natural Resources). 2005. Database of municipal solid waste in Sri Lanka. Colombo, Sri Lanka: MENR.
- MENR. 2007. National policy on solid waste management. Colombo, Sri Lanka: MENR.
- Rouse, J.; Rothenberger, S.; Zurbrügg, C. 2008. Marketing compost: A guide for compost producers in low and middle-income countries. First edition. Dübendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag).