DECISION SUPPORT TOOL FOR IMPLEMENTING MUNICIPAL WASTE SEPARATION AT SOURCE:

Incorporating Socio-Economic and Environmental Impacts

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Need for S@S & the SASCOST model

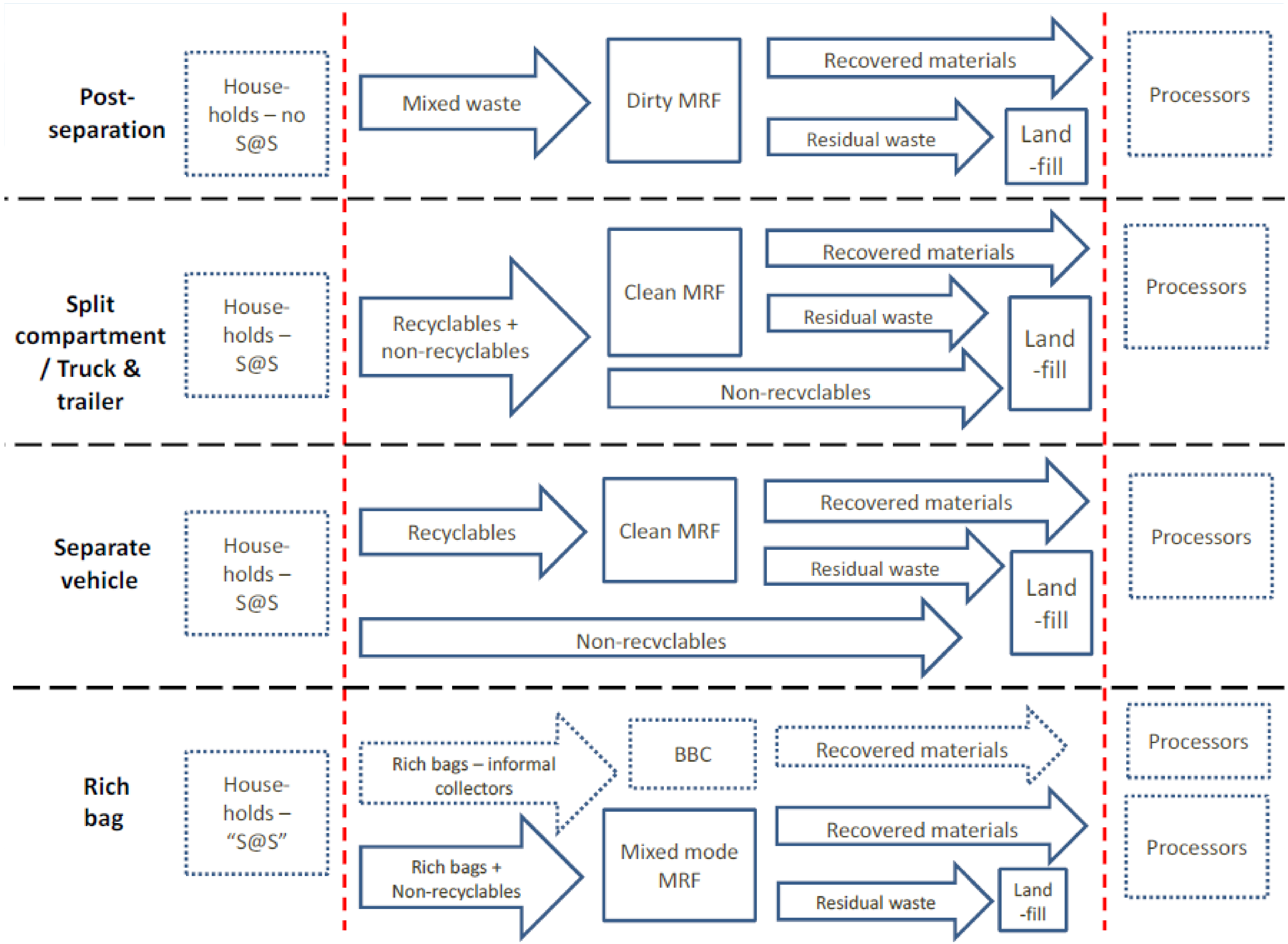
- Waste Act (2008) calls for increased diversion of waste away from landfill towards re-use, recycling and recovery.
- Aim is to reduce pressure on landfill space, create jobs & business opportunities in the recycling industry, & ensure that valuable resources are not just buried (at huge cost)
- National Waste Management Strategy (NWMS) sets target for metros, secondary cities and large towns to implement "Separation at Source" (S@S) (DEA, 2011)
  - Households and businesses must separate recyclables from their general waste,
  - Municipalities must provide (or out-source) a collection system that keeps recyclables separated from general waste to allow for recovery & recycling

