Waste Management in the Seychelles – Pathways for Systemic Change: Appendix

USYS TdLab Transdisciplinary Case Study 2018

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Pius Krütli, Danny Nef, Marius Zumwald, Mélanie Haupt, Jérôme Harlay, & Michael Stauffacher (Eds.)

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Contents

Appendix 1
Waste collection and sorting: Consumers’ perspective

1.1 Expert interviews

Table 1.1
List of all interviewed experts.

Interviewee	Position/Profession	Organization/Company
Government		
H. De Letourdie		National Bureau of Statistics Seychelles (NBS)
Consultants, scientists		
F. Schmidt		École polytechnique fédérale de Lausanne (EPFL)
S. Schwarzer		Amt für Abfall, Wasser, Energie und Luft (AWEL)

1.2 Map of Mahé

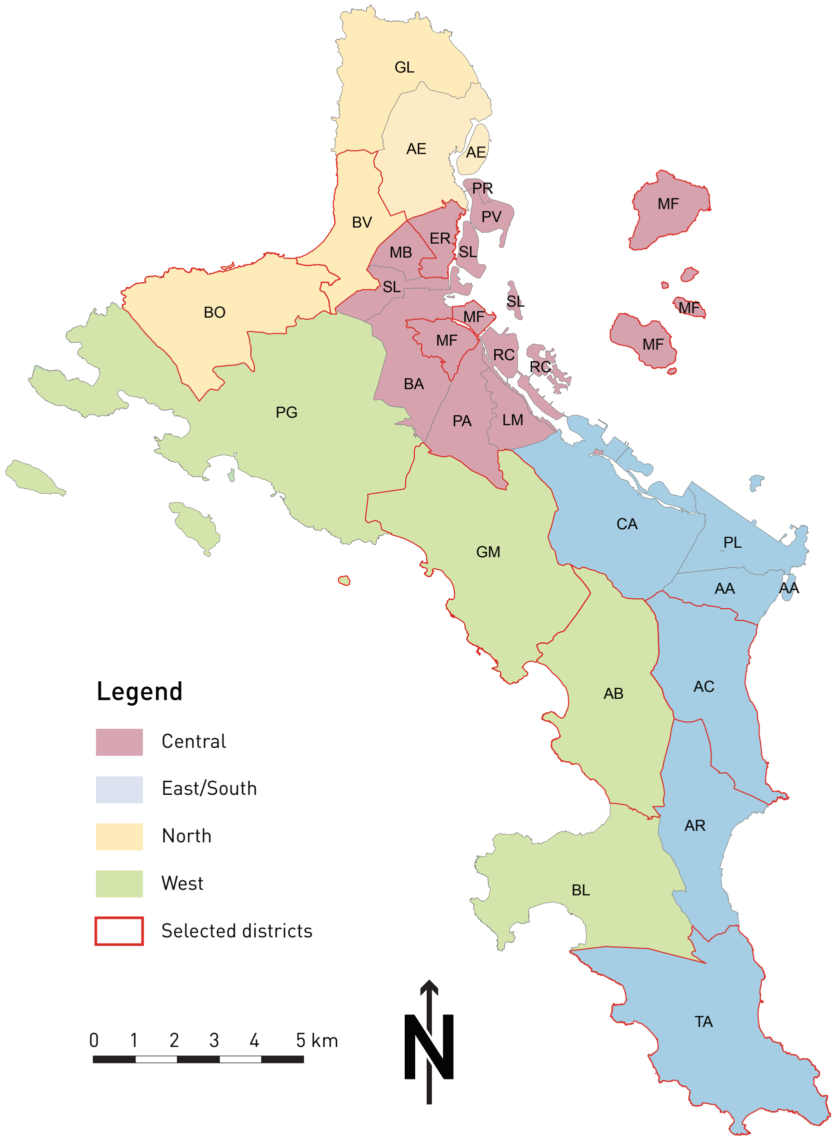


Figure 1.1
Map of Mahé Island. 8 districts in which we conducted door-to-door survey are highlighted with red line. The different colours indicate the four different regions we sampled (Central, East/South, North, West).

1.3 Sampling of door-to-door survey

Table 1.2
Sampling of door-to-door household survey.

Region	District	Enumeration area (EA)	Collected sample	Target sample
North	Beau Vallon (BV)	4221 (Boat house area, Mare anglaise) 4228 (Pascal Village)	20	22
	Bel Ombre (BO)	4112 (St. Roch Area) 4119 (Central 4)	19	21
Central	English River (ER)	1115 (Krishna Mart Area) 1118 (Union Vale)	20	18
	Mont Fleuri (MF)	1523 (Foret Noire, Mahé Bakery) 1531 (Mont Fleuri, Hermitage)	15	17
West	Anse Boileau (AB)	3321 (Anse Louis 1) 3323 (Anse Louis, Anse Boileau)	18	19
	Grand Anse Mahé (GM)	3418 (Ethiopie estate) 3424 (Ptl Barbarons, Part 1)	21	17
South-East	Takamaka (TA)	2510 (Quatre Borne, Police Station) 2521 (Anse Forban)	15	14
	Au Cap (AC)	2601 (Turtle Bay) 2619 (Jerusalem)	23	23
			N_{total}=151	N_{total}=151

1.4 Theoretical background and results of CE and CL

CE assumes that a respondent chooses an alternative that maximizes the respondent's utility (U). Therefore, the probability that a respondent n chooses an alternative i from j alternatives is

$$P_{ni} = \Pr(U_{ni} > U_{nj}) \quad (1)$$

Respondents' utility is a sum of two components, namely representative utility and a random component. The utility for respondent n to choose alternative i can be expressed as below.

$$U_{ni} = V_{ni} + \varepsilon_{ni} \quad (2)$$

Where U_{ni} is the respondent's utility, ε_{ni} is the random component and V_{ni} is the representative utility, which is dependent on characteristics of the alternative and characteristics of respondents. Assuming that the representative utility is a linear function of characteristics of an alternative, the representative utility can be written as follows.

$$V_{ni} = \alpha_i + \sum_{k=1}^{K} \beta_{xi} x_{kni} \quad (3)$$

Where χ_{kni} is a characteristics of alternative, α_i is an alternative-specific constant. It captures any systematic variations in choice observations that are associated with an alternative and that are not explained by the attribute variation or the observed socioeconomic characteristics of the respondents. β_{xi} is a parameter for χ_{kni}. Parameters are derived of applying maximum likelihood estimation method, which tries find a set of parameters that explain the given observation data the best.

In concrete, conditional logit model was used in our study. Assuming that the error term in equation (2) is 2 Dimensional, we defined utility function depicted in equation (3) as follows.

$$U_{ij} = \alpha + \beta_1 \cdot sort2 + \beta_2 \cdot sort3 + \beta_3 \cdot frequency5 + \beta_4 \cdot frequency7 + \beta_5 \cdot fee \quad (4)$$

Results

Results of the CL model (A variable with positive coefficient indicates that the variable contributes to respondents' utility whereas a negative coefficient indicates that the variable reduces respondents' utility. Significant coefficients are marked with two or three stars according to significance level) Pseudo $-R^2$ takes value between 0–1 and the larger value indicates higher goodness of fit. Note that pseudo $-R^2$ returns considerably smaller value than R^2 and therefore cannot be compared with each other (Domencich & McFadden 1975).

Table 1.3
Results of Choice Experiment.

Variable	Coefficient	Standard error
Sort2	0.327**	0.152
Sort3	0.868***	0.146
Frequency5	–0.086	0.147
Frequency7	0.203	0.152
Fee	–0.007***	0.001
Pseudo $-R^2$	0.061	

Note. ** Significance at 5% level, *** Significance at 1% level

1.5 Semi-structured interviews

Retails

1. General Information

Date and Time of the interview	
Place of the interview	
Who is filling out this sheet?	

2. Company's information

Name of company	
Type of company	
Address	
Name and Position of contact person	
Telephone	
Email	

3. Questions about General Waste Behaviour

How do you describe your company's waste disposal activities?	
How much waste does your company produce per week?	
Have you recorded the amount of waste produced in your company?	
-----If **yes**, has the waste production been increased over the years?	

4. Questions about Sorting Behaviour

How does your company sort waste?	
-----If they **do** sort waste	
What are the motivations? Are motivations related to public images? Since when? Why did you start sorting?	
------If they do **not** sort	
Why do not sort waste? Have you ever sorted waste in the past? Are you planning to sort in the future?	

5. Questions about Collection System

How is waste collected?	
By which company?	
How much money do you pay for collection?	
How many times are the waste collected per week?	
Are you satisfied with the collection system?	
------If **yes**, why?	
------If **no**, why?, what are the challenges? What improvements do you expect in the future?	

6. Function as a collection point

How do you think about the idea that retail shops function as a collection points?	
pros and cons?	
------If they **do,**	
How is it working? Which waste classes? Are people informed? What do you do with collected waste(selling)? What's the motivation? Do you know any other company working as collection point?	
------If they are **negative**,	
What would trigger you to function as a collection point?	
------If they are **positive**,	
How many household could you accept? What is the motivation?	

7. Government

How is government related to your company's waste behavior?	
What do you think about their current sorting system?	
Does government give any subsidies?	
------If **yes,** how does it work?	
------If **no,** Do you want them to establish any subsidie framework?	

8. Invitation for the final event

Figure 1.2
Questionnaire for the semi-structured interview for retailers.

Restaurant

1. General Information

Date and Time of the interview	
Place of the interview	
Who is filling out this sheet?	

2. Company's information

Name of company	
Type of company	
Address	
Name and Position of contact person	
Telephone	
Email	

3. Questions about General Waste Behaviour

How do you describe your company's waste disposal activities?	
How much waste does your company produce per week?	
Have you recorded the amount of waste produced in your company?	
-----If **yes**, has the waste production been increased over the years?	

4. Questions about Sorting Behaviour

How does your company sort waste?	
-----If they **do** sort waste	
What are the motivations? Are motivations related to public images? Since when? Why did you start sorting?	
------If they do **not** sort	
Why do not sort waste? Have you ever sorted waste in the past? Are you planning to sort in the future?	

5. Questions about Collection System

How is waste collected?	
By which company?	
How much money do you pay for collection?	
How many times are the waste collected per week?	
Are you satisfied with the collection system?	
------If **yes**, why?	
------If **no**, why?, what are the challenges? What improvements do you expect in the future?	

6. Function as a collection point

How do you think about the idea that hotels function as a collection points?	
pros and cons?	
------If they **do,**	
How is it working? Which waste classes? Are people informed? What do you do with collected waste(selling)? What's the motivation? Do you know any other company working as collection point?	
------If they are **negative**,	
What would trigger you to function as a collection point?	
------If they are **positive**,	
How many household could you accept? What is the motivation?	

7. Composting

Does your company compost organic waste?	
------If **yes**, What for?, How much? Where is the composted waste going to? (Do you sell it c	
------If **no**, why?	

8. Government

How is government related to your company's waste behavior?	
What do you think about their current sorting system?	
Does government give any subsidies?	
------If **yes,** how does it work?	
------If **no,** Do you want them to establish any subsidie framework?	

7. Invitation for the final event

Figure 1.3
Questionnaire for the semi-structured interview for restaurants.

1.6 Questionnaire for door-to-door household survey

Date&Time	Location				Name		
household survey							
1 What is your preferred language?	English	Creole					
WILLINGNESS TO SORT							
2 Are you willing to sort your waste?	Yes, I am sorting.	Yes, but I am not sorting.	No.				
3 Why?							
4 What do you do with your organic waste?							
5 Do you use redeem center currently in place for PET?	Yes	No	I didn't know the system				
6 Do you use redeem center currently in place for glass?	Yes	No	I didn't know the system				
7 Do you use redeem center currently in place for cans?	Yes	No	I didn't know the system				
Do you know what will happen to your waste after collection?							
8 CHOICE EXPERIMENT							
Number of the Block used	Block 1	Block 2	Block 3				
	Alternative 1	Alternative 2	Alternative 3				
Choice set A							
Choice set B							
Choice set C							
GENERAL INFORMATION							
9 Reasons for lack of implementation	I strongly disagree	I disagree	Neutral	I agree	I strongly agree	I don't know	
The plans are unrealistic							
Inefficient organizational structures							
Lack of finances							
Lack of public awareness and collaboration							
Corruption and intransparancy							
Lack of skilled labour							
Lack of political will							
10 Overall, are you happy with how waste disposal is handled in the Seychelles?	1	2	3	4	5		
10 What year were you born?							
11 What is your gender?	female	male					
12 What level of education do you have?	Primary School	Secondary School	Post-Secondary School	University			
14 How many people are in your household?							
Are you a head of household?							
15 How many people in your household are working?							
16 What is the monthly income of your household?	< 5'000 SCR	5'000 - 10'000 SCR	10'000 - 20'000 SCR	> 20'000 SCR	I don't know / I don't want to answer		

Figure 1.4
Questionnaire for door-to-door household survey.

