

Why is Municipal Waste Management Reform so difficult? An Analysis of Dynamic and Social Complexities

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ABSTRACT

In this paper, we reflect on the experiences and challenges of a waste management planner in Cape Town between 2005 and 2013 through the lenses of systems dynamics and of stakeholder complexity. Since the new Waste Act was promulgated in 2008, a South African municipality has a responsibility over and above its basic service mandate to become a key enabler in the development of a waste-based economy. The transformation from a classic end-of-pipe waste disposal system to an integrated waste management system aimed at extracting economic value from waste is complex.

Stakeholders, responsibilities, multiple systems and dependencies, funding and complex legislation that govern municipalities, supply chain and procurement, and energy matters frame the system dynamics and complexity. The identification and use of system leverage points could create the necessary momentum. Paradigm shifts that create stakeholder collaboration, however, may be the key to solving the current impasse towards implementing projects.

1. INTRODUCTION

South Africa reformed its environmental legislation dealing with pollution and waste management in 2008 after a ten-year policy drafting process. Globally-accepted best practice principles such as “precaution”, “prevention”, “the polluter pays” and “separation at source” are enshrined in the National Environmental Management Act (NEMA)¹ and the National Environmental Management Waste Act (NEMWA). The NEMWA stipulates a fundamental change to the classic municipal waste management (MWM) system that is based on end-of-pipe waste disposal.

Traditional MWM forward planning relies on a mechanistic, almost-linear logic and a narrow analysis focused on technology-based solutions to cope with growth and development. The National Waste Management Strategy (NWMS) with its timelines and waste minimisation targets requires systems and infrastructure changes with far reaching capital funding and status quo change implications. The NEMWA forces a re-evaluation of the systems, infrastructure and funding necessary for a municipality to meet the new waste management objectives and to generate economic opportunity. This comes in the face of the many growing challenges and backlogs most municipalities already face. MWM will have to adapt to integrate municipal and private sector systems, with complexities that cannot be addressed by the classic planning approach.

Concerns being expressed louder and more often by society relate directly to environmental damage and waste impacts. The calls to action and the expression of need or benefits often ignore complexities surrounding the associated changes, compliance issues and costs to slow down impacts and effects. Mistrust about the intention of municipalities has led to adversarial stakeholder relationships and a breakdown in communication and accusations of a lack of will to effect change for the common good.

The processes between stakeholder groups made up of government, the private sector and society are informed by multiple socio-economic factors, and uncontrollable influences, that make exactitude in planning impossible. All parties, however, have a collective responsibility to act and behave in a manner that will keep the environment healthy for the benefit of future generations, but often ignore these responsibilities. This introduces complexity that is thus far not well understood in the waste sector. To improve waste planning requires a deeper systems evaluation and an understanding of the complexities that are currently lacking in the waste management literature. In this paper we attempt to analyse the complexities and to identify leverage points using a systems perspective. This analysis may suggest opportunities for the municipality and other actors to make systemic shifts through targeted interventions.

¹ All legislation related to municipal governance, structures, systems, waste and environmental management, and energy may be accessed online from www.gov.za or via South African national department websites.

2. THEORY

2.1. System Dynamics and Leverage Points

Jay W. Forrester, recognised as the father of Systems Dynamics, stated “*The systems dynamics process starts from a problem to be solved – a situation that has to be better understood, or an undesirable behaviour that is to be corrected or avoided.*” (Forrester, 1991) He postulated that complex systems seldom have intuitive solutions, and that leverage points are not intuitive due to the complexity of the systems. In this context, the real problem that needs solving is not how diversion will be achieved (a waste type, amount and technology focus), but who will pay and how costs and benefits will be shared.