Need for S@S & the SASCOST model

- DEA is also considering mandatory implementation of S@S by municipalities
- But: Adapting collection systems to allow separate collection will be costly
- Various options exist, each with own costs and benefits – in turn, these will vary with each municipality's circumstances
- Therefore municipalities need decision support in assessing costs and benefits of alternative systems
- CSIR has developed a spreadsheet-based economic model (the SASCOST Model) for assessing costs and benefits of alternative systems, given each municipality's unique context
- Can be used as a Decision Support Tool to assist in identifying an appropriate system for implementation

Version 1 of the SASCOST Model

- Spreadsheet-based, online interface is being developed
- Focus on household packaging waste (paper, plastic, metals, glass)
- Assesses costs and benefits of four alternative options:
  - Post separation
  - Truck and trailer
  - Separate Vehicle
  - Rich bag
- Focuses on financial costs and benefits:
  - communication costs
  - container costs
  - costs of collection and transport to MRF
  - costs of sorting at the MRF
  - costs of transporting residual fraction from MRF to landfill
  - income from sale of recyclables
  - savings from reduced collection, transport & disposal to landfill



Post-separation
House-holds – no S@S
Mixed waste
Dirty MRF
Recovered materials
Residual waste
Land-fill
Processors
Split compartment / Truck & trailer
House-holds – S@S
Recyclables + non-recyclables
Clean MRF
Recovered materials
Residual waste
Non-recyclables
Land-fill
Processors
Separate vehicle
House-holds – S@S
Recyclables
Clean MRF
Recovered materials
Residual waste
Non-recyclables
Land-fill
Processors
Rich bag
House-holds – "S@S"
Rich bags – informal collectors
BBC
Recovered materials
Processors
Rich bags + Non-recyclables
Mixed mode MRF
Recovered materials
Residual waste
Land-fill
Processors

Version 1: Results tab (based on hypothetical input data)