1.7 Choice experiment

Suppose municipal government is considering to introduce a new waste collection system. The new collection system works as follows:
You bring waste to the designated collection point whenever you want to (shared with several households).All waste classes are collected every collection day.

Below you will be given various alternatives of the new waste collection system, each of which has different conditions regarding:
(a)Method of sorting: You have to sort none or several waste classes at your house
(b)Days of collection
(c)Monthly cost for your household: Each household has to pay a particular cost to maintain the system.

Please note that waste sorting reduces the amount of waste that ends up in landfills. However, the more waste classes you sort, the more space you need in your house to store them and the more time consuming sorting the waste becomes.
You will be given 3 questions, in each of which you choose one preferable alternative out of 3 alternatives. Example of a choice set is shown below.

Example	Alternative1	Alternative2	Alternative3
Method of sorting	No sorting	Cans & PET are collected separately	Cans, PET & organic are collected separately
Days of collection	Monday Wednesday & Friday	Everyday(Mon–Fri)	Everyday(Mon–Sun)
Monthly cost for your household(SCR)	0	50	100

Figure 1.5
Example of choice experiment with explanations of the choice experiment on top (used during field phase and in online survey).

Which following collection system do you prefer the most?

1st out of 3	Alternative1	Alternative2	Alternative3
Method of sorting	Cans, PET & organic are collected separately	Cans, PET & organic are collected separately	Cans, PET & organic are collected separately
Days of collection	Everyday(Mon–Sun)	Everyday(Mon–Fri)	Monday Wednesday & Friday
Monthly cost for your household(SCR)	100	0	50

Which following collection system do you prefer the most?

2nd out of 3	Alternative1	Alternative2	Alternative3
Method of sorting	Cans, PET & organic are collected separately	Cans, PET & organic are collected separately	Cans & PET are collected separately
Days of collection	Everyday(Mon–Fri)	Everyday(Mon–Sun)	Everyday(Mon–Sun)
Monthly cost for your household(SCR)	0	100	0

Which following collection system do you prefer the most?

3rd out of 3	Alternative1	Alternative2	Alternative3
Method of sorting	Cans & PET are collected separately	Cans & PET are collected separately	No sorting
Days of collection	Everyday(Mon–Sun)	Everyday(Mon–Fri)	Monday Wednesday & Friday
Monthly cost for your household(SCR)	0	50	0

Figure 1.6
Choice experiment (Block1).

Which following collection system do you prefer the most?

1st out of 3	Alternative1	Alternative2	Alternative3
Method of sorting	No sorting	Cans, PET & organic are collected separately	No sorting
Days of collection	Everyday(Mon–Sun)	Monday Wednesday & Friday	Everyday(Mon–Fri)
Monthly cost for your household(SCR)	50	50	100

Which following collection system do you prefer the most?

2nd out of 3	Alternative1	Alternative2	Alternative3
Method of sorting	No sorting	No sorting	Cans, PET & organic are collected separately
Days of collection	Monday Wednesday & Friday	Everyday(Mon–Sun)	Everyday(Mon–Sun)
Monthly cost for your household(SCR)	0	50	100

Which following collection system do you prefer the most?

3rd out of 3	Alternative1	Alternative2	Alternative3
Method of sorting	Cans & PET are collected separately	No sorting	Cans & PET are collected separately
Days of collection	Monday Wednesday & Friday	Everyday(Mon–Fri)	Everyday(Mon–Fri)
Monthly cost for your	100	100	50

Figure 1.7
Choice experiment (Block 2).

Which following collection system do you prefer the most?

1st out of 3	Alternative1	Alternative2	Alternative3
Method of sorting	No sorting	Cans & PET are collected separately	Cans, PET & organic are collected separately
Days of collection	Everyday(Mon–Fri)	Monday Wednesday & Friday	Everyday(Mon–Fri)
Monthly cost for your household(SCR)	100	100	0

Which following collection system do you prefer the most?

2nd out of 3	Alternative1	Alternative2	Alternative3
Method of sorting	Cans & PET are collected separately	Cans & PET are collected separately	No sorting
Days of collection	Everyday(Mon–Fri)	Everyday(Mon–Sun)	Everyday(Mon–Sun)
Monthly cost for your household(SCR)	50	0	50

Which following collection system do you prefer the most?

3rd out of 3	Alternative1	Alternative2	Alternative3
Method of sorting	Cans, PET & organic are collected separately	No sorting	Cans & PET are collected separately
Days of collection	Monday Wednesday & Friday	Monday Wednesday & Friday	Monday Wednesday & Friday
Monthly cost for your household(SCR)	50	0	100

Figure 1.8
Choice experiment (Block 3).

Appendix 2
Feasibility of recycling: an appraisal methodology

2.1 Expert interviews

Table 2.1
List of all interviewed experts.

Interviewee	Position/Profession	Organization/Company
Government Seychelles		
Arthur Berta	Consultant	Ministry of Environment, Energy and Climate Change (MEECC)
Private Enterprises		
Kandan Ren-gassamy	CEO	Harini & Co (Pty) Ltd.
Leeroy Ernesta	CEO	DE Recycling
Shebra		Hunt, Deltel & Co. Ltd
R.S. Naidu		Navin's Recycling Paper Industries
R. Finesse		Seychelles Breweries Ltd
R. Jothinathan Naidoo		Surya Enterprises
M. Tonner		InnoRecycling AG
K. Berchat		Seyconsulting
Mark Benoiton	Environment, Health & Safety Manager	Indian Ocean Tuna (IOT)
Consultants, scientists		
Cliff Gonzalves	Consultant	AAI Enterprise Pty Ltd
Dr. Melanie Haupt	Postdoctoral Researcher	ETH Zurich
Dr. Marco Cinelli	Postdoctoral Researcher	ETH Singapore Centre

2.2 MCDA Results

Table 2.2
MCDA: Evaluation of recycling alternatives in the national market.

			Alternatives				
Cate-gory	Criteria	Qualitative measurable	Crushed glass	Paper bags	Char-coal	Egg trays	Cardboard boxes
Waste input	How simple is the collecting and sorting of the waste for the product?	1 = not simple, 5 = simple	5.00	4.00	4.00	4.00	5.00
Waste input	Can the product be manufactured with the quality the waste after collection and sorting?	1 = quality not given, 5 = quality given	5.00	4.00	4.00	5.00	5.00
Category waste input average			**5.00**	**4.00**	**4.00**	**4.50**	**5.00**

Table 2.2
continued

Category	Criteria	Qualitative measurable	Alternatives: Crushed glass	Paper bags	Charcoal	Egg trays	Cardboard boxes
Technological aspects	Can a sufficient amount of waste be collected in Seychelles for local pre-processing of the product?	1 = not sufficient, 5 = sufficient	5.00	5.00	5.00	5.00	5.00
	How simple is the dismanteling or pre-processing of the waste input resource to manufacture the product?	1 = not simple, 5 = simple	5.00	3.00	5.00	4.00	4.00
	Are disassembly or pre-processing steps economically feasible in Seychelles?	1 = not feasible, 5 = feasible	5.00	3.00	4.00	3.00	3.00
	Is required equipment for the pre-processing of the product already available in Seychelles?	1 = not available, 5 = available	3.00	4.00	5.00	5.00	3.00
	Do input resource fluctuations have a negative influence on the processing of the product?	1 = high influence, 5 = no influence	5.00	5.00	4.00	5.00	5.00
	How easy is the technical maintainance of the processing of the product?	1 = not easy, 5 = easy	4.00	4.00	5.00	4.00	4.00
Category technological aspects average			**4.50**	**4.00**	**4.67**	**4.33**	**4.00**
National market	Is there currently a market for the product?	1 = no market, 5 = market present	5.00	3.00	5.00	4.00	5.00
	Will the market for the product remain in the long term perspective?	1 = maintenance of market unclear, 5 = maintenance of market secure	4.00	3.00	5.00	5.00	5.00
	Can the market absorb the locally processed quantity of the product?	1 = no absorbtion, 5 = full absorbtion	5.00	3.00	5.00	4.00	5.00
	Is the market demand for the product stable?	1 = not stable, 5 = stable	5.00	2.00	5.00	4.00	5.00
	Is the market price for the product stable?	1 = not stable, 5 = stable	4.00	4.00	4.00	2.00	4.00
	Have best practices in other countries with similar contexts shown financial viability of the product?	1 = no financial viability, 3 = self-sustaining, 5 = net positive benefit	5.00	3.00	4.00	5.00	4.00
Category national market average			**4.67**	**3.00**	**4.67**	**4.00**	**4.67**

Table 2.2
continued

Category	Criteria	Qualitative measurable	Crushed glass	Paper bags	Charcoal	Egg trays	Cardboard boxes
			Alternatives				
Implementation in the national market	How is the public perception of the product on the market?	1 = negative perception, 3 = neutral, 5 = positive perception	3.00	3.00	2.00	3.00	5.00
	Is the product socially accepted?	1 = not accepted, 5 = accepted	5.00	3.00	5.00	5.00	5.00
	What local experiences exist from earlier recycling projects for the product?	1 = negative, 5 = positive	2.00	2.00	3.00	5.00	4.00
	Can common retailing systems be used to distribute the product?	1 = no usage, 5 usage	5.00	5.00	5.00	5.00	4.00
	Does the product cause negative social impacts?	1 = high impact, 5 = low impact	4.00	5.00	5.00	5.00	5.00
	Does the product cause negative economic impacts?	1 = high impact, 5 = low impact	5.00	5.00	5.00	5.00	5.00
	Does the product cause negative environmental impacts?	1 = high impact, 5 = low impact	5.00	5.00	2.00	5.00	5.00
Category implementation in national Market average			**4.14**	**4.00**	**3.86**	**4.71**	**4.71**
Total average			**4.48**	**3.71**	**4.33**	**4.38**	**4.52**

Table 2.3
MCDA: Evaluation of recycling alternatives in the international market.