Table 1: Leverage points in a system (Meadows, 1999)

	Leverage point		Leverage Point
12 (least powerful)	Constants, parameters, numbers (such as mass, volume, subsidies, taxes, standards)	6	Structure of information flows (who does and does not have access to information)
11	Size of buffers and other stabilising stocks, relative to their flows	5	Rules of the system (such as incentives, punishments, constraints)
10	Structure of material stocks and flows (such as transport networks and population age) and modes of intersection	4	The power to add/ change/ evolve/ self-organise system structure
9	Length of delays relative to the rate of system changes	3	Goals of the system
8	Strength of negative feedback loops, relative to the impacts they are trying to correct against.	2	The mind set or paradigm out of which the system — its goals, structure, rules, delays, parameters — arises.
7	Gain around driving positive feedback (self-reinforcing) loops relative to impacts they are trying to correct against.	1 (most powerful)	The power to transcend paradigms

Donella Meadows identified twelve types of leverage points that could be used to make changes to a system (Meadows, 1999). Table 1 lists these from the weakest (parameters, 12) to the most powerful (transcending paradigms, 1). Small changes at a particular leverage point could have big effects to cause lasting changes in a system, indicating non-linearity. The more powerful a type of leverage, the more difficult it is to achieve, as the 10-year waste management law reform process illustrates (rule change, 5).

Intuitively, obvious leverage points seem to reside in key parameters, e.g. waste disposal tariffs. These often have little effect on changing systems or behaviour (e.g. with continuous illegal dumping). However, quantifying variables and their effects is vital for good planning, modelling and design (Cilliers, 2006).

2.2. Going beyond system dynamics: Social, Dynamic and Emergent Complexity

Paul Cilliers echoed Forrester and Meadows in his essay on the characteristics of complex systems (Cilliers, 2006). He noted that interactions between elements in complex systems are non-linear. Complex systems have large numbers of elements with rich, mostly short range interactions that could have positive or negative feedback loops that can influence other elements widely irrespective of the range of interaction. Each element only responds to information available in its immediacy and is oblivious to the system's behaviour, which is important, as the assessment of the behaviour of a complex system requires a focus on the complex structure of the system, and not just individual elements.

Cilliers distinguished between complex and complicated systems. The latter can usually be analysed and modelled more easily to produce accurate results despite being able to perform sophisticated tasks, or having large numbers of elements. This implies that complexity must be identified and reduced to simplify an analysis for answers, without becoming reductionistic.

Waste management infrastructure development and investment is long-term, especially in government where supply chain processes involving tenders, awards and appeals are notoriously onerous. Planning has to include modelling with good data to predict and respond to increasing service needs and demands. However, the waste industry is generally notorious for its poor information and data sharing to protect market

share. This affects planning assumptions that could lead to inappropriate infrastructure responses. This uncertainty increases risk aversion and delays decisions about alternatives to landfilling due to an emerging complexity that underpins the integration between public and private sector systems.

Cilliers also noted that the scope of a complex system is defined by the description of its functionality, but this will depend on the relative position of an observer. For municipalities, an IWM system equates to reducing landfill and enabling a waste economy at affordable tariffs, while the private waste sector equates the waste recovered from an IWM system to profit. This illustrates conflicting opinions and objectives between observers with different perspectives that will generate complexity, and possibly points to how a solution could be designed to find the middle ground linked to the common good.

Table 1: Three Dimensions of Complexity²

Type of Complexity	Definition	Technical Approach	Adaptive Approach for Challenges of Complexity	Process Requirements
Dynamic	Cause and effect are far apart in time	Piece by piece	System as a whole	Systemic
Social	Actors have diverse perspectives and interests	Experts and authorities	Stakeholders	Participative
Generative (emergent)	Future is unfamiliar	Existing solutions	Emerging solutions	Emergent

Adam Kahane describes the differences between social, dynamic and emergent complexity (Kahane, 2010), which is a summary of work in the field of leadership and collaboration with Heifetz, Scharmer and Senge. Stakeholder complexity results from the relationships among and between different stakeholder groups. Dynamic complexity impacts further on stakeholders, their behavioural responses and their decisions due to multiple changes in the environment. The plethora of legislation, national imperatives and diverse initiatives meant to drive waste minimisation, add to the emergent complexity that results from change. The emerging solutions to cope and respond are uncertain and, paradoxically, have the known dimension of the unknown.

3. METHODS

To apply systems and complexity analyses, the system is first described, in terms of stocks and flows, structure and feedback. This forms a basis for describing the network and connections that should be created to improve materials economies and reduce the impacts of waste and landfills. The following is a non-exhaustive overview of some of the key systems, connections and interdependencies from a resource and waste perspective, which generate the complexities associated with the systems transformation.