RESULTS*

*Note that results will be updated once input data is entered

	POST SEPARATION				TRUCK & TRAILER				SEPARATE VEHICLE			
Costs/benefits	R/year	R/tonne (collected/ processed)	R/tonne (recovered / diverted)	R/ hhold/ month	R/year	R/tonne (collected/ processed)	R/tonne (recovered / diverted)	R/ hhold/ month	R/year	R/tonne (collected/ processed)	R/tonne (recovered / diverted)	R/ hhold/ month
NET COST (OR BENEFIT)	**649 196**	**110.43**	**736.22**	**2.85**	**(261 743)**	**(252.31)**	**(296.83)**	**(1.15)**	**3 086 598**	**2 975.32**	**3 500.38**	**13.54**
S@S costs (benefits)	**332 900**	**56.63**	**377.53**	**1.46**	**1 087 715**	**1 048.50**	**1 233.53**	**4.77**	**4 436 057**	**4 276.13**	**5 030.74**	**19.46**
Communication costs	0	0.00	0.00	0.00	342 000	329.67	387.85	1.50	342 000	329.67	387.85	1.50
Bag costs	0	0.00	0.00	0.00	691 600	666.67	784.31	3.03	691 600	666.67	784.31	3.03
Collection & transport to MRF	0	0.00	0.00	0.00	116 311	112.12	131.90	0.51	3 508 708	3 382.21	3 979.07	15.39
Transport costs MRF-Landfill	832 200	141.56	943.76	3.65	25 916	24.98	29.39	0.11	25 916	24.98	29.39	0.11
(Collection/transport savings)	(499 300)	(84.94)	(566.23)	(2.19)	(88 112)	(84.94)	(99.92)	(0.39)	(132 168)	(127.40)	(149.89)	(0.58)
MRF costs (benefits)	**444 296**	**75.58**	**503.86**	**1.95**	**(1 221 458)**	**(1 177.42)**	**(1 385.20)**	**(5.36)**	**(1 221 458)**	**(1 177.42)**	**(1 385.20)**	**(5.36)**
MRF costs	2 090 320	355.58	2 370.54	9.17	424 566	409.26	481.48	1.86	424 566	409.26	481.48	1.86
(Income from sale of recyclables)	(1 646 024)	(280.00)	(1 866.68)	(7.22)	(1 646 024)	(1 586.68)	(1 866.68)	(7.22)	(1 646 024)	(1 586.68)	(1 866.68)	(7.22)
Disposal costs (benefits)	**(128 000)**	**(21.77)**	**(145.16)**	**(0.56)**	**(128 000)**	**(123.39)**	**(145.16)**	**(0.56)**	**(128 000)**	**(123.39)**	**(145.16)**	**(0.56)**
(Disposal cost savings)	(128 000)	(21.77)	(145.16)	(0.56)	(128 000)	(123.39)	(145.16)	(0.56)	(128 000)	(123.39)	(145.16)	(0.56)
Tonnes of waste collected/ processed and recyclables recovered/diverted through S@S	Households serviced	t/year collected / processed	t/year diverted / recovered		Households serviced	t/year collected / processed	t/year diverted / recovered		Households serviced	t/year collected / processed	t/year diverted / recovered	
	19 000	**5 878.60**	**881.79**		**19 000**	**1 037.40**	**881.79**		**19 000**	**1 037.40**	**881.79**	

Objectives of the DST Waste RDI Roadmap Grant Project

- DST Waste RDI Roadmap Grant funding was received for 2 years (April 2016 – March 2018), with the following objectives:
  - To incorporate socio-economic and environmental impacts of the S@S options into “Version 2” of the SASCOST model
  - To value the impacts in monetary terms such that they can be incorporated within the cost-benefit framework
  - To enable the model to calculate the net cost or benefit of alternative S@S options; taking into account financial, socio-economic and environmental costs and benefits.
  - Ultimately, to develop a tool that can be used to inform decision making regarding how best to implement S@S, from an integrated financial, socio-economic and environmental perspective; taking into account each municipality’s unique context

Approach

1. Key socio-economic and environmental variables to incorporate in the model were identified based on literature review and expert workshop
2. Drivers of each of impact were identified (factors affecting direction and magnitude of the impact)
3. Sub-model developed for each impact (quantifies magnitude of the impact per tonne of waste, as a function in of its drivers)
4. Impacts incorporated quantitatively in the SASCOST model
5. Impacts valued in monetary terms, using an appropriate economic valuation technique
6. Economic value of the impacts incorporated within the monetary cost-benefit framework

Socio-economic and environmental impacts to incorporate in the model

- Impacts identified to incorporate in Version 2:
  1. Impacts of informal collectors on the viability of a S@S programme
  2. Impacts on employment and livelihoods (including formal job creation and informal sector livelihoods)
  3. Additional/avoided emissions from collection and transport
  4. Avoided social and environmental externalities from landfill disposal
  5. Landfill airspace savings and increased lifespan

Impact	Description of impacts
Impacts of informal collectors on viability of S@S programme	Recyclables (particularly the higher value materials) are collected by informal pickers before the collection truck arrives. This may impact on the feasibility of a formal S@S programme: • lower volumes of recyclables will remain • The materials that remain will on average be of lower value, because the high value materials would have been cherry-picked
Impacts on employment and livelihoods	• Job creation opportunities for drivers/assistants in collection (for some options); as well as sorters at the MRF (for all options). • Potential improved access to recyclables for kersbide pickers • Reduced opportunities for pickers at landfill site
Additional/ avoided emissions from collection and transport	• Additional emissions (including greenhouse gases such as CO_2) associated with additional collection vehicles • Reduced emissions from reduced collection by compactor vehicles • Reduced emissions associated with reduced transport to landfill • Additional emissions from transport of residual waste from MRF to landfill