Category	Criteria	Qualitative measurable	Aluminium cans	Egg trays	Heavy scrap	PET flakes	Mixed light scrap	Sorted light scrap	Industrial packaging foil and PP shredded
			Alternatives						
Waste input	How simple is the collecting and sorting of the waste for the product?	1 = not simple, 5 = simple	4.00	4.00	3.00	4.00	4.00	2.00	4.00
	Can the product be manufactured with the quality the waste after collection and sorting?	1 = quality not given, 5 = quality given	5.00	5.00	4.00	3.00	4.00	4.00	5.00
Category waste input average			**4.50**	**4.50**	**3.50**	**3.50**	**4.00**	**3.00**	**4.50**

Table 2.3
continued

Category	Criteria	Qualitative measurable	Alternatives: Aluminium cans	Egg trays	Heavy scrap	PET flakes	Mixed light scrap	Sorted light scrap	Industrial packaging foil and PP shredded
Technological aspects	Can a sufficient amount of waste be collected in Seychelles for local pre-processing of the product?	1 = not sufficient, 5 = sufficient	4.00	5.00	5.00	4.00	5.00	5.00	2.00
	How simple is the dismanteling or pre-processing of the waste input resource to manufacture the product?	1 = not simple, 5 = simple	5.00	4.00	4.00	5.00	3.00	2.00	4.00
	Are disassembly or pre-processing steps economically feasible in Seychelles?	1 = not feasible, 5 = feasible	4.00	3.00	5.00	4.00	4.00	4.00	3.00
	Is required equipment for the pre-processing of the product already available in Seychelles?	1 = not available, 5 = available	4.00	5.00	5.00	5.00	5.00	5.00	4.00
	Do input resource fluctuations have a negative influence on the processing of the product?	1 = high influence, 5 = no influence	3.00	5.00	5.00	4.00	3.00	2.00	4.00
	How easy is the technical maintainance of the processing of the product?	1 = not easy, 5 = easy	5.00	4.00	5.00	5.00	5.00	5.00	4.00
Category technological aspects average			**4.17**	**4.33**	**4.83**	**4.50**	**4.17**	**3.83**	**3.50**
International market	How accessible is the international market for the product?	1 = internationl trade not accessible, 5 = international trade accessible	5.00	5.00	5.00	5.00	5.00	5.00	4.00
	Will the market for the product remain in the long term perspective?	1 = maintenance of market unclear, 5 = maintenance of market secure	5.00	4.00	5.00	2.00	5.00	5.00	2.00
	Can the market absorb the locally processed quantity of the product?	1 = no absorbtion, 5 = full absorbtion	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	Is the demand for the product stable?	1 = not stable, 5 = stable	4.00	5.00	4.00	2.00	4.00	5.00	2.00
	Is the market price for the product stable?	1 = not stable, 5 = stable	2.00	3.00	3.00	3.00	2.00	3.00	3.00

Table 2.3
continued

Category	Criteria	Qualitative measurable	Alternatives: Aluminium cans	Egg trays	Heavy scrap	PET flakes	Mixed light scrap	Sorted light scrap	Industrial packaging foil and PP shredded
International market	Have best practices in other countries with similar contexts shown financial viability of exporting the product?	1 = no financial viability, 3 = self-sustaining, 5 = net positive benefit	4.00	2.00	4.00	3.00	5.00	5.00	3.00
	Does the logistics of the product to the market represent a technical limitation?	1 = technical limitation, 5 = no technical limitation	4.00	5.00	4.00	5.00	5.00	5.00	5.00
	Does the logistics of the product to the market represent a financial limitation?	1 = financial limitation, 5 = no financial limitation	1.00	1.00	5.00	2.00	4.00	5.00	1.00
Category inational market average			**3.75**	**3.75**	**4.38**	**3.38**	**4.38**	**4.75**	**3.13**
Implementation in the international market	What experiences exist from earlier recycling projects for the product?	1 = negative,5 = positive	5.00	3.00	4.00	3.00	4.00	5.00	3.00
	Can common retailing systems be used to distribute the product?	1 = no usage,5 usage	5.00	5.00	5.00	5.00	5.00	5.00	4.00
	Does the product cause negative social impacts?	1 = high impact, 5 = low impact	4.00	5.00	3.00	4.00	2.00	2.00	5.00
	Does the product cause negative economic impacts?	1 = high impact, 5 = low impact	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	Does the product cause negative environmental impacts?	1 = high impact, 5 = low impact	4.00	5.00	5.00	3.00	3.00	3.00	5.00
Category implementation in national Market average			**4.60**	**4.60**	**4.40**	**4.00**	**3.80**	**4.00**	**4.40**
Total average			**4.14**	**4.19**	**4.43**	**3.86**	**4.14**	**4.14**	**3.67**

Table 2.4
MCDA: total average score of recycling potential per categories in the national market.

National market	Crushed glass	Paper bags	Char-coal	Egg trays	Cardboard boxes
Waste input	5.00	4.00	4.00	4.50	5.00
Technological Aspects	4.50	4.00	4.67	4.33	4.00
National Market	4.67	3.00	4.67	4.00	4.67
Implementation in national market	4.14	4.00	3.86	4.71	4.71
Total average	**4.48**	**3.71**	**4.33**	**4.38**	**4.52**

Table 2.5
MCDA: total average score of recycling potential per categories in the international market.

National market	Alumini-um cans	Egg trays	Heavy scrap	PET flakes	Mixed light scrap	Sorted light scrap	Shred-ded plastic
Waste input	5.00	4.00	4.00	4.50		5.00	
Technological Aspects	4.50	4.00	4.67	4.33		4.00	
International Market	4.67	3.00	4.67	4.00		4.67	
Implementation in international market	4.14	4.00	3.86	4.71		4.71	
Total average	**4.48**	**3.71**	**4.33**	**4.38**		**4.52**	

2.3 Interviews

Questionnaire for interview in connection with pet recycling

- Why did you start in the business of PET recycling?
- What quality issues have occurred in the past? How did you overcome them?
- What are the biggest challenges in your daily business?
- Technological/Technical challenges in the process of PET Recycling?
- What regulatory policy would help you?
- Consistency of PET input given? and impacts?
- Do you see any alternatives to the Export of PET?
  (If yes → questions on Implementation (Social Restrictions etc.))
- How is the demand and the price in the international market? Stable?
- Are there any financial problems that you see in PET recycling? Shipping costs etc.
- Did you ever consider other plastics (PE, PP, PS) than PET? Why not?
- Are local NGOs working in plastic related fields here in SEY?
  What are they doing? How do they help your business?
- In your opinion, why do not more people start a recycling business?

Questionnaire for interview in connection with redeem centers

- Why did you start the Recycling business? Tell us your story
- What problems do you face with the quality of the aluminium of the cans you receive? What quality requests your buyer?
- What kind of aluminium waste do you process? Considera-tion of other aluminium wastes? Why yes/ why not
- How do you manage times of higher or lower supply of aluminium?
- In your daily business what technical challenges do you face? Are there technical issues that could be improved? (more, better equipment)
- How is your collaboration with the government?
- What obstacles and regulations restrict your business?
- How did you find your international buyer from India?

- If you have a container full, can you describe how you proceed? (description of fixing the price, quantity, quality, delivery date)
- How do you manage higher or lower demand for your products?
- What financial challenges are involved in your process? (Shipping costs)
- Can you explain your Energy costs of production and maintenance of equipment? (complexity, frequency, knowledge required)
- How do the Seychellois think of your business of exporting Alu bars? Is it well seen what you do? Do they value your work? (Public Perception)
- Do you see opportunities to recycle aluminium fully nationally in Seychelles to e.g. new cans? Why not?
- In your opinion, why do not more people start a recycling business?
- If you are primary minister tomorrow, what would you change first in the waste management system? Explain why?

Questionnaire for interview in connection with paper recycling

- How quality does gets ensured?
- How does the waste paper get collected and sorted?
- How is the waste paper stored?
- Is energy cost high to recycle the paper?
- Have you ever thought about exporting your products?
- Have you ever thought of other end products apart from egg trays?
- What happens if you have too much paper coming in??? Where do you store it?
- Is there social barriers when distributing your product to the local market?
- Did you ever collaborate in a way with the GOV?
- What are the challenges that you face?
- How do you feel about your business in general?

Questionnaire for interview in connection with glass recycling

- In your daily business what technical challenges do you face?
- Are there technical issues that could be improved?
- Do you get any governmental support for the reusing of the bottles?
- Do you see options for recycling the glass bottles in Seychelles? (melting, crushing)
- Would exporting the waste glass be an option financially and technically?
- What are Seychellois perspective on reusing the bottles?
- Is it known and appreciated?
- Is the energy consumption high?
- Are the incentives to bring back the bottles on all the bottles that they produce?
- What do you do with the damage glass?

Questionnaire for interview in connection with charcoal

- So how does the charcoal industry works?
- What type of materials do you burn to get the charcoal as the final product?
- Is there a request for specific types of materials that you burn to get a better charcoal quality?
- What are the challenges that you face?
- Is there a limit to what you can store? If yes what happens if there is excess income?
- Have you ever considered using wooden pallets to produce charcoal? If Yes how? If no why?
- Do you collaborate with the Government?
- What kind of collaboration do you have with the government?
- Who decides on who get the machine?
- How does your company collaborate with the other two companies?
- Is the market for the charcoal stable?
- Is there any social challenges when selling to the local market? Price? Quality?
- How does the national shipping work?
- Is the income of materials to produce charcoals constant?
- In your opinion why do you think more people doesn't venture in the recycling business?
- What got you started in the charcoal/bio-char business?

Questionnaire for interview in connection with scrap metal

- Why did you get started in the recycling business?
- What problems do you face with the quality of the scrap metal?
- Do you accept all scrap metal that you receive?
- Is there a collection system?
- How is the scrap metal stored? Storage capacity?
- How do you dismantle and separate the metals? And, what are the challenges?
- What obstacles and regulations restrict your business?
- Is the necessary technology for the processing available?
- How do you handle hazardous parts? Are there environmental concerns?
- How do you manage times of higher or lower supply of scrap metal?
- Is the demand and the price in the international market stable?
- Formalities and costs at the port for shipping?
- Are there any financial constraints such as shipping costs?
- What are the costs of production (energy) and maintenance of equipment?
- Have you received support from the government for your recycling effort?
- In your opinion, why do not more people start a recycling business?

Questionnaire for interview with LWMA

- What type of landfill cover do you use?
- Do you have any contact to the Port Authority?
- How do you estimate the potential for Seychelles to recycle waste paper/cardboard to new cardboard boxes?

Questionnaire for interview with MEECC

- How does the Waste management system work in la Reunion?
- How does the system of subsidies here work (Aluminium gets some, Pet not, there are contract) how is the communication?
- What obstacles and barriers do you see for recycling business' in Seychelles?
- Did you ever hear of waste derived fuel pellets for cement industries? What do you think about it?
- What secondary products do you see potential in recycling?
- How do you think can the government improve the support to ensure market access for recycling products to create incentives?

Questionnaire for interview in connection with shipping

- What are restriction and barriers for recyclers?
- Are there products that cannot be shipped?
- How is the process when someone wants to ship their goods? (Administration) Small vs. Large businesses?
- IOT with regular shipping vs. only a few containers – differences in administration?
- Do you have any export data?
- How stable are the shipping prices?
- Is the Port from the Government? If not, how does the collaboration work?
- How do you estimate the potential of shipping recycling waste?
- We heard about the idea of joint shipping. What is your opinion?
- How much does a container cost? To India etc.
- What influences the costs?
- How much in advance do you have to book the container?
- Do recycling goods have special regulations?

Appendix 3 Hazardous waste: Material flows

3.1 Expert interviews

Table 3.1
List of all interviewed experts.

Person interviewed	Function	Institution
Fredrick Kinloch	Director waste management	Ministry of Environment, Energy and Climate Change (MEECC)
Michelle Azemia	Quality and Standards Officer	
Lemmy Payet	Consultant	Landscape Waste Management Agency (LWMA)
Franky Laporte	Project Manager	Seychelles Ports Authority (SPA)
David Bianchi	Director for Strategies	
Sarah Romain	Commercial Manager	Seypec
Eric Frost	Airport Manager Terminal and Landside Operation	Seychelles Civil Aviation Authority (SCAA)
Rajiv Gowessoo	CEO	Samlo and Sons
R. Jothinathan Naidoo	CEO	Surya Enterprises
Elvis Frederick		Public Utilities Corporation Ltd. (PUC)
Robert Rose		RMP Engineering
Branda Rath	Manager Hospital Support Services	Ministry of Health / Health Care Agency
Mr. Weli		
Samuel Brutus	Senior Biosecurity Officer	Biosecurity Agency

3.2. Hazardous Waste classification used for this study

Table 3.2
Hazardous Waste classification .

Category	Sub-categories
Chemical Waste	1. Pharmaceutical products, drugs and medicines 2. Biocides & phytopharmaceuticals 3. Organic solvents 4. Waste from heat treatment and tempering operations containing cyanide 5. Waste from the production of inks, dyes, varnish, paints, pigments and lacquers 6. Wastes from production of resins, glues/adhesives, plasticizers 7. Photographic chemicals 8. Wood preserving chemicals
Waste Oils	1. Engine oils 2. Other waste oils and oil emulsions 3. Cooking oils
Clinical Waste	1. Pathological waste 2. Radioactive waste 3. Contaminated material (sharps, glassware, plastics, metals etc.)
Batteries	1. Vehicle batteries 2. Household batteries
Tires	1. Car tires 2. Special tires

3.3 Questionnaire on HW distributed during the field phase

Seychelles Hazardous Waste Assessment
– Solid Waste Management Case Study, ETH Zürich & UniSey

Company Details:
Please specify the name and/or type of your company. We would like to remind you that this information will be kept confidential.

