An analysis of the dynamic and social complexities of municipal waste management reform.

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Barry Coetzee, Pr. Eng, MBL

Utility Services Directorate, City of Cape Town,

South Africa

Harro von Blottnitz , Pr. Eng, PhD.

Dept. of Chemical Engineering, Univ. of Cape Town

South Africa

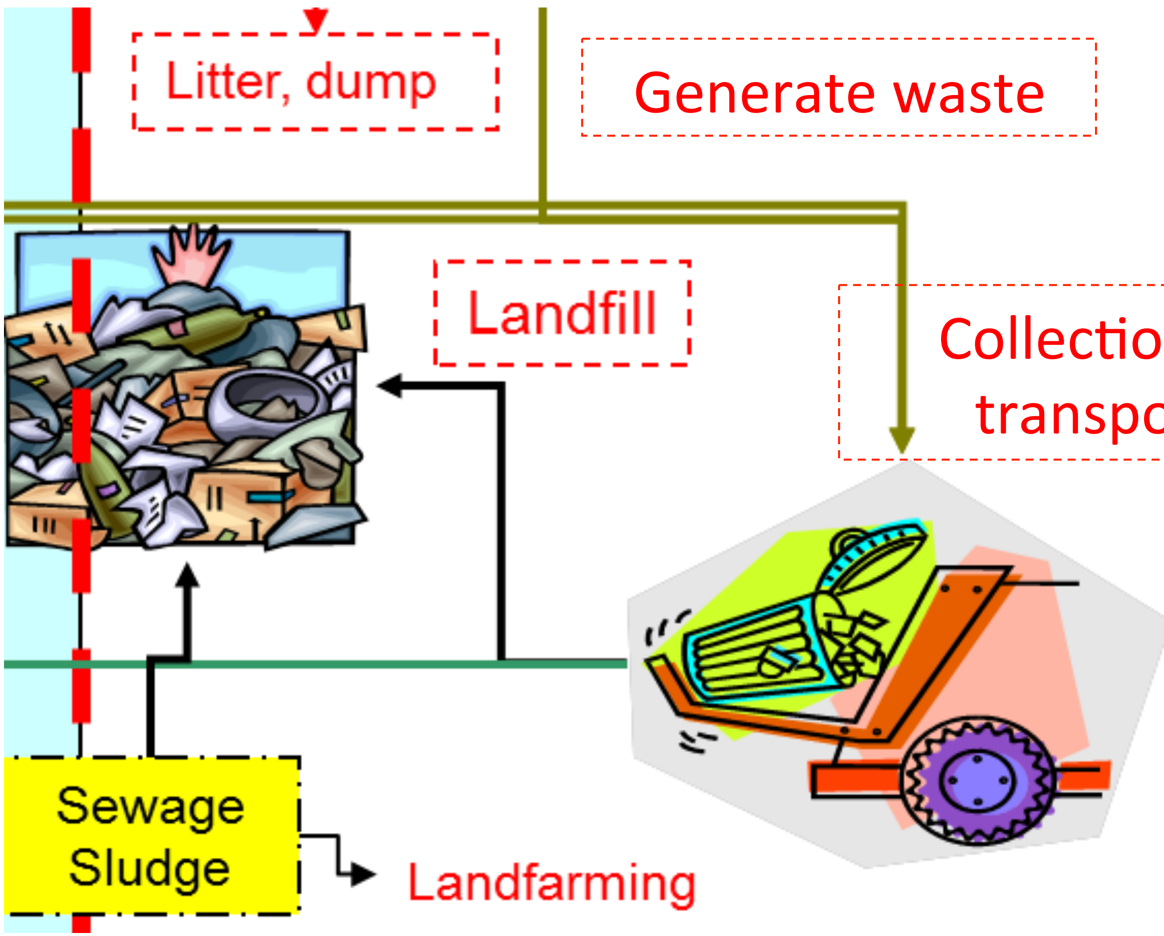
Ralph Hamann, PhD.

Graduate School of Business, Univ. of Cape Town

South Africa

The transformation challenge:

Changing a classic end-of-pipe (disposal-to-landfill) municipal waste management system of a metropolitan municipality in a developing country to a sustainable integrated, cyclical system.