Avoided externalities from landfill disposal	• Reduced waste to landfill will result in a reduction in the socio-economic and environmental impacts of landfilling.
	• Impacts associated with inorganic packaging waste (i.e. benefits of diversion) include:
	  ○ Using up valuable airspace (see below)
	  ○ Windblown litter
	  ○ Water accumulates in plastics – breeding ground for mosquitoes, odours, etc.
	  ○ Paper and packaging burns easily causing fires (methane exacerbates this)
	• Impacts associated with organic waste (which includes paper) include:
	  ○ Leachate
	  ○ Landfill gas (methane – global warming)
	  ○ Odours, pests etc.

Landfill airspace savings	Diversion of waste from landfill results in airspace savings and increased lifespan of landfills.

1. Impacts of informal collectors on the viability of a S@S programme

- Not strictly a socio-economic impact; rather impacts on financial viability from municipality's perspective
- From socio-economic perspective, this is not a problem – waste still being diverted from landfill, while contributing to livelihoods
- Nevertheless would be of interest to highlight volumes of recyclables specifically recovered by the informal sector relative to the total volumes recovered in the system
- However due to lack of reliable data, and wide range of factors affecting informal sector activity, not possible to provide a default % of recyclables likely to be removed
- Instead users must enter a %, for each of the S@S options (as it will differ between options)
- Based on these %'s, model calculates total volumes (and value) recovered by informal sector; vs. total volumes and value recovered at the MRF

2. Impacts on employment and livelihoods

- Job creation in collection and transport
  - No. of jobs created calculated by multiplying number of drivers and assistants per vehicle by the number of vehicles required
  - Economic value calculated based on salaries – own data or default values (based on Road Freight Association 2014[1])
- Job creation at the MRF
  - Statistical regression model used to estimate no. of jobs created per tonne of waste, based on data relating to no. of employees and tonnes of waste processed at 23 MRFs in SA
  - Economic value calculated based on salaries – own data or default values (based on salary data from MRFs in SA)

[1] Road Freight Association of South Africa (2014). Vehicle Cost Schedule. Edition 50, October 2014. Road Freight Association of South Africa: Johannesburg

2. Impacts on employment and livelihoods

- Job creation in downstream processing
  - No. of jobs calculated using figures from CSIR (2017[2]) on jobs in recycling per 1,000 tonnes (for each packaging stream)
  - Economic value calculated based on median salary for "production operators" in SA, as per PayScale, Inc (2018[3])
- Indirect and induced job creation
  - Calculated using multipliers from CSIR (2017): 1.5 indirect jobs and 1.75 induced job per direct job created
  - Economic value calculated by applying the same salaries used for the direct jobs (in proportion to no. of jobs in each activity)

[2] Council for Scientific and Industrial Research (CSIR) (2017). The economic and employment opportunities from increased paper and packaging recycling in South Africa. CSIR: Pretoria
[3] PayScale, Inc. (2018). Production Operator Salary (South Africa). Online. Available at: https://www.payscale.com/research/ZA/Job=Production_Operator/Salary. Accessed 12 March 2018.