	Category	Average annual disposal	Type of disposal
Left-over, excess & used chemicals	Pharmaceutical products, drugs and medicines (e.g. antipsychotics, antibiotics, hormones, cardiac, sulfonamides)	o Not disposed o < 1kg o 1 - 10 kg o 10 - 100 kg o 100 - 1000 kg o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Biocides & phytopharmaceuticals (e.g. pesticides, herbicides, plant growth regulators, preservatives, antiparasitic agents)	o Not disposed o < 1 L o 1-5 L o 5-50 L o 50 - 100 L o 100 - 250 L o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Organic solvents (e.g. acetone, methanol, isopropyl alcohol, toluene)	o Not disposed o < 1 L o 1-5 L o 5-50 L o 50 - 100 L o 100 - 250 L o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Residues of heat treatment and tempering operations containing cyanide	o Not disposed o < 1 L o 1-5 L o 5-50 L o 50 L + o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Inks, dyes, varnish, paints, pigments	o Not disposed o < 1 L o 1-5 L o 5-50 L o 5 – 100 L o 100 – 250 L o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Raisins, glues/adhesives, plasticisers	o Not disposed o < 1 L o 1-5 L o 5-50 L o 50 - 100 L o 100 - 250 L o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Photographic chemicals	o Not disposed o < 1 L o 1-5 L o 5-50 L	o Normal mixed waste o Incinerator • power station • airport

Figure 3.1
Questionnaire on hazardous waste.

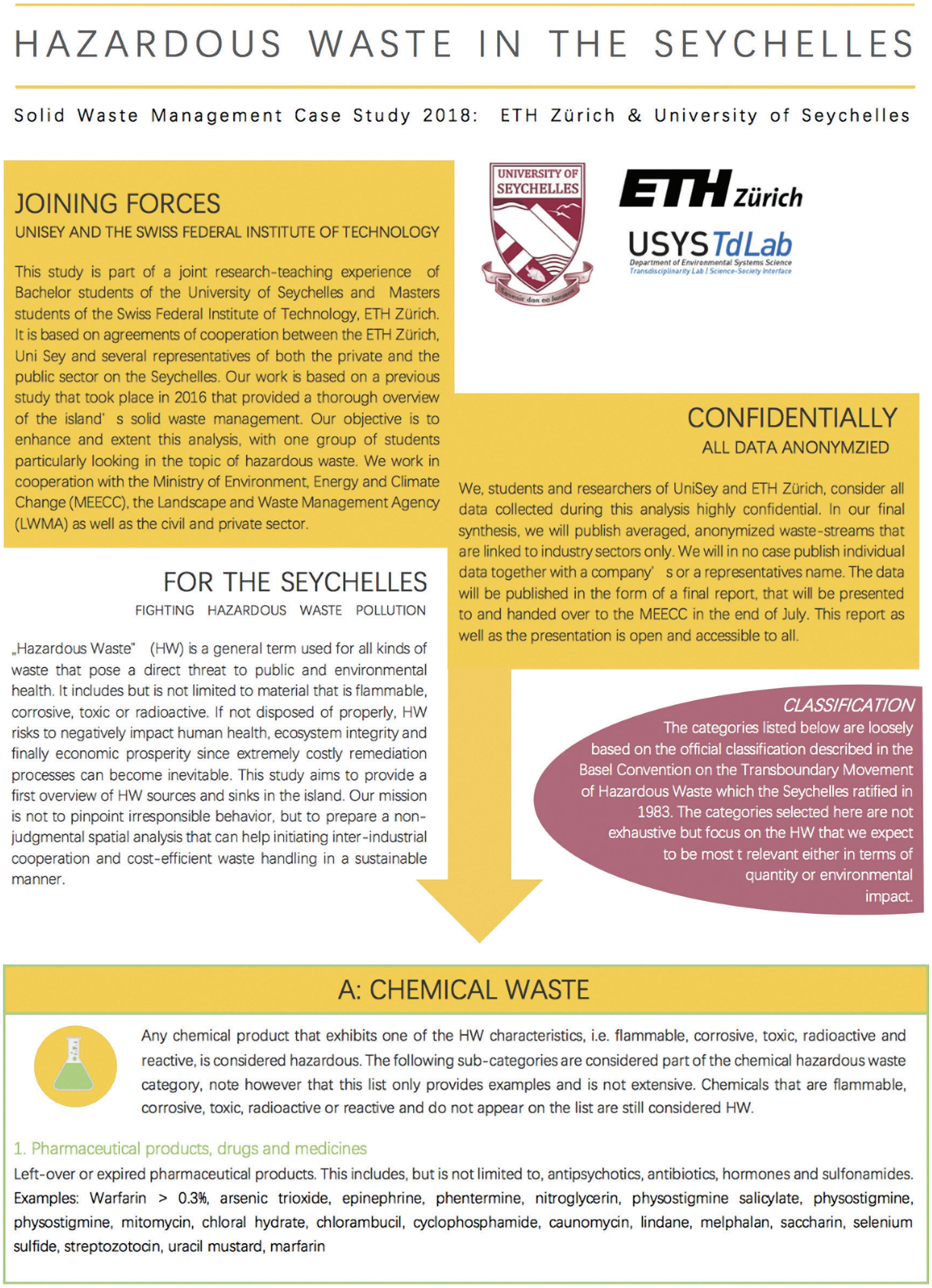
		o 50 - 100 L o 100 - 250 L o Other:	• port of Victoria o Other:
	Wood preserving chemicals	o Not disposed o < 1 L o 1-5 L o 5-50 L o 50 - 100 L o 100 - 250 L o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Others (please specify):	o Not disposed o < 1 L o 1-5 L o 5-50 L o 50 - 100 L o 100 - 250 L o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
Waste oils, emulsions* (Please note in case your oils are subject to special contamination)	Engine oils	o Not disposed o < 10 L o 10 - 100 L o 100 - 1,000 L o 1,000 - 10,000 L o 10,000-100,000 L o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Other waste oils and oil emulsions	o Not disposed o < 10 L o 10 - 100 L o 100 - 1,000 L o 1,000 - 10,000 L o 10,000-100,000 L o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Cooking oils	o Not disposed o < 10 L o 10 - 100 L o 100 - 1,000 L o 1,000 - 10,000 L o 10,000-100,000 L o Other:	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
Clinical wastes (from medical care in hospitals, medical centres and clinics)	Pathological waste	o Not disposed o < 1 kg o 1-50 kg o 50 - 100 kg o >100 kg o Other	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Radioactive waste	o Not disposed o < 1g o 1-10g o 10-100g o >100g	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Contaminated material (sharps, glassware, plastics, metals etc.)	o Not disposed o < 1 kg o 1-50 kg	o Normal mixed waste o Incinerator • power station

Figure 3.1
continued

		o 50 - 100 kg o 1000 – 10000 kg o >10.000 kg	• airport • port of Victoria o Other:
	Other (please specify):	o Not disposed o < 1 kg o 1-50 kg o 50 - 100 kg o 1000 – 10000 kg >10.000 kg	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
Batteries	Vehicle batteries (please specify)	o Not disposed o 1 o 2-3 pieces o 4-5 piecs o 6-10 pieces o > 10 pieces	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Household batteries (e.g. AA; 9V-block)	o Not disposed o 1-5 pieces o 5 – 20 pieces o 20 – 50 pieces o >50 pieces	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
Waste tyres	Car tyres	o Not disposed o 1-4 tyres o 5-8 tyres o 9-16 tyres o 17-30 tyres o Other	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:
	Special tyres	o Not disposed o 1-4 tyres o 5-8 tyres o 9-16 tyres o 17-30 tyres o Other	o Normal mixed waste o Incinerator • power station • airport • port of Victoria o Other:

Figure 3.1
continued

3.4 Information Sheet handed out with questionnaire



HAZARDOUS WASTE IN THE SEYCHELLES

Solid Waste Management Case Study 2018: ETH Zürich & University of Seychelles

JOINING FORCES

UNISEY AND THE SWISS FEDERAL INSTITUTE OF TECHNOLOGY

This study is part of a joint research-teaching experience of Bachelor students of the University of Seychelles and Masters students of the Swiss Federal Institute of Technology, ETH Zürich. It is based on agreements of cooperation between the ETH Zürich, Uni Sey and several representatives of both the private and the public sector on the Seychelles. Our work is based on a previous study that took place in 2016 that provided a thorough overview of the island' s solid waste management. Our objective is to enhance and extent this analysis, with one group of students particularly looking in the topic of hazardous waste. We work in cooperation with the Ministry of Environment, Energy and Climate Change (MEECC), the Landscape and Waste Management Agency (LWMA) as well as the civil and private sector.

UNIVERSITY OF SEYCHELLES

ETH Zürich

USYS TdLab

Department of Environmental Systems Science

Transdisciplinarity Lab | Science-Society Interface

CONFIDENTIALLY

ALL DATA ANONYMZIED

We, students and researchers of UniSey and ETH Zürich, consider all data collected during this analysis highly confidential. In our final synthesis, we will publish averaged, anonymized waste-streams that are linked to industry sectors only. We will in no case publish individual data together with a company' s or a representatives name. The data will be published in the form of a final report, that will be presented to and handed over to the MEECC in the end of July. This report as well as the presentation is open and accessible to all.

FOR THE SEYCHELLES

FIGHTING HAZARDOUS WASTE POLLUTION

„Hazardous Waste" (HW) is a general term used for all kinds of waste that pose a direct threat to public and environmental health. It includes but is not limited to material that is flammable, corrosive, toxic or radioactive. If not disposed of properly, HW risks to negatively impact human health, ecosystem integrity and finally economic prosperity since extremely costly remediation processes can become inevitable. This study aims to provide a first overview of HW sources and sinks in the island. Our mission is not to pinpoint irresponsible behavior, but to prepare a non-judgmental spatial analysis that can help initiating inter-industrial cooperation and cost-efficient waste handling in a sustainable manner.

CLASSIFICATION

The categories listed below are loosely based on the official classification described in the Basel Convention on the Transboundary Movement of Hazardous Waste which the Seychelles ratified in 1983. The categories selected here are not exhaustive but focus on the HW that we expect to be most t relevant either in terms of quantity or environmental impact.

A: CHEMICAL WASTE

Any chemical product that exhibits one of the HW characteristics, i.e. flammable, corrosive, toxic, radioactive and reactive, is considered hazardous. The following sub-categories are considered part of the chemical hazardous waste category, note however that this list only provides examples and is not extensive. Chemicals that are flammable, corrosive, toxic, radioactive or reactive and do not appear on the list are still considered HW.

1. Pharmaceutical products, drugs and medicines

Left-over or expired pharmaceutical products. This includes, but is not limited to, antipsychotics, antibiotics, hormones and sulfonamides. Examples: Warfarin > 0.3%, arsenic trioxide, epinephrine, phentermine, nitroglycerin, physostigmine salicylate, physostigmine, physostigmine, mitomycin, chloral hydrate, chlorambucil, cyclophosphamide, caunomycin, lindane, melphalan, saccharin, selenium sulfide, streptozotocin, uracil mustard, marfarin

Figure 3.2
Information Sheet handed out with questionnaire.

A: CHEMICAL WASTE

2. Biocides & phytopharmaceuticals

A biocide is a product that destroys, renders harmless or prevents the action of any harmful organism by biological or chemical means. The following are examples of products that are considered biocides: disinfectants, preservatives, antiseptics, pesticides, herbicides, fungicides, antifouling agents (e.g. for boats) and insecticides.