3.1. Waste and Resource Management Systems Description and Economics

3.1.1. Simple Waste Management System: No Recovery and Diversion (Landfill only)

Classic waste management centres round the availability of landfill airspace. The primary stock is a sanitary landfill, or more accurately, the available airspace, which is depleted if there are no recovery or diversion activities. This system has few elements and is devoid of connections to other systems that will complicate the stock calculation due to impacts on it by the other systems. The simple system needs to be made slightly more mathematically complicated to incorporate the rate of growth of the flow as a function of growth and development. Refuse Transfer Stations (RTSs) merely add efficiency elements along with waste compaction and larger, heavier containers to reduce the cost of logistics, repairs and maintenance. The heavy vehicles and containers impact on roads so the saving and efficiency gain have a negative cost, and have an effect on the rate and the volume of transfer that effectively depletes the landfill stock faster.

Stock depletion is an unintended consequence of an efficiency mechanism. With sufficient time available, new (airspace) stocks can be created to ensure that the impacts of not disposing waste responsibly (i.e. dumping in non-engineered landfills) will be minimised. Stocks are, however, influenced by a range of other

² Source: Hamann, R. *The Southern Africa Food Lab: Linking action research to collaborative innovation* (Graduate School of Business, University of Cape Town, November 2011), after Kahane.

systems, including natural systems as described below. Measurement to set control parameters (Meadows 12, Table 1) is important, as weighing will manage the stock depletion and delay of future capital investment, and will maintain the revenue necessary to pay for the current capital investment and services.

3.1.2. Recovery and Diversion System that improve an End-of-Pipe System

Modern waste management systems have evolved to include elements that form a Recovery and Diversion System that is driven mainly by two cost and revenue aspects: (1) the need to protect landfill airspace to defer capital costs for the creation of more airspace over time, and (2) to exploit the economic value of recovered materials. By adding elements (at substantial cost) such as Material Recovery Facilities (MRFs) to recover economically viable waste materials for diverting material flows from landfill, the primary stock (airspace) can be protected and future investment deferred. A community drop-off facility provides the same functionality at a smaller scale, at a lower efficiency and much higher unit cost (Akhile Consortium, 2011).

The function of a Recovery and Diversion System is not only complementing the landfilling of waste, but also the beneficiation of recovered goods and materials, which can be diverted for treatment, processing and converting to create a stock of used materials for reuse either in the same form or a different form for manufacturing. Recovered materials can also be diverted to an Energy System to extract energy for manufacturing fuels (Refuse Derived Fuel, RDF), for heating or electricity generation. Used goods can also be recovered as second hand goods to become a feedstock for the retail and end-use system that will slow down demand on raw materials with consequent economic effects.

3.1.3. Impacts of other systems on the key Stock (Landfill) and Feed Stocks

The demand in other downstream systems will drive the demand of stock from the Waste Management System. The demand could also be driven by upstream systems, i.e. in the Raw Materials System, if stock is low or is constrained, the demand for recovered stock could increase. Demand for recovered materials is irregular and tends to be cyclical. This indicates interplay between competing supply options with volatile demand and poorly understood stock management that creates instabilities, which affect decisions about landfill alternatives. In future, recovered materials will become a key economic driver in the commodities sector as stocks of non-renewables are depleted and prices increase (World Bank Online, 2014)

The scope of this paper does not allow for elaboration, but there are key systems that influence waste flows, and raw material and landfill stocks. The most notable are Natural Ecosystems and uncontrolled events that create waste not planned for, Agriculture and Food Production Systems Events, the Raw Materials Production System, Manufacturing Systems (where design and material, selection and use efficiencies are primary avoidance measures that benefit natural stocks), the Finished Goods Systems that include, wholesale, retail, end-use and consumption, and the markets that are either real or artificially created to stimulate the economy. The Finished Goods System is complex and sophisticated with many role players and touch points (outlets) that interact with end-users. Marketing is, thus, a capitalistic system that has an impact on the earth's natural, non-renewable resource system, but that does not necessarily address the responsibilities of these impacts.

3.1.4. A Systems and Economic View of Integrated Waste Management

By deductive reasoning, all the above can be combined in Figure 1 (Coetzee, 2006) to show how waste recovery introduces feedback loops that integrates various systems and infrastructure to form an IWM system. This system is based on supply and demand principles that will be constrained by availability that creates dependencies, and should rely on free market forces which determine the system's performance against waste minimisation objectives.