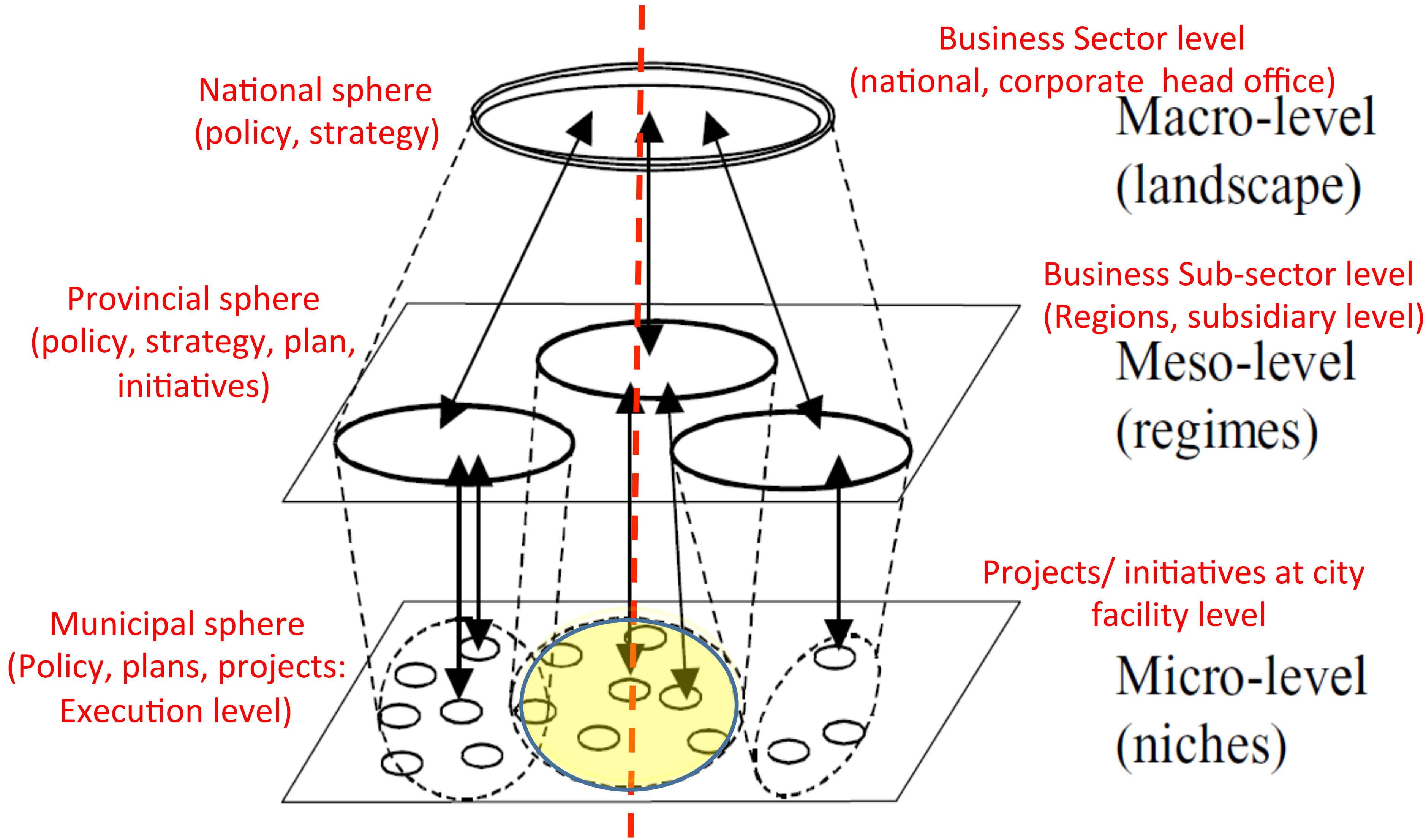


Legislation is driving SA's transformation of Municipal Waste Management (MWM)

- National Environmental Management: Waste Act, NEMWA:
  - Municipalities must enable systems to reduce waste to landfills and other impacts that will generate economic benefit in addition to the basic/primary service mandate & responsibilities.
  - Responsibilities: shared by all waste generators
  - Extended Producer Responsibility (EPR): Industry Waste Plans.

- Traditionally, municipalities provide funding & develop infrastructure for waste management services:
  - Technology, waste-based assessments and solutions prevail.
  - Key paradigm to be changed: to develop a waste-based economy that creates value chains beyond waste management.
  - Key questions: who participates, benefits and funds/pays for the creation of infrastructure that will divert waste into the productive economy (circular economy argument)?

Transition theory: towards integration



Transition from “waste management” to “resource management”

Will require an understanding of how different systems integrate “waste management” elements & develop feedback loops to become part of a “resource management” system:

- Systems dynamics (Forrester).
- Systems complexity (Cilliers).
- Leverage points in systems (Meadows).
- Emerging complexity (Kahane).

Systems Dynamics (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."

- Complex systems seldom have intuitive solutions,
- Leverage points are not intuitive due to systems complexity.

(Forrester, J. (1991). Systems Dynamics and the Lessons of 35 Years.)

In the local context, the real problem that needs solving is:

- not how diversion from landfill will be achieved focussing only on waste types, amounts and technology, but also;
- how stakeholder behaviour can be changed; and
- who will pay and how costs and benefits will be shared in the interest of present and future sustainability.

Characteristics of Complex Systems (1)

(Cilliers, 2006)

- Complex systems: Many elements with rich, mostly short range interactions.
- Interactions create positive or negative feedback loops (flow of stocks…):
    - Can influence other elements widely irrespective of range of interaction.
    - Interactions between elements are non-linear.
- Each element only responds to information available in its immediacy & is oblivious to behaviour of system:

- Importance: assessment of behaviour of a complex system requires -
    - ❖ focus on the complex system structure,
    - ❖ not just individual elements.