3. Organic solvents

Organic solvents are a large group of chemicals that is defined by their ability to dissolve non-water-soluble materials such as oils, resins, plastic materials etc. They are mainly used as cleaning agents, as raw material or feedstock in the production and manufacture of other substances and as a carrying/dispersion medium in chemical synthetic processes. Many, but not all, organic solvents are classified as HW. Note that halogenated solvents should always be kept apart from non-halogenated ones, since they are not acceptable for common incineration. Examples of organic solvent HW include halogenated (Cl, I, Br, F) hydrocarbons, toluene, methyl ethyl ketone, acetone, xylene, methanol, carbon disulfide, isobutanol, pyridine, benzene, 2-ethoxyethanol and 2-nitropropane.

4. Heat treatment and tempering operations containing cyanide

Wastes occurring during the heat treatment of metal workpieces can be hazardous. Generally speaking, the heating operations of stress relieving, austenitizing, and tempering do not generate hazardous waste, the furnace lining created can be disposed off as non-HW waste. On the other hand, the salt baths in liquid carburizing, liquid nitriding, and liquid cyaniding processes (typically containing molten sodium, potassium, cyanide and cyanate salts) are considered hazardous when spent. The media (oil or water baths) used for quenching material after heat treatment is also considered hazardous, since it commonly gets contaminated with cyanide. Lastly, salts containing barium compounds used in high temperature applications such as hardening high speed steel, hot work steels, and other air hardening tool steels are considered HW.

5. Waste from the production of inks, dyes, varnish, paints, pigments and lacquers

Wastes from the production of certain dyes, pigments, cosmetic colorants etc. are considered hazardous under the Basel Convention and the Environmental Protection Agency of the United States (EPA). These could for example be wastewater treatment sludges, filtering cakes, dust collector fines and still bottoms. Critical constituents rendering these materials hazardous are aniline, o-anisidine, 4-chloroaniline, p-cresidine, 1,2-phenylenediamine, 1,3-phenylenediamine and 2,4-dimethylaniline.

6. Wastes from production of resins, glues/adhesives, plasticizers

The production of resins, glues/adhesives and plastic materials can involve large amounts of substances that are classified as hazardous. In plastic production for examples, common hazardous additives are sodium hydroxide, carbon disulfide and chlorine.
Examples: organic halogenated solvents, aqueous washing liquids, waste plastic, (halogenated) still bottoms and reaction residues, (halogenated) filter cakes and spent absorbents, sludges from on-site effluent treatment containing hazardous substances.

7. Photographic chemicals

This category involves all hazardous chemicals encountered in a photographic darkroom.

- Developer solutions and powders. Some common ingredients in developers are: hydroquinone, sodium sulfite, monomethyl para-aminophenol sulfate and phenidone
- Stop baths. Common ingredients: acetic acid and potassium chrome alum
- Fixers. Common ingredients: sodium thiosulfate, sodium sulfite, sodium bisulfite, potassium aluminum sulfate and boric acid
- Hypo eliminators. Common ingredients: hydrogen peroxide, ammonia, potassium permanganate, bleaches and potassium persulfate
- Intensifiers. Common ingredients: hydrochloric acid, potassium dichromate or potassium chloromate
- Reducer. Common ingredients: potassium ferricyanide and hypo eliminators, Toners
- Hardener. Common ingredient: formaldehyde

8. Wood preserving chemicals

The wood preserving chemicals are the chemical products that control wood degradation which occurs due to fungal decay, wood destroying insects, molds or sapstain. Major hazardous wood preserving chemicals are: chromated arsenicals (CCA), pentachlorophenol (PCP) and creosote.

Figure 3.2
continued

B: WASTE OILS AND OIL EMULSIONS

The term waste oil is a generic term used to describe any petroleum-based or synthetic oil that through contamination has become unsuitable for its original purpose. In case this waste oil is contaminated with hazardous waste, it is itself considered as being hazardous waste and thus must be managed according to hazardous waste management standards.

1. Engine oils
Hydraulic oil, transmission oil, brake fluid, motor oil, crankcase oils, gearbox oil

2. Other waste oils and oil emulsions
Rosin oil, disperse oil, grease and oil mixture from oil/water separation, antifreeze fluids, vegetable oil, fuels (diesel, benzene)

C: CLINICAL WASTE

This includes all waste arising from medical, nursing, dental, veterinary, or similar practices, and wastes generated in hospitals or other facilities during the investigation or treatment of patients, or research projects. This type of waste is generated by health-care establishments, research facilities, laboratories and households (i.e. in the course of health care undertaken in the home, e.g. insulin injections etc.).

1. Pathological waste
Human tissues, organs or fluids, body parts and contaminated animal carcasses. Also included are cultures and stocks of infectious agents from laboratory work (e.g. waste from autopsies and infected animals from laboratories).

2. Radioactive waste
All products contaminated by radionuclides including radioactive diagnostic material or radiotherapeutic materials.

3. Contaminated material (sharps, glassware, plastics, metals etc.)
This category includes material such as syringes, needles, disposable scalpels and blades that are contaminated with blood and other bodily fluids (e.g. from discarded diagnostic samples) or waste from patients with infections (e.g. swabs, bandages and disposable medical devices).

D: BATTERIES

Many types of batteries employ toxic, flammable and/or corrosive materials such as lead, mercury, cadmium, nickel, lithium or sulfuric acid as an electrode or electrolyte. Cadmium and nickel are for instance known carcinogens while lead has been linked to birth defects and to neurological and developmental damage. Lithium in contrast is volatile and might cause landfill fires.
If leakage occurs (e.g. through corrosion or physical damage) these hazardous chemicals will be released into the environment where they might cause serious harms to organisms and ultimately also to human beings.

1. Vehicle batteries
(Valve-regulated) Lead-acid / SLI / Deep cycle / Wet-cell / Lithium-ion batteries

2. Household batteries

- Primary/non-rechargeable batteries (e.g. Alkaline / Aluminum-air / Atomic batteries/ Lithium / Nickel oxyhydroxide / Nickel-zinc batteries and voltaic pile)
- Secondary/rechargeable batteries (e.g. Flow batteries / Lead-acid / Lithium-ion / Nickel-cadmium / Nickel metal hydride

E: TIRES

According to the Basel Convention waste tires are generally not considered to be "hazardous waste" . In certain cases, however, scrap tires may be contaminated with hazardous materials (oils etc.) and in such cases should be treated as hazardous. Moreover, when stored in large quantities they can present a fire hazard or can harbour disease vectors such as mosquitos and vermin.

1. Car tires
High performance/ Summer / Winter / All season / Mud/ All terrain / Highway terrain / Highway luxury / Caravan tires

2. Special tires
Heavy duty (also referred to as Bus/Truck)/ Off-the road (e.g. wheel loaders, backhoes, graders, trenchers, airplanes, mining vehicles or forestry machinery) / Agriculture (e.g. tractor or harvester) / Off-road floatation (e.g. off-road vehicles in mud, sand, deep snow, high flotation)/ Racing tires

?

Questions? Do you have questions concerning your particular waste, waste management on the Seychelles in general or on the ETH Zürich/Uni Sey Solid Waste Management Case study?
Please do not hesitate to contact us at **ethzuerich.casestudy@gmail.com**

Figure 3.2
continued

3.5 List of companies from which data was analysed

Table 3.2
List of companies. [S] represents the data collected from the survey, [P] are data extracted from the HW permits and [H] represents the companies listed in the hospital incinerator database

Medical & Beauty	Management & Education	Automotive & Construction	Transport	Manufacture of consumables	Retail & Print
Panafricare Clinic[S]	ABC International[S]	The Pit shop (airport)[S]	Landmarine Limited[S]	Indian Fishing Marine[S]	Grocers supermarkets Pty Ltd.[S]
Beauty Salon Anse Royal[S]	Eden Resort VMA[S]	Anse Royal Petrol Station[S]	Air Seychelles Technical Part[S]	Fishtech Pty. Ltd.[S]	Xpress Printing[S]
Anse Royal Pharmacy[S]	Ascent Project[S]	Dinesh Auto Parts[S]	Air Seychelles Cargo Part[S]	Oceana fisheries[S]	Dulux Paint Centre[S]
Central Point Pharmacy[S]	Intercontinental Trust Ltd.[S]	Club Cars and tropical store[S]	DHL[S]	Ferox Feed[S]	Body and Paint Shop[S]
Sunkissed Hair Salon[S]	National Information Service Agency[S]	Joining Workshop[S]	MSM Sewage[S]	Seybrew[S]	Madeleine Store[S]
P.S.M. Medical Health Centre[S]	World health organisation[S]	SF Hybrid Motors[S]	SPTC[S]	IOT[P]	Hardware Store[S]
Vision Care[S]	Four Seasons Hotel[P]	CSYIC Construction[S]	Taylor Smith Shipyard[S]	Oceana Fisheries[P]	Bluesky Trading Pty.[S]
Dental Services[S]	North Island Company[P]	Sey. Electr. Maritime Co. Ltd.[S]	AirSeychelles[P]		Paint World (Providence)[S]
Quincy Pharmacy[S]	Seychelles Bureau of Standards[H]	Seychelles Institute of Tech.[S]	Tornado Company[P]		Paint World (Mont Fleuri)[S]
English River Hospital[S]	Seychelles Bureau of Standards (Department I)[S]	Sun Motors[S]	Hamamoti Sapmore, Aquarius[P]		Penlac Company Limited[S]
Jivan's clinic (le chantier health services) (good health pharmacy)[S]	Seychelles Bureau of Standards (Department II)[S]	MNM Builders Centre[S]	Aquarius Shipping[P]		Lenso World[S]
Eden Pharmacy[S]	Seychelles Fishing Authority[S]	Mahe Autoport Industry[S]			Max Meyer Auto Parts[S]

Table 3.2
continued

Medical & Beauty	Management & Education	Automotive & Construction	Transport	Manufacture of consumables	Retail & Print
Victoria Hospital[S]	Red Cross Society[P]	Electro vehicles[S]			Aluminium and Granite[S]
Doffay Pharmacy[S&P]		Renault motor providence (Henri Fraise)[S]			DIY Seychelles[P]
Navaloka Hospital[H]		Seychelles Fire and Rescue Service Agency[S]			Printon Agency[P]
Mail Master[H]		Seychelles Petroleum Company Limited[S&P]			National Information Services Agency[S&P]
Uri Smile Dental[H]		KIA motors[S]			Aaron Store[P]
German Dental Clinic[H]		Toyota[S]			SBC Hermitage[P]
Eureka Clinics[S]		Shreeji[S]			Penlac[P]
VMK Medical Enterprises[P]		Autoland automobile company[S]			
Smile Dent[H]		Curite (Andre Sauzier)[S]			
Renaisance Dyalysis[H]		Tuffliners[S]			
		Hyundai[S]			
		Victoria South Petrol[S]			
		Marine and Engineering[S]			
		PUC[S&P]			
		Island Development Company[P]			
		Glerible Maintenenance Services[P]			

Appendix 4
Waste treatment I: Anaerobic digestion

4.1 Expert interviews

Table 4.1
List of all interviewed experts.

Interviewee	Position/profession	Organization/company
Governmental Seychelles		
Lemmy Payet	Consultant	Landscape Waste Management Agency (LWMA)
Helena De Letourdis	Deputy CEO	National Bureau of Statistics (NBS)
Frankie Dupres	Wastewater Engineer	Public Utilities Corporation Ltd. (PUC)
Henry Leste	Wastewater Plant Operator	
Gretelle Isaac	Agricultural Statistician	Seychelles Agricultural Agency (SAA)
Mr. Berne		
Tony Imaduwa	CEO	Seychelles Energy Commission (SEC)
Guilly Moustache	Principal Officer	
Cynthia Alexander	Principal Officer	
Aubrey Lesperance	Principal Aquaculture Officer	Seychelles Fishing Authority (SFA)
Pat Matyot		Seychelles Broadcasting Agency (SBA)
Hotels		
Helen Fay	Learning Manager	Four Seasons Resort
Jacqueline Golding	Duty Manager	Banyan Tree Resort
Gwenaël Briat		
Vishal Bhagerutty	Food & Beverage Manager	Berjaya Beauvallon Bay Resort
Mr. Samriddha	Food & Beverage Manager	Coral Strand Hotel
Manuel Policarpo	General Manager	Eden Bleu
Morias Kufa	Associated Food & Beverage Manager	
Dhanushika Ariyaratne	Pers. Assistant to General Manager	Kempinski Seychelles Resort

Table 4.1
List of all interviewed experts.