2. Impacts on employment and livelihoods

- Impacts on informal sector livelihoods
  - Has two dimensions:
    1. increased opportunities for kerbside pickers to access high value materials
    2. reduced opportunities for pickers at the landfill site
  - Likely that some pickers will migrate from landfill to suburbs, in search of improved opportunities.
  - Difficult to quantify the overall impact
  - We therefore assume that these two issues will essentially cancel each other out
  - Therefore no changes are made to the model

3. Additional/avoided emissions from collection and transport

- Additional emissions from separate collection & transport of recyclables from households to the MRF
  - Calculated by applying a standard emission factor[4] (GHG emissions per litre of fuel used) x fuel use (in litres)
  - Fuel used calculated based on fuel consumption per km (weighted by collection vs transport distance) x km's driven
- Avoided emissions from reduced collection and transport of mixed waste from households to landfill
  - Same emission factor applied as above
  - Savings in fuel use calculated based on data from literature on fuel use per tonne of waste x tonnes diverted

[4] DEFRA (2017). Greenhouse gas reporting: Conversion factors 2017. Online. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2017

3. Additional/avoided emissions from collection and transport

- Additional emissions from transport of residual fraction from MRF to landfill
  - Calculated by applying a standard emissions factor[5] (specified in GHG emissions per km) x the total distance driven (based on distance from MRF to landfill and assumed no. of trips, based on tonnes of residual waste and payload of the vehicle)
- Economic valuation of GHG emissions
  - Based on “social cost of carbon” – i.e. damage cost per tonne of CO_2 in terms of the resulting climate impacts
  - We use $85 per tonne of CO_2 as per Stern (2006)[6]

[5] DEFRA (2017). Greenhouse gas reporting: Conversion factors 2017. Online. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2017

[6] Stern, N. (2006). Stern review on the economics of climate change. Online. Available at: http://webarchive.nationalarchives.gov.uk/20080910140413/http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm.

4. Avoided social and environmental externalities from landfill disposal

- Economic value calculated based on Rand value of damage cost per tonne of waste landfilled x tonnes of waste diverted
- Users have option to provide their own estimate of the externality cost per tonne
- Default value is provided based on Nahman (2011)[7] – R107 per tonne including impacts from leachate, LFG emissions and 'disamenities' such as odours and pests (in City of Cape Town)
- However users are advised to modify this value taking into account actual waste composition (default is based on general waste, not specifically recyclables) and site-specific factors (e.g. differences in LFG and leachate management practices)

[7] Nahman, A. (2011). Pricing landfill externalities: emissions and disamenity costs in Cape Town, South Africa. Waste Management, 31, 2046-2056.

5. Landfill airspace savings and increased lifespan

- Incorporated in model via the existing variable "disposal cost savings", albeit modified to account for full airspace value (closure & rehabilitation costs + replacement costs of building new landfills, in addition to CAPEX and OPEX for disposal)
- Users can provide their own value, if known
- Alternatively, a default is calculated, taking into account the remaining lifespan of existing landfills (shorter remaining lifespan = higher airspace value, and vice versa)

Putting it all together

- Version 2 of the model has been expanded significantly since V.1
- Results tab now has two parts: “key indicators” & cost-benefit analysis
- Key indicators include:
  - Number of households serviced
  - Tonnes of waste collected from households
  - Tonnes of waste diverted from landfill / recovered for recycling
    - Tonnes recovered at the MRF
    - Tonnes recovered by the informal sector
  - Total value of recyclables recovered
    - Value of recyclables recovered at the MRF
    - Value of recyclables recovered by the informal sector
  - Job creation (collection & transport, MRF, downstream, indirect & induced
  - Total savings in tCO_2e
    - Increase/decrease in GHG emissions (tCO_2e) from collection and transport
    - Savings in tCO_2e from reduced disposal
- Cost-benefit analysis now includes socio-economic & environmental impacts in addition to financial costs/benefits

Version 2 Results tab: Key indicators (based on hypothetical input data)