Characteristics of Complex Systems (2)

- Complex system's scope: defined by the description of its functionality, but
  - Depends on relative position of an observer.
    - **Municipalities**: IWM system = reducing landfill, enabling a waste economy at affordable tariffs;
    - **Private sector**: Waste recovered via IWM system = profit (but is there a market…?).
    - **Informal sector:** subsistence (what's in it for survival)?)
    - **Consumer**: Recycling should mean a lower tariff…

- Generates more complexity, conflicting opinions & objectives between observers with different perspectives:
  - Sustainable, affordable, inclusive, yet can cover costs, and/or generate profit …

System leverage points (Meadows, 1999)

- 12 types of leverage points that could be used to intervene and make changes to a system.
  - Small changes at a particular leverage point could have powerful effects to cause lasting changes (non-linearity).
  - The more powerful a type of leverage, the more difficult it is to achieve,
    - E.g. 10-year national waste management law reform process (rule change, #5).
    - Development of EPR systems by industry, introduction of Waste Bureau & potential landfill tax by DEA (system evolution, #4; rule change, #5) …

Table 1: Leverage points in a system [1]

	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.

[1] **Meadows, D. H. (1999). Leverage Points: Places to intervene in a System.**

Table 2: Leverage points already used by CoCT

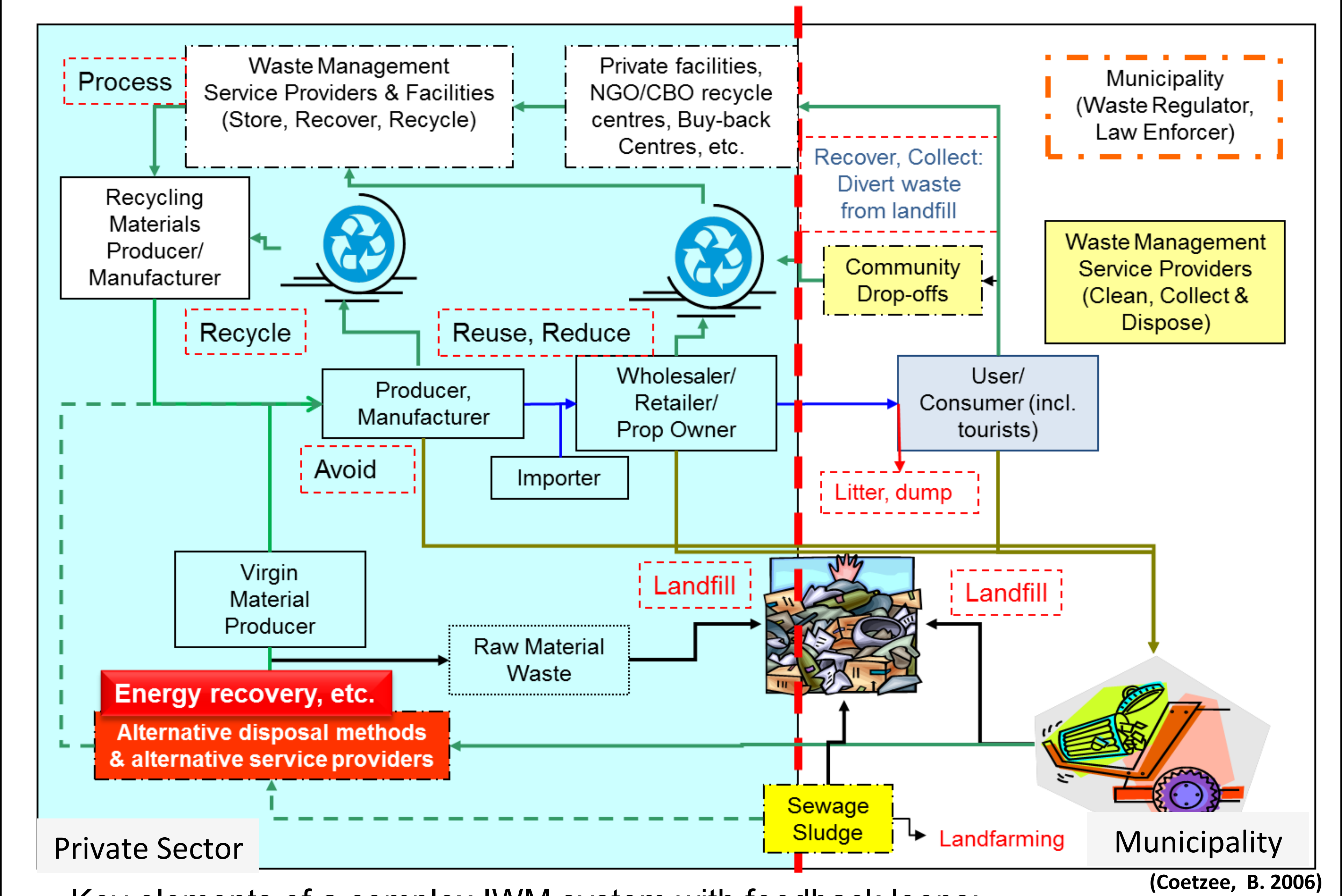
	Leverage point		Leverage Point
#12 (least powerful)	Planning, Design: mass, volume, population growth).	#6	WasteWise education and awareness campaign, web-based IWEX, City & SWM Dept webpages., WISP
#11	Waste diversion (systems & infrastructure), landfill airspace optimisation.	#5	CoCT IWM Policy, IWM By-law and tariff policies.
#10	MRFs, community drop-offs; separation-at-source contracts, builder's rubble and chipping contracts,.	#4	Efforts since early 2000s to add/ change/ evolve/ self-organise system structure.
#9	Extending current infrastructure: MSA S.78 alternative mechanism evaluation. Pending PPP feasibility assessment.	#3	Goals of the system.
#8	MRFs, separation-at-source contracts, builder's rubble and chipping contracts, community drop-offs, greening of events.	#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.