Interviewee	Position/profession	Organization/company
Private Enterprises (others)		
Guynemer Corgat	Owner	Fresh Way Farm
Jose Pool	Owner	Jojo's Farm
Herve Morin-Adeline	Managing Director	Ferox Feed
Mark Benoiton	Environment, Health & Safety Manager	IOT
Lekha Nair		Seychelles Pension Fund
Sarah Romain	Commercial Manager	Seypec
Research institutions		
Prof. Dr. Christian Zurbrügg	Head of Sandec	EAWAG, Switzerland
Dr. Melanie Haupt	Postdoctoral Researcher	ETH Zurich
Prof. Dr. Urs Baier		ZHAW, Switzerland
Other organisations		
Diana Körner	Sustainable Tourism Consultant	Seychelles Sustainable Tourism Foundation

4.2 Anaerobic digestion

As the input determines the quality of the output, it is important to know its composition. Scientifically, input is called feedstock material or substrate. Substrate for AD plants often consist of vegetable and fruit wastes, meat and fish waste, sewage sludge and animal manure. These residues largely consists of water. The rest is dry matter and is called "Total Solids" (TS). The TS in turn consists of an inorganic and an organic share. Only the organic biodegradable fraction contributes to the biogas production. This fraction is called "Volatile Solids" (VS) and consists of proteins, carbohydrates and lipids (see Figure 4.1).

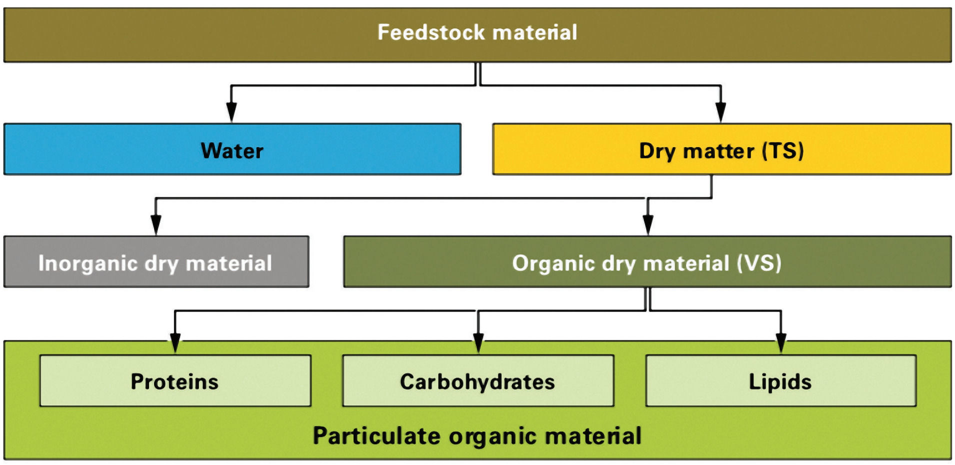


Figure 4.1
Classification of feedstock material (Vögeli, Lohri, Gallardo, Diener, & Zurbrügg, 2014).

The TS and VS values can be obtained from the literature which, however, contains diverging information. Nevertheless, these values are helpful towards gaining a rough feeling for the order of magnitude (see Table 4.2 as an example to calculate the biogas yield). Usually, substrates with a VS content of the TS below 60 % are not considered as valuable substrates for AD.

Table 4.2
Biogas Calculation example (Vögeli, Lohri, Gallardo, Diener, & Zurbrügg, 2014).

	Substrate	TS	VS	Methane yield
	Vegetable waste	5–20 % of raw waste	76–90 % of TS	0.42 m^3/kg VS
Example	1,000 kg	50–200 kg	38–180 kg	15.96–75.6 m^3

The quality of the produced biogas depends not only on the VS content of the substrate, but also on the temperature and mixing conditions during the process. To estimate the biogas yield, we used values that are characteristic for the biological methane potential (BMP). BMP describes the maximum possible volume of methane gas that can be produced per unit mass of solid or volatile solid matter. The average methane yield of municipal solid waste (MSW) is between 0.36 and 0.53 m^3/kg VS (Vögeli, Lohri, Gallardo, Diener, & Zurbrügg, 2014).

In detail, the anaerobic digestion process for biogas production includes four metabolical steps (see Figure 4.2.

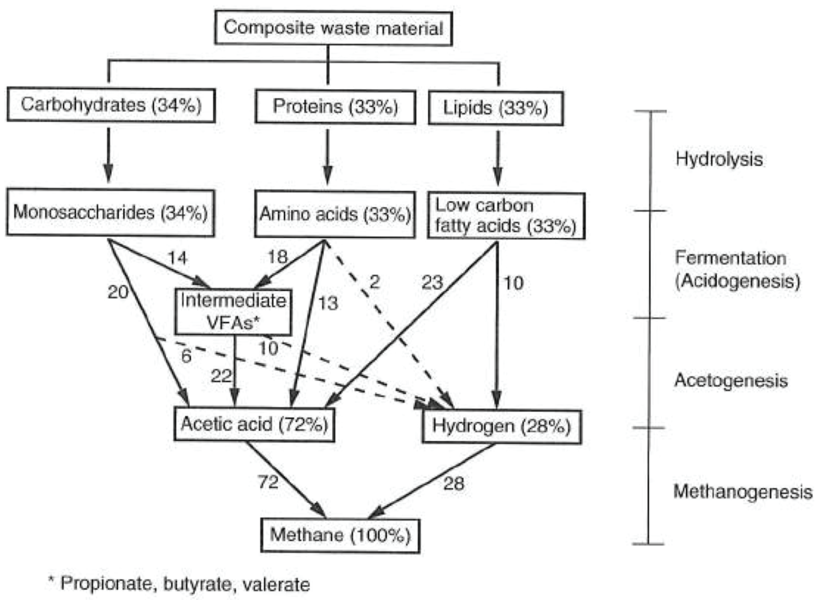


Figure 4.2
Anaerobic Digestion Process (Metcalf & Eddy, 2013).

Hydrolysis

Bacteria transform the incoming proteins, carbohydrates, and lipids into monomers and polymers: Amino acids, monosaccharides and fatty acids.

Fermentation (Acidogenesis)

The products from hydrolysis are converted to ethanol and acids (propionate and butyrate), acetate, H_2 and CO_2. The degradation of amino acids also leads to the production of ammonia.

Acetogenesis

Long chain fatty acids, volatile fatty acids, and alcohols are transformed into hydrogen, CO_2 and acetic acid. During this stage, the biological oxygen demand (BOD) and the chemical oxygen demand (COD) are reduced, both parameters of which indicate the degree of pollution.

Methanogenesis

This is the final stage, where hydrogen and acetic acid are converted to methane gas (CH_4). This can be achieved from two different groups of organisms. The first one splits acetate (CH_3COOH) into methane and carbon dioxide (CO_2). The second group uses hydrogen as electron donor and CO_2 as an electron acceptor to produce CH_4 (Metcalf & Eddy, 2013).

In the first group, the ratio of the biogas (CH_4:CO_2) is usually in the range 50:50 to 60:40. The higher the fat content of the substrate, the higher the biogas fraction (Morgenroth, 2017). Next to the main two gaseous products CH_4 and CO_2, biogas contains several other gaseous "impurities" such as hydrogen sulphide, nitrogen, oxygen and hydrogen. The higher the CH4 content, the higher the energy value of the biogas (Vögeli, Lohri, Gallardo, Diener, & Zurbrügg, 2014).

There are several ways to use the produced biogas. A very common practice in developing countries, where the plant is small-scale and fed by and connected to several households, is the direct usage as cooking gas. If this is not the case, i.e. when the plant is big-scale and commercial, the biogas needs further processing. If the methane should be used as natural gas, the biogas needs "Upgrading", meaning that that the methane fraction is concentrated to more than 90 % methane content.

If the aim is to produce electricity, the combined heat and power (CHP) technology is the most common applied technology. Please see chapter 'Combined heat and power' for further explanations.

During the whole process, heat is produced. The other product, next to the biogas, is the digestate. The AD process does not remove nitrogen nor phosphorus, hence, the digestate is sludgy, rich in nitrogen and phosphorus, and it also contains potassium. It is therefore a good fertilizer. However, it should not be directly applied to plants due to hygienic reasons (pathogens) and may therefore require aerobic post-treatment like sedimentation or composting (Vögeli, Lohri, Gallardo, Diener, & Zurbrügg, 2014). During composting, high temperatures up to 75°C (Schleiss, 2018) can be reached, which leads to a hygienized product.

Operational Parameters and Reactor Configurations

The AD process highly depends on the temperature because the performance of the bacteria - which are responsible for the process - is temperature-sensitive as well. There are two temperature ranges that lead to a successful process: Mesophilic (25-40°C) and thermophilic (45-60°C). The difference between the two ranges mainly lies within the process rates of the microorganisms. Mesophilic microorganisms are slower and thus need a longer retention time in the digester to maximize biogas yield. This downside of the mesophilic range is compensated by the advantage it brings for tropical regions: The temperature in tropical regions usually provides enough heat in average, so that no external heating system is required, which significantly lowers the investment and operational costs and therefore is the more favourable system. (Vögeli, Lohri, Gallardo, Diener, & Zurbrügg, 2014)

Depending on the substrate fed into the digester, the system is either called wet (TS content < 16 %) or dry (TS content < 16 %). As shown in the results section, the substrate in the context of this study leads to a wet system. For this project, we therefore use a wet, mesophilic system.

4.3 Combined heat and power (CHP)

CHP is the generation of automated power/electricity as well as thermal energy (=heat) with a single process known as cogeneration. It is not a technology but more of an accession of implementing technologies. The excess energy generated as heat is usually being lost in a traditional electric plant but recovered in CHP.

Using new technologies CHP can reach up to 86 – 97% efficiency with only 0.2 -2% losses of CH4 (the gas is not released in the atmosphere, but captured by a catalytic filter). Nonetheless, the maximum electricity efficiency is around 40%.

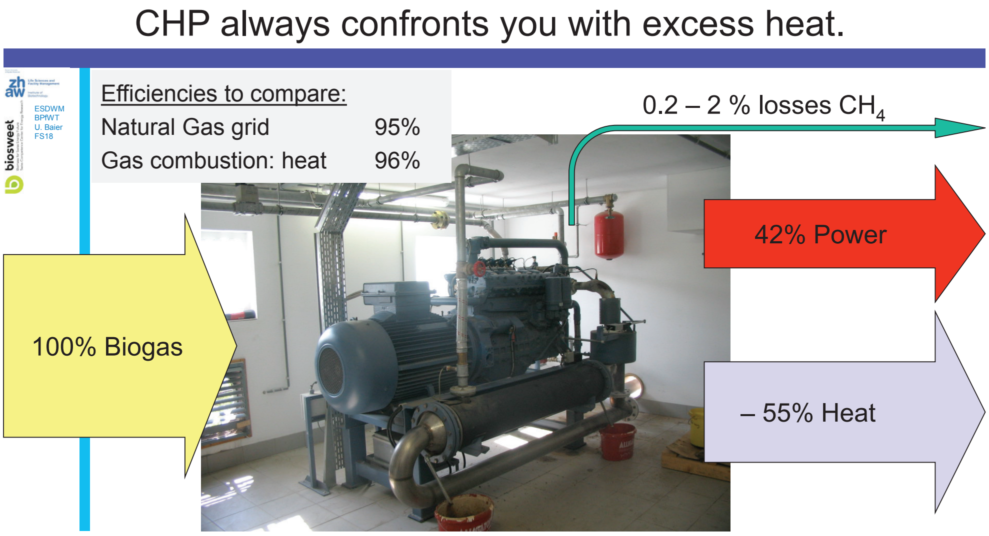


Figure 4.3
CHP output and efficiency.

4.4 Black soldier flies (BSF)

In the following, we describe the basics of the BSF processes. This information is based on the publication "Black Soldier Fly Biowaste Processing - A Step-by-Step Guide" by Sandec - department of Sanitation, Water and Solid Waste for Development within the Swiss Federal Institute of Aquatic Science and Technology (EAWAG).