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RESULTS*	POST SEPARATION	TRUCK & TRAILER	SEPARATE VEHICLE
Key indicators	**Per annum**	**Per annum**	**Per annum**
No. of households serviced	19 000	19 000	19 000
T's of waste collected/processed	5 878.60	1 037.40	1 037.40
T's of waste diverted/recovered	881.79	881.79	881.79
Tonnes recovered at the MRF	793.61	705.43	705.43
Tonnes recovered by informal sector	88.18	176.36	176.36
Total value of recyclables recovered (R)	1 464 584.45	1 464 584.45	1 464 584.45
Value of recyclables recovered - MRF	1 318 126.00	1 171 667.56	1 171 667.56
Value recovered - informal sector	146 458.44	292 916.89	292 916.89
Jobs created - collection & transport	0	0	21
Jobs created - MRF**	12	3	3
Jobs created - downstream	11	11	11
Jobs created - indirect and induced	74	44	112
tCO_2e - Collection & transport to MRF	0.00	10.65	68.02
(Reduced tCO_2e - Col/trans savings)	(19.58)	(3.45)	(11.52)
tCO_2e - Transport MRF to Landfill	9.10	0.28	0.28
Increase (decrease) in tCO_2e from collection/transport	(10.48)	7.48	56.78
(Reduced tCO_2e from reduced disposal)	(519)	(519)	(519)
(Total tonnes CO_2e saved)	(530)	(512)	(463)

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V.2 Results tab: Cost/benefit analysis (based on hypothetical input data)

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RESULTS*	POST SEPARATION				TRUCK & TRAILER				SEPARATE VEHICLE			
Cost-benefit analysis***	R/year	R/tonne (collected/ processed)	R/tonne (recovered/ diverted)	R/ hhold/ month	R/year	R/tonne (collected/ processed)	R/tonne (recovered/ diverted)	R/ hhold/ month	R/year	R/tonne (collected/ processed)	R/tonne (recovered/ diverted)	R/ hhold/ month
NET COST (OR BENEFIT)	**(8 685 526)**	**(1 477.48)**	**(9 849.88)**	**(38.09)**	**(6 774 817)**	**(6 530.57)**	**(7 683.03)**	**(29.71)**	**(13 046 508)**	**(12 576.16)**	**(14 795.48)**	**(57.22)**
S@S costs (benefits)	**332 900**	**56.63**	**377.53**	**1.46**	**1 087 715**	**1 048.50**	**1 233.53**	**4.77**	**4 436 057**	**4 276.13**	**5 030.74**	**19.46**
Communication costs	0	0.00	0.00	0.00	342 000	329.67	387.85	1.50	342 000	329.67	387.85	1.50
Bag costs	0	0.00	0.00	0.00	691 600	666.67	784.31	3.03	691 600	666.67	784.31	3.03
Collection & transport to MRF	0	0.00	0.00	0.00	116 311	112.12	131.90	0.51	3 508 708	3 382.21	3 979.07	15.39
(Collection/transport savings)	(499 300)	(84.94)	(566.23)	(2.19)	(88 112)	(84.94)	(99.92)	(0.39)	(132 168)	(127.40)	(149.89)	(0.58)
Transport costs MRF to Landfill	832 200	141.56	943.76	3.65	25 916	24.98	29.39	0.11	25 916	24.98	29.39	0.11
MRF costs (benefits)	**625 735**	**106.44**	**709.62**	**2.74**	**(1 040 019)**	**(1 002.52)**	**(1 179.44)**	**(4.56)**	**(1 040 019)**	**(1 002.52)**	**(1 179.44)**	**(4.56)**
MRF costs**	2 090 320	355.58	2 370.54	9.17	424 566	409.26	481.48	1.86	424 566	409.26	481.48	1.86
(Income from sale of recyclables)	(1 464 584)	(249.14)	(1 660.92)	(6.42)	(1 464 584)	(1 411.78)	(1 660.92)	(6.42)	(1 464 584)	(1 411.78)	(1 660.92)	(6.42)
Disposal costs (benefits)	**(293 980)**	**(50.01)**	**(333.39)**	**(1.29)**	**(293 980)**	**(283.38)**	**(333.39)**	**(1.29)**	**(293 980)**	**(283.38)**	**(333.39)**	**(1.29)**
(Disposal cost savings)	(293 980)	(50.01)	(333.39)	(1.29)	(293 980)	(283.38)	(333.39)	(1.29)	(293 980)	(283.38)	(333.39)	(1.29)
Social/environmental costs (benefits)	**(9 350 181)**	**(1 590.55)**	**(10 603.64)**	**(41.01)**	**(6 528 534)**	**(6 293.17)**	**(7 403.73)**	**(28.63)**	**(16 148 566)**	**(15 566.38)**	**(18 313.39)**	**(70.83)**
(Job creation - collect/transport)	0	0.00	0.00	0.00	0	0.00	0.00	0.00	(2 275 137)	(2 193.11)	(2 580.13)	(9.98)
(Job creation - MRF)**	(877 897)	(149.34)	(995.59)	(3.85)	(218 204)	(210.34)	(247.46)	(0.96)	(218 204)	(210.34)	(247.46)	(0.96)
(Job creation - downstream)	(1 297 469)	(220.71)	(1 471.40)	(5.69)	(1 297 469)	(1 250.69)	(1 471.40)	(5.69)	(1 297 469)	(1 250.69)	(1 471.40)	(5.69)
(Job creation - indirect & induced)	(7 069 940)	(1 202.66)	(8 017.71)	(31.01)	(4 925 939)	(4 748.35)	(5 586.30)	(21.60)	(12 320 133)	(11 875.97)	(13 971.73)	(54.04)
Emissions - Collection & transport to MRF	0	0.00	0.00	0.00	10 648	10.26	12.07	0.05	68 006	65.55	77.12	0.30
(Reduced emissions - Col/trans savings)	(19 574)	(3.33)	(22.20)	(0.09)	(3 454)	(3.33)	(3.92)	(0.02)	(11 514)	(11.10)	(13.06)	(0.05)
Emissions - Transport MRF to Landfill	9 098	1.55	10.32	0.04	283	0.27	0.32	0.00	283	0.27	0.32	0.00
(Avoided externalities at landfill)	(94 398)	(16.06)	(107.05)	(0.41)	(94 398)	(90.99)	(107.05)	(0.41)	(94 398)	(90.99)	(107.05)	(0.41)