Modern economic systems are modelled on production and consumption, forgetting that nature additionally makes use of decomposition. The end product of consumption is waste, growing in proportion with the demand for limited resources that is threatening long term sustainability. A focus on waste recovery for reuse, recycling and for energy recovery from high calorific materials has thus become non-debatable. These activities, with the exception of recovery during production, occur post-consumption, which is where much of the integration is now needed in the waste management sector.

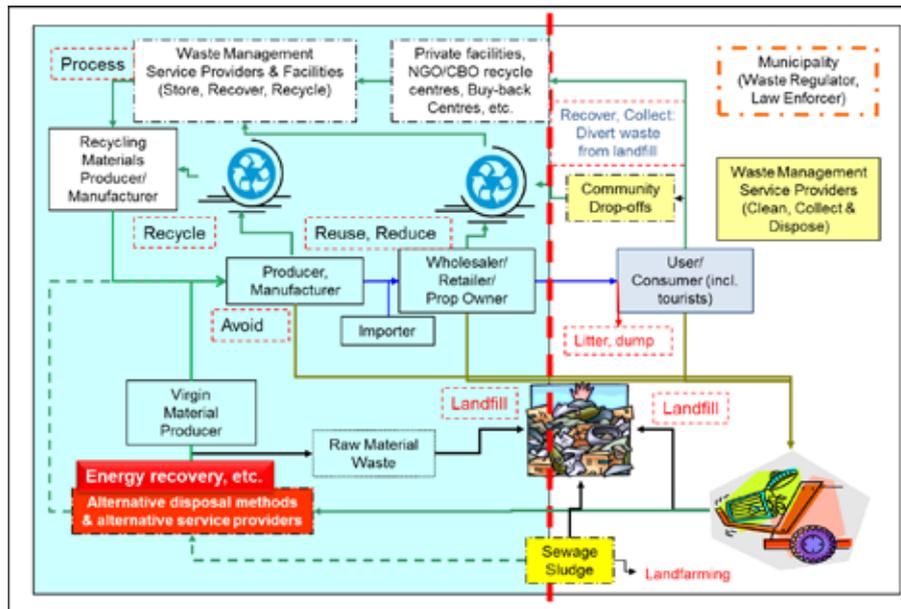


Figure 1: A systems view of a typical Integrated Waste Value Chain

It is apparent there are many systems, impacts, dependencies and related factors that need to be evaluated and understood to determine the demand and plan for the supply of appropriate infrastructure-based waste management and recovery services that can link with manufacturing and reuse. This will require a fundamental change to waste management and the investment of additional infrastructure that should loop back to link with processing and manufacturing industries that produce goods that have end-use markets in order to make this circular economic system work.

3.2. Leverage Points for changing the MWM system

With reference to the numbered leverage points per Table 1 (Meadows, 1999), the analysis of the various systems and influences, constants, parameters and numbers (12) are vital for planning and design purposes. Coupled with this, the size of buffers and stocks (11), the structure of material stocks and flows (10), the length of delays relative to the rate of system changes (9), the strength of negative feedback loops (8) and gains around driving positive feedback loops (7) are considerations of the physical infrastructure that will be needed to reduce the negative impacts of poor or inadequate waste management and waste on health, the environment, resources and the economy.

All of the above are influenced by the structure and quality of information flows (6) from both the public and private sector. Quality waste management information is notoriously hard to come by and directly affects the decisions that will create a lasting impact.

An important consideration when dealing with waste is the “out of sight out of mind” attitude, which seeks to ignore unwelcome information feedback – significant leverage may thus lie in changing information flows. However, changing the rules of the system (5) to improve information flows through the promulgation of the Waste Information System Regulations has thus far had little documented effect, causing a reliance on dated, inaccurate data that is being used for extrapolation purposes for modelling and policies formulation purposes. Combined, Meadows 6 – 12 have had some effect on changing behaviour and enabling the growth of the recycling sector as well as lessen impacts caused by disposal sites. However, real deep change has not happened, and these gains are not entrenched yet to promote sustainability, pointing to the use of Meadows more powerful forms of leverage, types 1 - 5.