Cape Town's Waste Management Systems

Systems and sectoral sub-systems operate, interact to provide waste management services:

- Municipal sector: residential and some commercial waste generation, public areas: littering, illegal dumping.
- Informal sector: collection of recyclables for subsistence earning mostly (unorganised).
- Private sector: commercial & industrial generators & waste management (most commercial waste management, small scale recycling, industrial/ hazardous waste exclusively)

Interactions between stakeholders: multiple socio-economic factors & uncontrollable influences that make exactitude in planning impossible.



(Coetzee, B. 2006)

Key elements of a complex IWM system with feedback loops: Integrating Production, Consumption, Municipal & Commercial WM and other Systems

System leverage points : Not so obvious

- 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. illegal dumping does not change).
- Quantifying variables and their effects is vital for good planning, modelling and design (Cilliers, 2006), but...
    - Waste industry is notorious for poor information & data sharing to protect market share (and profit).
    - Poor data/info affects planning assumptions that could lead to inappropriate infrastructure responses.
    - Uncertainty increases risk aversion, delays decisions about alternatives to landfilling due to emerging complexity and costs that underpin integration between public and private sector systems.

Unintended Consequences

Due to poor or poorly-informed decisions (1)

- Not knowing or understanding markets, the structure & capacity of a sector, sub-sectors or the value chains necessary to make sustainable diversion possible:
  - Over-investment, stranded assets.
  - Redundant systems & infrastructure if market demand changes, or technology advances improve efficiencies & returns.
- When legislating alternatives & not fully considering economic consequences - impacts on existing industries and municipalities:
  - Appropriate transition arrangements, allowances & financial support mechanisms – tax allowances, EPR allowances, pre-consumption levies, etc.

Unintended Consequences (2)

Due to poor or poorly-informed decisions

- Forcing implementation of alternative mechanisms without alternatives & systems being in place, or considering affordability
  - E.g. landfill liner requirements intended to make landfilling very expensive, will add to municipal tariffs and make MWM and extending IWM unaffordable!
- Competition for resources due to different solutions that affect economics of scale
  - Different methods applied as alternatives to landfill for certain materials e.g. either recovery for re-use, or for energy recovery purposes.

Table 3: Three Dimensions of Complexity [2]

Going beyond system dynamics

Type of Complexity	Definition	Technical Approach	Adaptive Approach for Challenges of Complexity	Process Require-ments
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