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Effect of incorporating socio-economic and environmental impacts on model results

- Version 1 (financial costs and benefits only):
  - most options yielded net costs (in some cases truck & trailer yielded net benefits)
  - e.g. based on hypothetical data for 5 high income suburbs in the CoCT, costs ranged from R736/tonne for post separation to R3 500/tonne for separate vehicle (truck & trailer = net benefit of R297 per tonne)
- Version 2 (socio-economic & environmental impacts included):
  - big swing - all options now yield significant net benefits; ranging from R7 683 per tonne for truck & trailer to R14 795 for separate vehicle option (now the most attractive option)
  - BUT: results dominated by benefits associated with downstream, indirect and induced job creation

Effect of incorporating socio-economic and environmental impacts on model results

- Even excluding these benefits, however, S@S appears more favourable when socio-economic & environmental impacts are considered vs. only looking at financial considerations
- E.g. truck and trailer: higher net benefit (R625/t, as compared to R297/t when only financial costs and benefits are considered
- Separate vehicle option: lower net cost (R647/t, as compared to R3500/t when only financial costs and benefits are considered
- Likewise for other options

Net cost (or benefit) per tonne of recyclables recovered	Post separation	Truck & trailer	Separate vehicle	Rich bag
Financial costs and benefits only	736.22	(296.83)	3 500.38	1 908.39
Socio-economic and environmental impacts included	(9 849.88)	(7 683.03)	(14 795.48)	(8 677.72)
Downstream, indirect and induced job creation excluded	(360.76)	(625.33)	647.65	811.40

Way forward for the SASCOST Model

- Model will be redesigned to allow users to easily select the scope of the analysis (municipal/financial vs socio-economic) and/or which specific costs/benefits should be included
- May also allow each variable to be ‘weighted’ according to the municipality’s specific needs and priorities
- Model values need to be updated to 2018 values
- Scope of model to be expanded beyond household packaging waste to include other sources & streams, esp. organics
- Need to assess a broader range of options e.g. drop-offs, multi-compartment vehicles (retrofit existing vehicles vs. procurement of new vehicles), etc.
- Expand model boundaries beyond the MRF to consider full value chain (including downstream recycling and processing)

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Thank you

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