3.3. Analysis of socio-political, dynamic and emergent complexity

Stakeholders in the waste management sector are protecting interests for commercial reasons which may make them unwilling to change. As Forrester predicts, the most appropriate solutions are not always obvious or intuitive. Government will have to consider a compromise to compensate for changes that lead to economic losses. What is missing from the current system, are markets and mechanisms that are appropriately incentivised to compensate for the very high costs associated with new recovery, treatment and processing infrastructure. The questions are, of course, what the compromise will entail, and what should support the compromise to avoid failure of an emerging system?

Social complexity between stakeholders results from the relationships among and between government, the industry and the civil society groups, and the expectations of value, gain and concern for the environment. End-user behaviour and acceptance influences the success of proposed new waste management practices and systems – this is possibly the largest obstacle to overcome. This arising stakeholder complexity will clearly need facilitation and collaboration between the many stakeholders that include several regulators in government to come to an agreeable solution that will reduce the impact on opportunities, costs, revenue and profits.

The legal system is characterised by a plethora of different legislation, as shown in the report on the assessment of alternatives per MSA S.78 (Akhile Consortium, 2011). Combined with perception, legislation often limits solutions, and the speed at which the system can be changed, and contributes to conflict. Municipalities, one of the three spheres of government, are charged with providing basic services, including waste management per Schedule 5B of the Constitution of South Africa. Service provision, obligations and objectives are prescribed by the Municipal System Act (MSA), and the Municipal Finance Management Act (MFMA). The City is the de facto implementer and developer of the related service infrastructure and systems and may contract out services it cannot render. This should be done on a zero sum basis by generating revenue through tariffs and rates set and approved by Council to ensure that infrastructure and services for the public good are viable, affordable, efficient and effective in order to be sustainable.

Many recent national waste management imperatives and initiatives to achieve waste minimisation targets, further add to the complexity of the legislation. Municipal waste managers are not able to control external influences as described above, yet are tasked with the implementation of waste minimisation, impact reduction and economic enablement. Cultures and the differing logics of public administration (services not for profit) and private enterprise (services at optimal profit) make definition of the middle ground difficult. International and local stakeholders compete for the same resources, as do different technologies for feedstock with different objectives (e.g. plastics recovery for reuse vs. for energy).

Deeper change may be supported by further rule changes, in the form of regulations being implemented as a result of national policy. A caveat is that rules need alignment, considering the anomalies that occur between regulations meant to support the same outcome, as seen with EIA regulations and air quality considerations, which are not completely aligned. Simplification of the energy and electricity related legislation and policies will go a long way to enable affordability for small-scale (1 – 5 MW) W-E project implementation in municipalities, especially the requirements of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), as reported in a recent trade publication (Kolver, 2014).

In addition, the National Treasury produced a draft fiscal reform policy (National Treasury Tax Policy Directorate, 2006), which could be finalised to include the primary principles and frameworks to allow specific incentive mechanisms to be developed. Very promising also may be the Dept. of Science and Technology initiative to add a human resource development system to the waste sector, a type 4 leverage which, if successful, may lead to more of the less-powerful levers being shifted in the right direction.

Dynamic complexity analysis considers the correlation between waste volumes trends and the key waste drivers, i.e. population growth and economic development are shown to determine expected growth trends, as can be seen in Figure 3: Available Landfill Airspace vs. Waste and Recycling Growth. Dynamic factors include urbanisation trends and economic cycles, both of which directly influence the quantity of waste and were correlated in the S.78 report. Life spans of current plant and equipment and the attendant capital replacement cycles, combined with budget constraints, future investment in new and appropriate capital equipment introduce another dynamic complexity that requires balancing priorities against compliance.

Emergent complexity analysis combines the waste system, the stakeholders, roles and responsibilities, the costs, incentives, objectives, funding needs, limits and changing perceptions, which are evaluated in context of the financial, socio-economic and political systems. The emergent complexity relates to the type, quantity and availability of valuable waste, an evolving IWM system, resource economics, and the funding and implementation of initiatives to minimise waste and to optimise beneficiation opportunities. A crucial aspect that informs the complexity and influences funding systems is shareholder profit expectations without consideration for the consequences.

Election cycles impact on political and administrative leadership continuity and decisions that affect spending cycles, budgets, and the resource allocation needed to implement major changes to infrastructure and systems that will transform MWM. Political tenure is earmarked by short-termism and lobbying for votes. A change in dispensation is invariably followed by policy shifts that create a disjuncture between the stark realities of resource limitations and integration effort, and the time needed to make lasting changes.