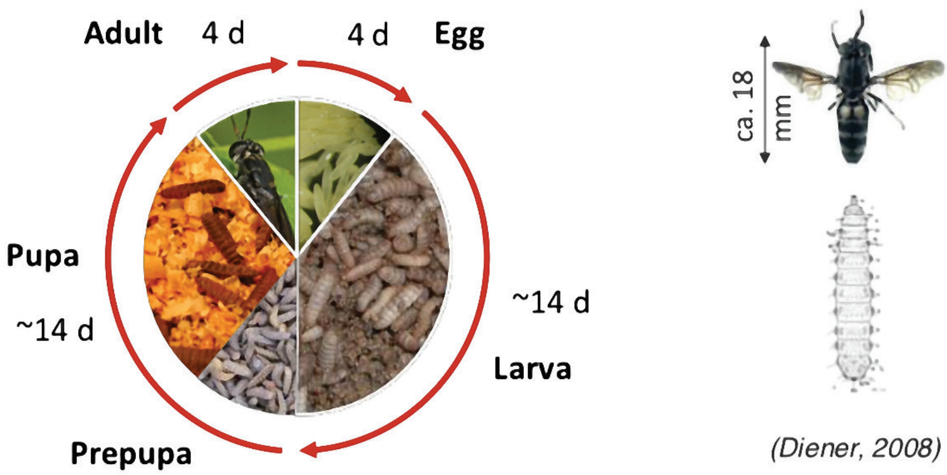


Figure 4.4
Life Cycle Black Soldier FLies (Dortmans B.M.A., 2017).

BSF is a vibrant research field. Various research projects are currently exploring the potential of alternative substrates such as sewage sludge and AD digestate as input for BSF transformation (Lalander et. al., 2013, Thomas Spranghers, 2017). In this connection it has already been shown that, a 6 log10 reduction off Salmonella spp., which can be found in human faeces, has been observed when BSF larvae grow on sewage sludge. If the larvae is being used as animal feed, the researchers propose further processing, such as drying. (Lalander, Diener, Magri, Zurbrügg, & Anders Lindström, 2013).

Black Soldier Flies (Hermetia illucens) occur naturally in tropical regions, including the Seychelles (Matyot, 2018). Only the larvae eat, the adults don't, which minimizes the risk of disease transmission. As substrate, various wastes can be used, like slaughterhouse waste, animal manure, food and market waste, and even human excreta. This waste is then fed to BSF larvae, which were reared in a nursery beforehand. After having grown on the biowaste, the larvae are harvested, post-processed and sold as animal feed product for f.e. chickens, pigs and fish.

4.5. Input and output characteristics

Green Waste

In the classes 1, 2, and 3 organic waste exists as food, cellulose packaging or as green waste, mainly comprising of tree trunks, bushes or grass clippings. During our visit to the landfill, we observed, that green waste is collected separately on the landfill. Especially class 3 (waste which is classified as only green waste) could hence easily be diverted from the rest of the waste. This would make a very suitable substrate for composting but it is not suitable as feedstock for an AD plant. This is because fibrous material lowers the biogas yield in an AD system, and with that its economic feasibility, (Zurbrügg, personal communication, 2018). We therefore exclude green waste as feedstock for the hypothetical AD plant, which lead to the complete exclusion of class 3 for this study.

Class 1

Class 1 consists of MSW and Commercial waste. More than half of this waste class contains organic material, mainly in the form of kitchen waste, followed by green waste and cellulose packaging (Darmstadt, 2016). Paper and Cardboard could also serve as substrate in the AD process. However, they also significantly decrease the yield (Baier, 2018). Therefore, the fraction classified as cellulose packaging is excluded from the study.

Class 2

Class 2 contains a lot of food waste from hotels, restaurants and other food producing and processing sources (Darmstadt, 2016). These are valuable substrates for AD, especially because they can be delivered in big quantities and the transport is therefore more cost-effective. According to a study about food waste from hotels (Alcindor, 2018), roughly 7t of food are wasted are produced each day in the tourism sector.

Class 4

The Case Study from 2016 revealed IOT as the biggest producer of organic waste (Lai A., 2016). Most of its waste stream was classified as class 4, liquid waste, which makes up almost half of this quantity. Since then, IOT has finalized their project with a WWTP and concurrent AD, which drastically reduces their waste going to the landfill. The other half from class 4 comprises of sludge from the PUC WWTP and waste from smaller fish producers (LWMA, 2018). Another potential stream of this waste class in the future could comprise sludge from the on-site landfill leachate treatment plant. Currently, the plant is running at 10 % capacity (40-50 % sludge is the intention), hence not yet running at full capacity (Mohtano, personal communication, 2018). Therefore this waste stream is not accounted for in this study. However, this waste stream could serve as additional substrate. In addition, some hotels (Banyan Tree, H Resort and Four Seasons) have their own WWTP, whose sludge (classified as class 4) could also serve as feedstock.

Class 5

This class, defined as mixed waste, is excluded from the study completely, as most of its organic share consists of wood, (34 %) of the total mass, followed closely by cellulose distribution packaging and only by < 5 % as kitchen waste (Darmstadt, 2016). It is also neglected on the assumption that sorting the remaining food waste would be very labor- and hence cost-intensive.

Class 7

Putrescent waste is defined as "animal waste from abattoirs" (LWMA, 2018). Therefore, we consider it a valuable substrate and include it fully as AD feedstock.

Class 8

Waste oil comprises engine, hydraulic and kitchen oil. According to the LWMA, this waste class has been diverted from the landfill since 2016. Engine oil is collected and upgraded by Seypec (Seypec, 2018) and then sold mainly to IOT for boiling purposes. Hydraulic oil is collected by STAR and exported (LWMA, 2018). According to interviews at LWMA, kitchen oil is also collected separately by Seypec. This information, however, was contradicting (Seypec, 2018). Thus, current handling of kitchen oil is unclear. For simplicity, the whole waste stream is therefore neglected. However, if kitchen oil were available, it would be a very valuable feedstock for AD, because of its high BMP.

4.6. Assumptions about waste class characteristics

The input characteristics for the different scenarios were calculated in the following steps:

1) The theoretical bio-methane production (BMP), total solids (TS) content and volatile solids (VS) of each class of organic waste was evaluated based on literature values (see Table 4.3). In order to take into account uncertainties, we estimated maximum (Max), average and minimum

Table 4.3
Assumptions for characteristics of waste classes.

		TS	VS (%TS)	BMP	Source
Sewage Sludge	Maximum	15.0%	88%	750	Deublein D. & Steinhauser A., 2011
	Average	12.5%	74%	475	tdCS2016
	Minimum	10.0%	59%	200	
OF MWS	Maximum	70.0%	70%	1000	Deublein D. & Steinhauser A., 2011
	Average	55.0%	50%	650	
	Minimum	40.0%	30%	300	
Food Waste	Maximum	37%	98%	1000	Deublein D. & Steinhauser A., 2011
	Average	23%	87%	700	
	Minimum	9%	75%	400	
Fish Waste	Maximum	39%	94%	823	Kafle et al., 2013
	Average	36%	88%	736	
		31%	86%	625	

(Min) values for each of the three parameters. These estimations are based on different parameters described in corresponding literature.

2) Subsequent, we calculated the specific composition for the co-digestion (in this case: anaerobic digestion of a mixture of different substrate) in order to have the average composition of the mixture in the three cases (Max, Average, and Min). This calculation is based on the percentage of each class (weighted average – see section 2.3).

The first two steps were repeated for the point in time when the AD plant reached the end of its operating time. The calculation was made with the above mentioned amounts (Qin tons/day) and composition shares. The different waste classes are growing differently in the different scenarios, which means the characteristics of the input change over time.

4.7. Calculated Input characteristics

Start

	Storyline 1			Storyline 2			Storyline 3			Storyline 4		
Parameter	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min
Input: Total solids (% weight)	17.53	14.11	10.65	20.31	15.38	10.41	20.12	15.27	10.4	24.14	19.73	15.0
Input volatile solids (%TS)	90	77	63	92	79	64	92	79	64	93	82	74

End

	Storyline 1			Storyline 2			Storyline 3			Storyline 4		
Parameter	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min
Input: Total solids (% weight)	17.53	14.11	10.65	21.14	15.76	10.34	20.2	15.26	10.29	28.61	24.62	20.01
Input volatile solids (%TS)	90	77	63	93	80	65	92	79	64	93	85	80

4.8. AD design input parameters

Table 4.4
Characteristics of the AD plant input for storyline 1.

		2022			2042		
Parameter	Unit	Max	Ave	Min	Max	Ave	Min
Q_{in}	t/d	61	61	61	61	61	61
Q_{in} H_2O	m^3/d	40	20	0	40	20	0
Q_{in} tot	m^3/d	101	81	61	101	81	61
	% of Q_{in}n tot [kg]	11%	11%	11%	11%	11%	11%
TS	m^3/d	11.37	9.04	6.67	11.37	9.04	6.67
	kg/d	11366	9037	6670	11366	9037	6670
	% of Q_{in} [kg]	16.91%	11.53%	7.02%	16.91%	11.53%	7.02%
VS	m^3/d	10.3	7.0	4.3	10.3	7.0	4.3
	kg/d	10325	7041	4286	10325	7041	4286

Table 4.5
Characteristics of the AD plant input for storyline 2.

		2022			2042		
Parameter	Unit	Max	Ave	Min	Max	Ave	Min
Q_{in}	t/d	76	76	76	81	81	81
Q_{in} H_2O	m^3/d	80	40	0	90	40	0
Q_{in} tot	m^3/d	156	116	76	171	121	81
TS	% of Q_{in}n tot [kg]	11%	11%	11%	11%	11%	10%
	m^3/d	16.76	12.39	7.98	18.73	13.61	8.46
	kg/d	16760	12390	7982	18728	13614	8461
VS	% of Q_{in} [kg]	20.64%	13.17%	6.97%	21.67%	13.62%	6.95%
	m^3/d	15.6	10.0	5.3	17.5	11.0	5.6
	kg/d	15611	9958	5270	17540	11022	5629

Table 4.6
Characteristics of the AD plant input for storyline 3.

		2022			2042		
Parameter	Unit	Max	Ave	Min	Max	Ave	Min
Q_{in}	t/d	78	78	78	94	94	94
Q_{in} H_2O	m^3/d	80	40	0	100	50	0
Q_{in} tot	m^3/d	158	118	78	194	144	94
TS	% of Q_{in}n tot [kg]	11%	11%	11%	11%	11%	10%
	m^3/d	17.14	12.71	8.24	20.65	15.21	9.74
	kg/d	17144	12710	8238	20648	15214	9741
VS	% of Q_{in} [kg]	20.40%	13.04%	6.93%	20.51%	13.02%	6.81%
	m^3/d	15.9	10.2	5.4	19.2	12.2	6.4
	kg/d	15949	10195	5421	19229	12206	6384

Table 4.7
Characteristics of the AD plant input for storyline 4.