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

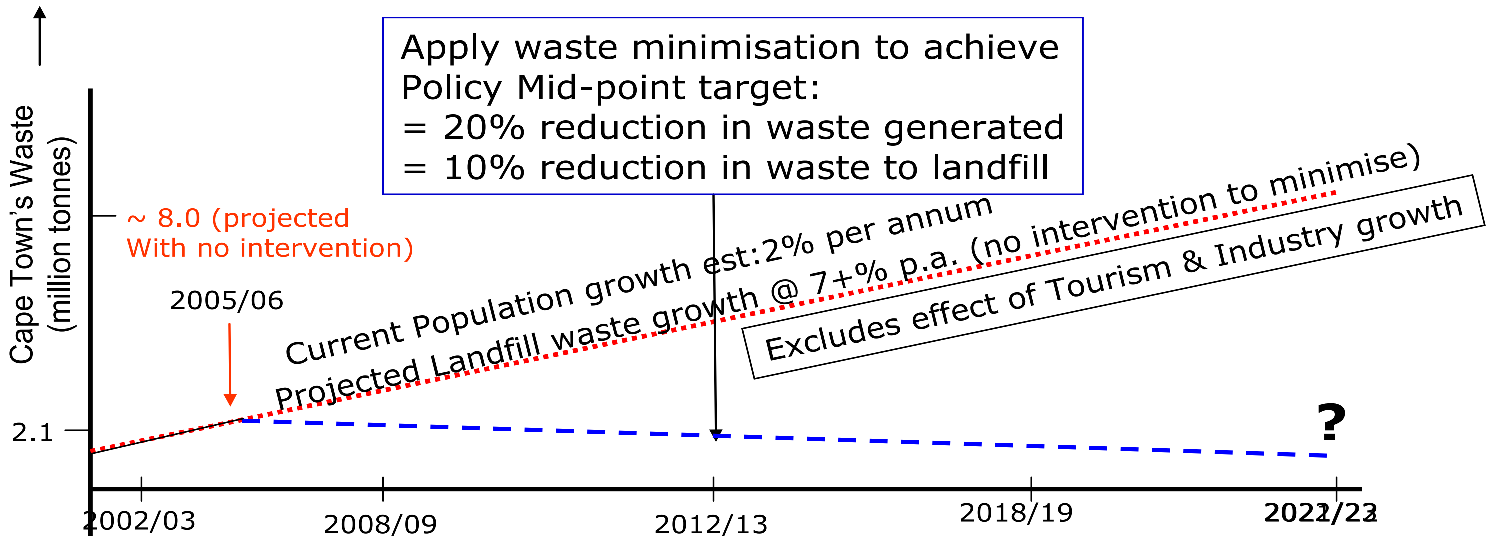
Analysis: Cape Town's Context

Planning for a complex, optimised future

Cape Town's waste management system	2004	2009[1]	2014
Households served	862 896	972 664	1 111 880
Waste generated (tonnes)[2] Material diverted from waste Waste disposed	2 022 547 Not measured 2 022 547	1 983 053 373 306 1 609 797	2 023 881 190 472 1 833 409
No. of compactors (collection trucks)	161[3]	198	192
Staff complement (excl. contracted staff)	2 528	1 689	2 942
Capital Budget Ops, Repairs, & Maintenance Staff	R 0.03–billion R 0.45–billion R 0.22–billion	R 0.165–billion R 0.967–billion R 0.278-billion	R 0.047–billion R 1.217–billion R 0.453–billion
Disposal sites/ landfills (City) Community Drop-off sites	5 operational 20	3 operational 20	3 operational 25
Population[4] Households	3 311 365 862 896	3 711 330 967 122	3.8-million 1.1-million

[1] Info supplied to CSIR, Sep 2009: "CSIR Interview guide – Integrated MSW management good practices – 2009"
[2] Waste generation figure includes all types of waste including private sector.
[3] Details not available for 2004, estimated
[4] Source: City of Cape Town, Strategic Information Dept. statistics, projections by Prof R Dorrington, Univ. of Cape Town

From "Pre-amble to the Integrated Waste Management (IWM) Policy of the City of Cape Town (2006)"



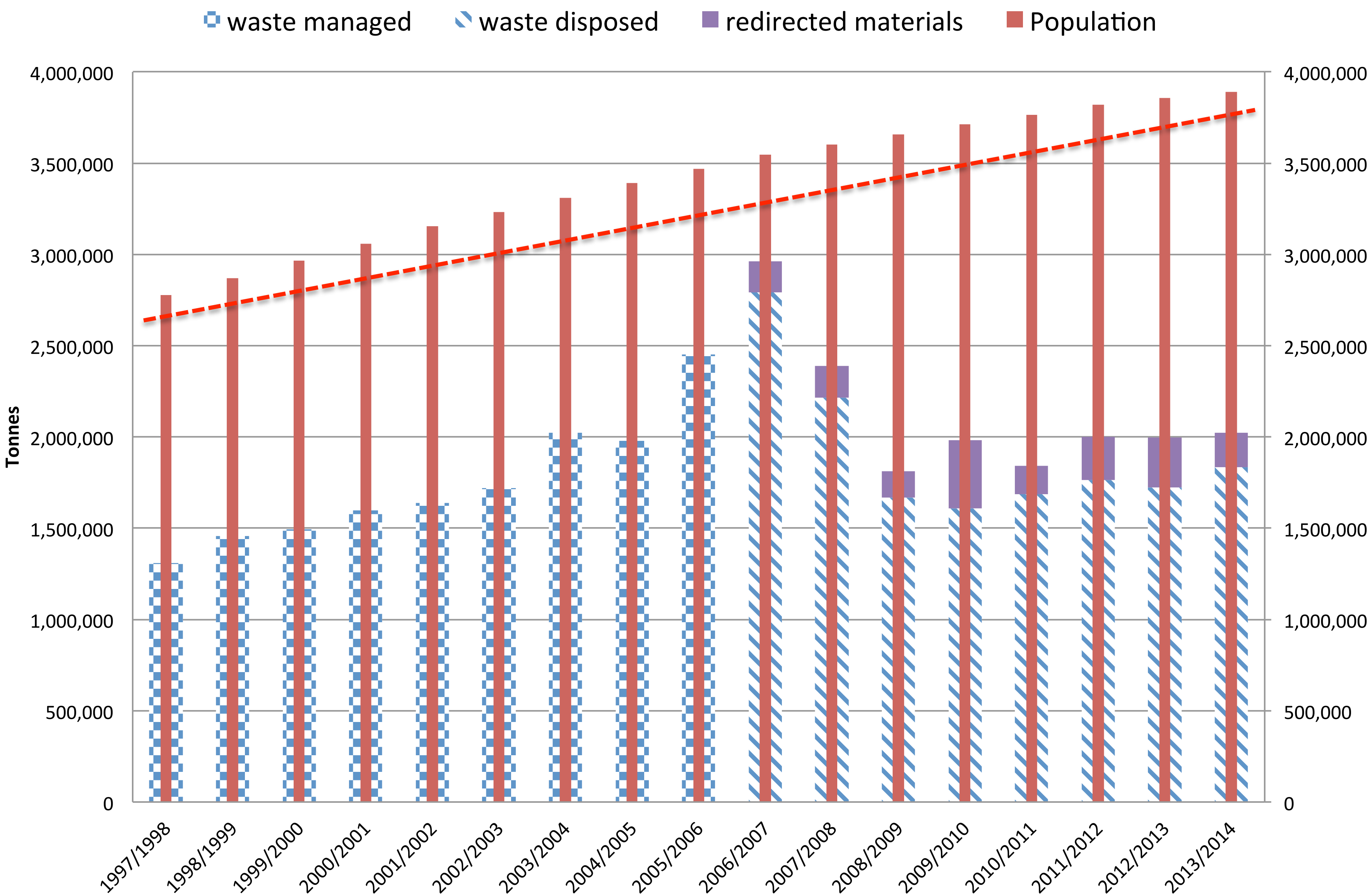
Effect/ Implications of Waste Minimisation Roll-out/Implementation must:

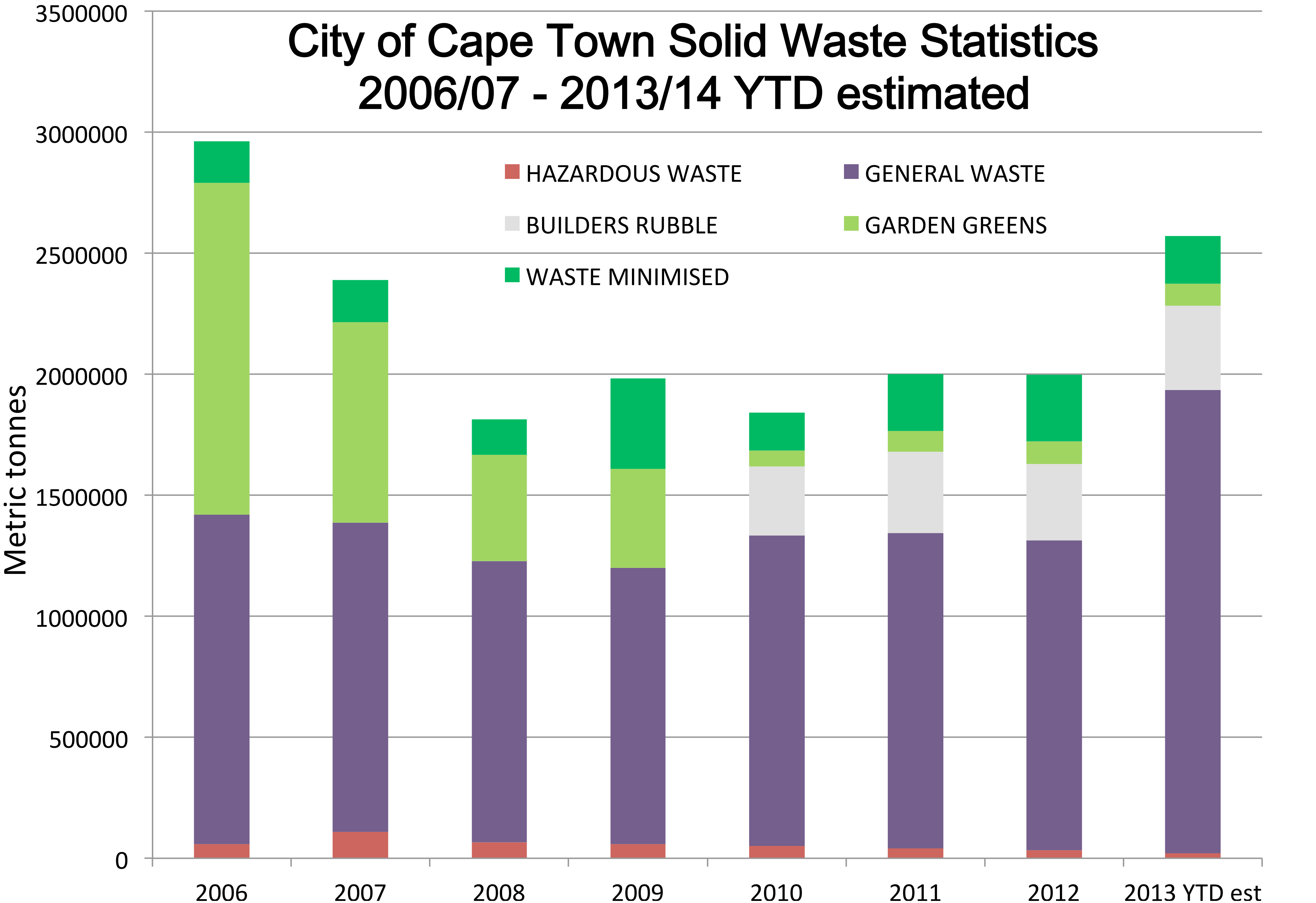
- Create infrastructure;
- Educate, make all aware;
- Encourage Public/industry participation;
- Facilitate creation of recycling market (industry);
- Enable job creation through recycling rather than through clean-ups
- Enforce stricter standards