3.4. Planning for Net Additional Cost and Benefit involving waste recovery

Supply and demand analysis to determine appropriate options is more complex than the classic end-of-pipe method normally used by waste planners. Classic planning is usually based on an extrapolation of population growth and assuming an almost-linear consumption and waste generation. Waste quantities in major metropolitan municipalities rarely reduce and exacerbate cost needs and funding deficiencies. The main waste drivers include urbanisation that affects natural population growth, and economic cycles. The 3% p.a. average population growth in Cape Town over the past decade (Statistics South Africa, 2011) is a reliable indicator of future impacts and waste growth, but needs further interpretation to account for the local context. Dynamic drivers that affect waste volumes are often forgotten in policy making, planning and in modelling, should include significant economic drivers such as events and tourism in Cape Town.

Thus, a systems approach informed transformation work by the city that started with the development of Integrated Waste Management by-law in 2008. De Wit developed a Waste Cost System Model (per Equation 1) in conjunction with the City (De Wit, 2009, amended 2012 to include Waste to Energy). The aim is to quantify net additional costs or benefits arising by implication of the NEMWA and the IWM Bylaw's imperatives to create a new function.

$$\begin{aligned} \text{Net Additional Benefit (Cost)} = & \text{Market Value Recyclables (MVR)} + \text{Avoided Disposal Cost (ADC)} + \\ & \text{Savings in Indirect Costs (SIC)} + \text{Energy Recovery Value/ Generation Savings (ES)} - \\ & \text{Additional Cost to Collect (ACC)} - \text{Additional Cost to Process (ACP)} - \\ & \text{Additional Cost to Transport (ACT)} - \text{Additional Cost for Energy Production (EC)} \end{aligned} \quad [1]$$

Equation 1 determines unit costs (Rand/ tonne). This gives an indication of the cost recovery that is needed or benefits that may be attained. It uses budget information for the direct and indirect costs of MWM services and infrastructure ranging from disposal sites, material recovery facilities and transfer stations, to community drop off facilities, and shows why an argument that often focuses on the value of landfill airspace saving when landfill alternatives are introduced, is too limited.

4. RESULTS

4.1. Overview and analysis of the City of Cape Town's Waste Management Transformation

A quick analysis using Table 1 shows which leverage points (denoted below, e.g. Meadows 5), the City has deployed to effect system changes to date.

Policy and bylaw reform (Meadows 5): The waste law reform was completed when Council adopted its Integrated Waste Management Policy as part of its Integrated Development Plan (City of Cape Town, 2006), and the new IWM By-law in March 2009 that was promulgated in August 2009.

Bulk diversion and recovery infrastructure (Meadows 10): Even before new obligations, the City had also implemented transfer and later recovery infrastructure at Athlone (packaging waste) and at Swartklip (green waste recovery) in the early 2000s, based on the findings and recommendations of a study funded by the USAID (Wright-Pierce, 1999). These facilities were not linked to formal household separation and recovery systems. Formal linkages happened in 2006 and more recently via the Kraaifontein IWM facility in 2011.

Separation at source (Meadows 11, 10, 9, 8): Prior to NEMWA, the City had already experimented with residential recycling on a very limited scale prior with the so-called yellow bag system. After the IWM Policy was adopted, a "Think Twice" pilot project based on the "separation-at-source" principle was started in August 2006 to recover packaging waste. Approx. 130 000 households were initially serviced. This scheme has gone through various phases with noted successes and failures. It serves almost 240 000 formal households at present or about one third of formal households, or 22% of all households in Cape Town, 2013. Further roll-out is limited by funding, which could be solved by introducing an appropriate tariff (Meadows 4). Success is limited by participation, yielding low results that impact return on investment for MRFs and result in expensive contracts to collect recycling materials separately.

Community drop off facilities (Meadows 10, 8): The household collection system is augmented by the recovery of materials at twenty community drop-off facilities. Recycling waste including e-waste, garden (green) waste and builders' rubble can be dropped off for free and is diverted via contracts to the private sector, e.g. rubble crushing and composting. This is a prime example of an economic enabling mechanism that costs the rate payer, as unit operating costs are high at approx. R14 000/t due to the low volumes that are handled at these facilities (Akhile Consortium, 2011).

Greening of events (Meadows 8): During the FIFA™ 2010 Football World Cup, the City planned for and implemented separation at source for this major event as part of the FIFA Green Goal™ initiative (City of Cape Town, 2010). This has become standard practice for events in the city since then with limited success.

Business-to-business recycling (Meadows 8, 6): The City also hosts an integrated waste exchange platform, IWEX (City of Cape Town, 2014), a business-to-business platform that makes it possible to advertise waste to anyone who has a need and is meant to avoid landfilling.

Communication, awareness and education (Meadows 6): Cape Town's WasteWise communication and education programme, already in place since 2004 to promote recycling, has been used as a key vehicle to promote the details of recycling to households, schools and businesses. This programme and its repeat message to recycle, is a fundamental requirement necessary for behaviour change in the general population.

4.2. Waste volumes and drivers in the waste system

The MSA S.78 systems-based study on waste management in Cape Town was used to evaluate alternatives to landfill to make recommendations to Council (Akhile Consortium, 2011). The S.78(3) study highlights non-linearity. Figure 2 indicates that growth in waste is not linear and varies with economic development. This contradicts the assumption of a linear projection in Figure 3 (Akhile Consortium, 2011). A regression analysis to predict waste generation showed correlation factors of 0.9 for estimated population growth and 0.42 for economic growth (GDP-based) respectively. Thus, if economic growth is negative, the upward trend in waste generation expected from population growth will slow down.

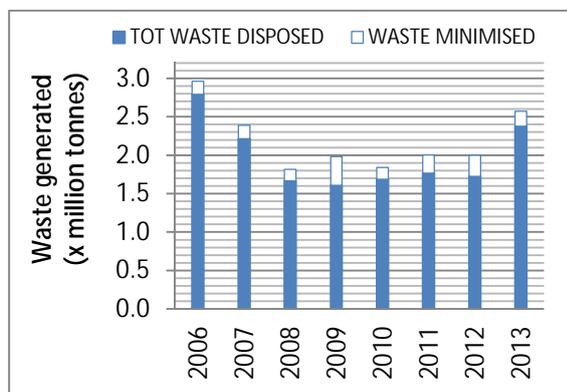


Figure 2: City of Cape Town Solid Waste Statistics (2006 – 2013 YTD)



Figure 3: Available Landfill Airspace vs. Waste and Recycling Growth

Figure 3 plots worst case estimates (i) without, and (ii) with current waste recovery against available landfill airspace (the BAU line). It shows an airspace saving of only one year can be achieved with current initiatives and no further investment over the next fifteen years.

A Pareto approach focused on the classification of waste by type (volumes and mass fractions) in order to make recommendations for appropriate IWM projects. Waste fractions by type seem like an obvious leverage point to reduce the impact on stocks (landfills) by diverting the largest flows linked to technology preferences. As Meadows indicates, these factors are not strong leverage points, and are unlikely to provide the momentum to transform the current system. Instead, they add to systems and decision making complexity regarding who and how much should be invested in alternative infrastructure.

Complementary studies have also been performed over the past fifteen years, e.g. ranging from future requirements for transfer stations (Wright-Pierce, 1999), to the most recent regarding a mechanical biological treatment study that would involve one of the MRFs (Consortium IU – ERM – PDNA, 2012). Common to all studies is the focus on technology options and little consideration of the funding requirements, efficiencies or affordability (tariff increases). The key decision-making considerations, therefore, remain funding, risk, appropriate options combined with available markets, costs, revenue and affordability.

The S.78(3) final report concluded and recommended an assessment of Private-Public Partnerships (PPPs) for projects to determine the feasibility, risk and viability of procuring various projects to address the possible sources and funding that is expected to run amount to hundreds of millions of Rand. The recommendations were adopted by Council in March 2011.

5. DISCUSSION

According to Forrester, “*The systems dynamics process starts from a problem to be solved – a situation that has to be better understood, or an undesirable behaviour that is to be corrected or avoided.*” Traditionally, municipalities provide funding and develop infrastructure for service provision. This is the current paradigm that will need to be addressed to develop a waste-based economy in view of the changed obligations.