Plan for "Zero waste" target

Fig 1: City of Cape Town Waste Minimisation Rationale

City of Cape Town: Trends in Waste Generation & Population Growth Statistics





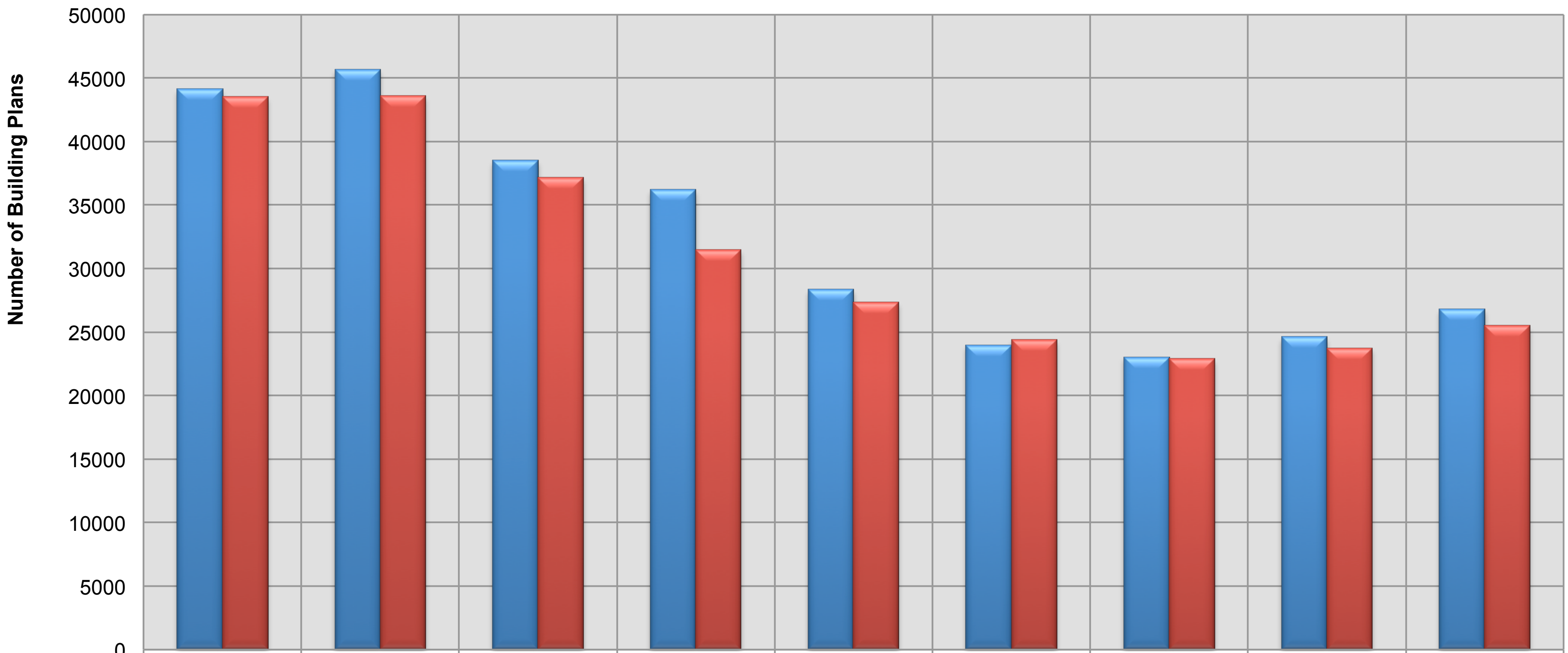
Source: City of Cape Town Solid Waste Management Dept. Statistics

Proxies for optimisation if waste data is questionable?