The absence of super-system wide controls and available diversion infrastructure has caused waste management services largely to have been provided via a reactive system. Modelling and forecasting that assumes predictability, and based on growth, dynamics and landfilling, has been the basis for classic waste management. The addition of the new waste minimisation function needs a parameter-based supply and demand analysis using a systems and leverage point approach (typically Meadows 6 – 12) to reduce waste to landfill. This is more complex than the classic end-of-pipe linear projection method normally used by waste planners to determine future infrastructure and systems responses.

Waste management in a municipality is to some extent contextual: geography and the local economy do matter – one set of generic solutions will not be appropriate for all, which makes the determination of national rules complex. The costs and service offerings, the level of compliance in terms of the NEMWA’s objects and the investment in landfill alternatives to reduce waste impacts and to improve economic growth through waste will vary and depend on a number of aspects. Recovery and reuse, however, must occur on a national basis by linking the private sector that has manufacturing and processing capacity. This should be supported by appropriate funding and incentive mechanisms for the implementation of systems and physical infrastructure that will change the system from being focused on waste disposal.

In Cape Town, work has advanced the municipality to a position where it can engage with the implementation of alternatives. This is, however, subject to further due diligence and risk assessment work to determine appropriate options that can be sustained in the long term. Implementation, though, will require a number of changes to the status quo. Some of these changes must take place in the non-municipal part of the system and will require substantial investments for large infrastructure projects. The reality is that it is not possible or advisable for a municipality and its ratepayers to fund the necessary changes. All parties have, but often ignore a collective responsibility to act and behave in a manner that will keep the environment healthy for the benefit of future generations. This introduces social complexity that is thus far not well understood in the waste sector as a whole or by the public, and creates complex dynamics that influence reform of municipal waste management. Changing paradigms is the very difficult, but powerful leverage point that will need continuous work before the changes are internalised by most.

An analysis for planning purposes should consider the non-parameter aspects as well. The emergent complexity derives from having to combine and consider the type, quantity and availability of valuable waste, being aware of available infrastructure, making changes to systems and system structures, defining the funding, procurement, timing and risks of landfill alternatives, tracking resource economics and economic volatility, calculating the costs and benefits, changing stakeholder perceptions, paradigms and habits, and creating markets and demand to optimise beneficiation opportunities. It is clear that recycling will impact or benefit more than just landfill airspace saving, an argument commonly-used to justify investment in more landfills or new waste recovery and related minimisation efficiency infrastructure. By implication, it also requires more than just municipal planning to formulate a long term sustainable plan.

The outcome of such an analysis may suggest opportunities for the municipality and other actors to make systemic shifts through targeted interventions that go beyond mechanistic planning to address the collaborative aspects necessary for lasting change to occur. Projects aimed at diverting valuable waste for economic gain, should be viewed in total and not individually to leverage optimum results despite competition. Agreement to a plan to reduce waste and wastage should, therefore, not focus on silos or groups, each with an own agenda or vested interests. These are important considerations for investment recommendations and decisions, as the over-provision of infrastructure will not be affordable by any of the sectors and will create unintended consequences, complexities and competitive dynamics that will be counterproductive to achieving objectives or fulfilling common obligations.

In this context, the real problem that needs solving is not how diversion will be achieved (a typical waste type, quantity, system and technology focus), but who will pay for what, and how will costs and benefits be shared (a cost-benefit and socio-economic focus)? A crucial aspect is shareholder profit expectations without consideration for the consequences. While the South African environmental and waste legislation aligns with developed world principles, an unintended but obvious consequence is the cost of compliance and the cost implications to effect real change that will reduce waste to landfill and will create economic benefit. Further attempts should be made by the regulators to finalise a fiscal reform policy aimed at

supporting waste-based economic initiatives as has been done with success in other parts of the world. This is perhaps one of the powerful leverage points that the regulators have not focused on enough to provide the necessary impetus to drive large scale projects that will make a real difference.

6. CONCLUSION

This paper has shown that municipal waste management reform is limited by funding constraints, is complex and made difficult by social dynamics, is hampered by not being systems focused, and is slowed down by having to navigate complexities induced by a multitude of legislation. A key reform obstacle seems to lie in the responsibility for funding new initiatives that will develop and drive a waste economy to reduce landfill, resource and waste impacts. We believe that collaboration between stakeholders may address the impasse by using an agenda of agreed priorities and responsibilities in the short to medium term that could pave the way towards better outcomes.

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