City of Cape Town: Planning and Building Development Management District Offices

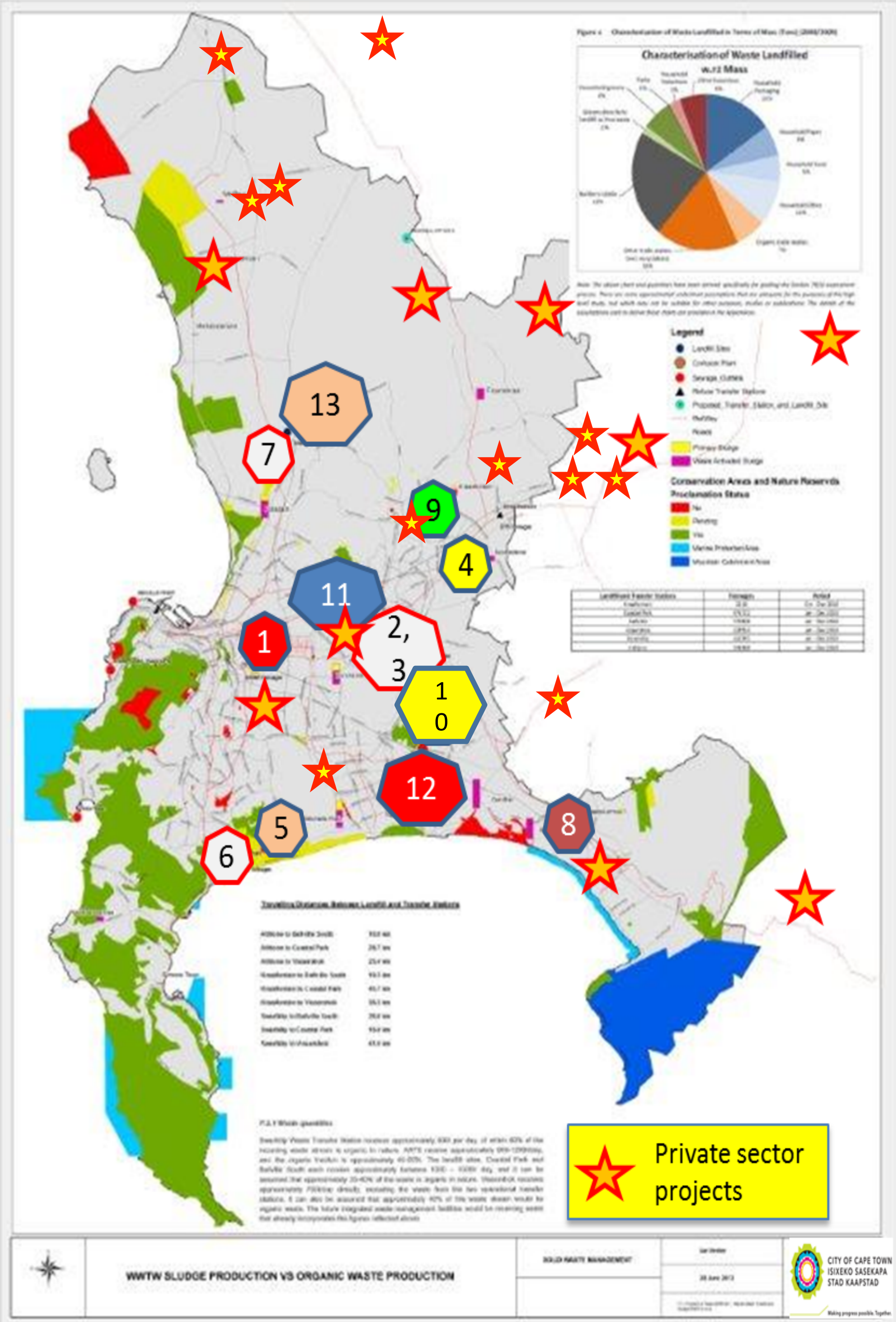
Number of Buildign Plans Submitted versus Number of Building Plans Approved

Period: July 2004 to June 2013



	2004 - 2005	2005 - 2006	2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013
Submissions	44105	45683	38492	36208	28320	23956	23045	24586	26817
Approvals	43512	43581	37156	31493	27362	24384	22875	23747	25483

Fiscal Year



City of Cape Town's Context

- 2470 km^2 municipal area.
- 2011 Census: Home to approx. 3.8-mill people or 1.1-mill households, growing at ave. 2.8% p.a.

Transition to full IWM still subject to determining best appropriate options i.t.o.

- Scale (type, volume/ mass of waste).
- Private sector investment appetite, needs.
  - ❖ W-E, IWM projects, other?
  - ❖ Synergies with key local, regional, national, industries (value chain...)?
- Best appropriate, long-term solutions that are affordable, have low risk, can accommodate a need for job creation?

Projects : Solid Waste Management Dept. & Water & Sanitation Dept (transversal) -

- Landfills: Landfill gas (#2, 6, 7/ 4, 7, 12).
- WWT sludge, bio-mass, organic solid waste (Anaerobic Digestion, AD – #5, 13).
- IWM sites (MRF/RTS, plus other options, e.g. AD: #1, 3, 9, 12).
- Pilot project (2015): pyrolysis …

Conclusions
Municipal Waste Management Transformation

- Understand the local context, systems, their interactions, dependencies and constraints to define the problem, before designing a solution.

- Collaboration between/among stakeholders may address impasse by using an agenda of agreed priorities & responsibilities in short to medium-term that could pave the way towards better outcomes.

- Key reform obstacle: responsibility for funding & ownership of new initiatives that will develop and drive a waste economy to reduce the need to landfill, the resource and waste impacts.

Research ahead?

- Cape Town is a tale of two cities not only socio-economically, but in terms of MWM too.
  - **What is the shape and function of an optimal MWM system that can include the economic needs of the poor in a developing country?**
- Legislation that compels transformation of MWM creates an emergent complexity that raises many questions:
  - Needs much more interaction and consensus within and between stakeholder groups to create a waste/resource-based economy.
    - **What mechanism can be used to handle emergent complexity to enable transition from BAU to IWM in an urban city with diverse challenges in a developing country?**
  - Cost-benefit sharing is a key stumbling block that needs resolution.
    - **What fiscal reform is needed to support the transformation and integration between municipal and private sector systems?**
  - Reliance on inadequate data underpinned by traditional linear logic, technology-based solutions are likely to retain the status quo.
    - **Shouldn't a simplified proxy based modelling technique be developed to optimise planning and investment in the absence of good data?**

Thank you for your attention. Questions?

Barry Coetzee, Pr. Eng, MBL

Utility Services Directorate, City of Cape Town,

South Africa

Harro von Blottnitz , Pr. Eng, PhD.

Dept. of Chemical Engineering, Univ. of Cape Town

South Africa

Ralph Hamann, PhD.

Graduate School of Business, Univ. of Cape Town

South Africa