		2022			2042		
Parameter	Unit	Max	Ave	Min	Max	Ave	Min
Q_{in}	t/d	108	108	108	203	203	203
Q_{in} H_2O	m^3/d	150	100	50	350	300	200
Q_{in} tot	m^3/d	258	208	158	553	503	403
TS	% of Q_{in}n tot [kg]	11%	11%	11%	11%	11%	11%
	m^3/d	28.58	23.28	17.56	62.64	54.04	43.98
	kg/d	28575	23281	17561	62640	54035	43977
VS	% of Q_{in} [kg]	24.75%	18.07%	12.46%	28.90%	22.82%	17.63%
	m^3/d	26.7	19.5	13.4	58.7	46.4	35.8
	kg/d	26695	19497	13439	58697	46361	35813

4.9 AD design formulae

1 Total Volume (V in m³):

$$V_{tot} = Q_{in\text{-}tot}\left(\frac{m^3}{d}\right) * HRT\ (d)$$

HRT = Hydraulic Retention Times (= SRT = Solid Retention Time as in wet systems $Q_{in} = Q_{out}$) = 30 days (Baier, 2018)

$Q_{in\text{-}tot}$ = Total input calculated as explained before

2 Height (H) and Diameter (D) of the Reactor(s):

H = 8 m (for $V_{tot} < 10{,}000\ m^3$) and H=10 m (for $V_{tot} > 10{,}000\ m^3$)

$$D\ (m) = \frac{Vtot/n}{(H * \pi)^{0.5}}$$

n = number of reactors expected to avoid re-circulations (assuming the V_{tot} is equally split among the different reactors) = 2 (for $V_{tot} < 3{,}000$), 3 (for $3000 < V_{tot} < 10{,}000$), **6 in two different AD plant** ($V_{tot} > 10{,}000$) (Baier, personal communication, 2018)

1 Organic Load Rate (OLR):

ORL (kg oTR/ m³ * d) = TS (kg VS/d)/Vtot (m³)

2 Volume reduction:

Vol.Reduction(%)= $(Q_{intot} - Q_{out\text{-}red})/Q_{intot}$

$Q_{out\text{-}red}$= initial Q_{in} – VS that have been degraded

4.10 Output characteristics

Start

Parameter	Storyline 1 Max	Storyline 1 Ave	Storyline 1 Min	Storyline 2 Max	Storyline 2 Ave	Storyline 2 Min	Storyline 3 Max	Storyline 3 Ave	Storyline 3 Min	Storyline 4 Max	Storyline 4 Ave	Storyline 4 Min
Output												
Liquid (t/day)	89.67	72.00	54.37	138.9	103.2	67.64	141.0	105.5	69.94	229.3	184.6	140.3
TS (t/day)	4.14	4.11	3.67	5.83	5.42	4.29	4.14	4.11	3.67	9.89	9.63	8.15
$N\text{-}NH_3$ (g/kg)	0.21	0.19	0.18	4.94	2.69	0.44	4.78	2.60	0.43	3.20	1.91	0.33
TN (g/kg)	12.10	11.83	11.57	22.01	15.68	9.36	21.72	15.60	9.48	19.55	14.45	9.95
P_2O_5 (g/kg)	0.81	0.72	0.63	1.54	1.02	0.51	1.51	1.01	0.52	182	1.25	0.71
K_2O (g/kg)	0.54	0.45	0.36	1.43	0.86	0.30	1.39	0.85	0.30	1.26	0.83	0.41

End

Parameter	Storyline 1 Max	Storyline 1 Ave	Storyline 1 Min	Storyline 2 Max	Storyline 2 Ave	Storyline 2 Min	Storyline 3 Max	Storyline 3 Ave	Storyline 3 Min	Storyline 4 Max	Storyline 4 Ave	Storyline 4 Min
Output												
Liquid (t/day)	89.67	72.00	54.37	152.21	107.32	72.48	173.09	128.52	84.00	490.48	449.08	359.14
TS (t/day)	4.14	4.11	3.67	6.45	5.90	4.52	7.19	6.67	5.27	21.55	21.58	18.91
$N\text{-}NH_3$ (g/kg)	0.21	0.19	0.18	6.24	3.37	0.51	5.37	2.91	0.45	2.55	1.31	0.24
TN (g/kg)	12.10	11.83	11.57	24.72	16.74	9.48	23.11	16.22	9.34	18.14	14.23	10.33
P_2O_5 (g/kg)	0.81	0.72	0.63	1.74	1.11	0.48	1.60	1.05	0.51	2.16	1.5	0.89
K_2O (g/kg)	0.54	0.45	0.36	1.67	0.97	0.28	1.50	0.89	0.29	1.18	0.84	0.50

1 Gas Flow:

Gas Flow (Nm^3/year) = Biogas Yield (Nm^3/t of VS) * VS (t/d)

The biogas yield used is the average substrate biogas yield and was calculated for each storyline and for each case (max, average, and minimum)

Nm^3 = normal cubic meters (at normal conditions of 20°C and 1 atm)

2 Digestate Production:

$Q_{out-red}$ = initial Q_{in} – VS that have been degraded = Q_{in}-VS_{in}(tVS/day) * a

a=degradation factor=0.7 Additionally, the new fraction (in % of $Q_{out-tot}$) of TS and VS in the digestate was calculated

4.11 Amounts of output products

1 Heat Production:

Heat (GJ/year) = Gas Flow (Nm^3/year) * 32 MJ/Nm^3 / 1000 GJ/MJ

2 Electricity Production (E):

E (GWh/year) = 2.4 kWh/Nm^3 * Gas Flow (Nm^3 / year) * 10(-6) (GWh/kWh)
Electricity Demand (% of tot demand covered) = E(GWh/year)/424 (GWh/year)
Power (MW) = (E (GWh/year) * 103)/(365*24)

3 Electricity Consumption (Econsump.):

This calculation was carried out to allow the estimation of the net electricity production.
Econsump = 2.135 kWh / tbiowaste * Q_{in-tot} (t/d)

4 Digestate by-products:

Digestate characteristics were obtained from literature about the anaerobic digestion of different waste input streams (organic fraction of the municipal solid waste (OFMSW), Sewage Sludge and Bone meal) (Borowski, Kubacki, 2015; Borowski et. al., 2018; Kalambura, et al., 2016; Kuusik et. al., 2014; Kuusik et. al., 2017; Peng & Pivato, 2017). Final digestate characteristic were calculated by merging literature values according to the input share for each storyline.

We assorted the amounts of solid and liquid digestate, which derived from the AD calculation, to output products (solid and liquid fertilizer, BSF larvae and landfill cover) according to local demand and highest potential for revenues. 80% of solid digestate was used together with 16% of liquid digestate to produce BSF. The goal was to divert most of the digestate to BSF in order to produce sufficient local protein sources for animal feed. 2% of solid digestate was used to produce solid fertilizer. The remaining 18% of solid digestate was composted to produce landfill cover. 84% of liquid digestate was turned into liquid fertilizer.

A list of the most used fertilizer in Seychelles with nutrient contents and prices was provided by Seychelles Agricultural Agency (Annex 7.6.3). We converted the N:P:K-ratio into N-, P_2O_5- and K_2O-contents by multiplying the N:P:K-ratio with 100 (g N, P, K/kg fertilizer). We then multiplied P- and K-contents with appropriate conversion factors to get P_2O_5- and K_2O-contents (P_2O_5 = 2.33, $K2_2O$ = 1.22).

In order to identify the potential of agricultural use of locally produced fertilizer from the digestate, we assessed the nutrient amounts and production prices as well as the demand for such fertilizers accordingly. We then identified the most suitable fertilizer for the local context by comparing the nutrient ratio (N:P:K) in the digestate with nutrient ratios from locally used fertilizer. Depending on the nutrient amounts in the digestate, the digestate needs to be concentrated to reach similar nutrient amounts. Because of high nitrogen but rather low phosphor and potassium contents in the digestate, total nitrogen was adjusted to reach N-content of the selected fertilizer. A concentrating factor was obtained for each considered fertilizer by dividing N-content of the fertilizer with N-content of digestate. Phosphor and potassium levels in the digestate varied accordingly:

$$Concentrating\ factor = \frac{\left[N - content\left(\frac{g}{kg}\right)\right]_{fertilizer}}{\left[N - content\left(\frac{g}{kg}\right)\right]_{digestate}} = 26.01$$

Because of the need for dewatering and concentrating the liquid digestate, in order to produce a fertilizer with similar N-, P_2O_5- and K_2O-content, liquid fertilizer production varied and was calculated as follows:

$$fertilizer\ (t) = \frac{Liquid\ digestate\ (t)}{Concentrating\ factor}$$

Solid digestate cannot be concentrated (process that would enrich its nutrients contents) by dewatering, because the TS content is already high. Consequently, solid digestate cannot be sold as a solid fertilizer with similar quality at local market prices because of its lower nutrient content. It was assumed that market price for solid fertilizer will vary proportionally according to the nutrient content of the solid digestate.

$$Market\ price\left(\frac{SCR}{t}\right) = \frac{N - content\ of\ solid\ digestate\left(\frac{g}{kg}\right)}{N - content\ of\ considered\ fertilizer} * price\ solid\ fertilizer\left(\frac{SCR}{t}\right)$$

Our data about local animal feed demand, protein content of animal meal and resource prices derived from an interview with a local animal feed company. Turnover rate from digestate to BSF as well as liquid-solid-ratio of digestate to BSF was obtained from the literature (Wu Li, 2015; Thomas Spranghers, 2017). BSF production was calculated as follows:

$$BSF\ (t) = \left[solid\ digestate\ (t) + \frac{liquid}{solid}\ ratio * liquid\ digestate\ (t)\right] * Turnover$$

Liquid/solid-ratio = 0.75
Turnover rate = 2.48 %

Table 4.8
Amount of output products.

Parameter		Unit	Storyline 1 Start 2022 & End 2042 (constant input)			Storyline 2 Start 2022			Storyline 2 Start 2042		
Outputs			Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
Gas quality		% CH_4	60%	60%	60%	60%	60%	60%	60%	60%	60%
Gas Flow		Nm^3/d	8,445	2,349	1,290	13,732	3,038	1,684	15,660	3,289	1,828
		$Nm^3/a*10^6$	3.1	0.9	0.5	5.0	1.1	0.6	5.7	1.2	0.7
Net Electricity Production		GWh/a	**7.40**	**2.06**	**1.13**	**12.03**	**2.66**	**1.48**	**13.72**	**2.88**	**1.60**
		% of el. Demand	**1.74%**	**0.49%**	**0.27%**	**2.84%**	**0.63%**	**0.35%**	**3.24%**	**0.68%**	**0.38%**
		MW	**0.84**	**0.23**	**0.13**	**1.37**	**0.30**	**0.17**	**1.57**	**0.33**	**0.18**
Heat		GJ/a	49,321	13,720	7,536	80,193	17,743	9,835	91,456	19,210	10,673
Di-ges-tate	TS out	t/d	4.14	4.11	3.67	5.83	5.42	4.29	6.45	5.90	4.52
	VS out	kg/d	3,097	2,112	1,286	4,683	2,987	1,581	5,262	3,307	1,689
		t/d	3.1	2.1	1.3	4.7	3.0	1.6	5.3	3.3	1.7
	VS(%)	%	3.30%	2.78%	2.22%	3.24%	2.75%	2.20%	3.32%	2.92%	2.19%
	VS/TS	kgVS/kgTS	0.75	0.51	0.35	0.80	0.55	0.37	0.82	0.56	0.37
	Liquid output	m^3/d	89.67	72.00	54.37	138.86	103.23	67.64	152.21	107.32	72.48

4.12 Fertilizer list

Manufacturer	Fertilizer type	$N:P_2O_5:K_2O$ -ratio	Retail Cost [SCR/kg]
The Mauritius Chemical &Fertilizer Industry Ltd.	Urea	46:0:0	14.00
ICL Specialty Fertilizer	Potassium sulphate (Nova SOP)	0:0:50	25.00
The Mauritius Chemical &Fertilizer Industry Ltd.	NPK (Granular Fertilizer)	13:13:20	15.00
Atlantic Fertilisers	Organic Fertilizer (Bio Ganic)	3:1:1	6.00
Green Plants	NPK (chelated with EDTA)	13:0:46	30.00
Green Plants	NPK (chelated with EDTA)	17:30:15	30.00
Plaaskem (Pty) Ltd.	Hydroponic Fertilizer (Hydroponic Pro Mix)	1:2:5	25.00
Unknown	NPK (good harvest)	15:15:15	18.00
Atlantic Fertilisers	Organic Fertilizer (Bio Rock)	1:2:1	7.00
Gouws and Scheepers (Pty) Ltd .	Fertiflo	3:2:1	50/litre
Farmisco (Pty) Ltd. (Kynoch Fertilizer)	Potassium sulphate	0:0:50	25.00
Atlantic Fertilisers	Organic Fertilizer (Bio-Ocean)	3:1:2	7.50
Van de Reijt Meststoffen B.V.	NPK	12:12:17	30.00

Storyline 3						Storyline 4					
Start 2022			Start 2042			Start 2022			Start 2042		
			Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
13,985	3,110	1,714	16,927	3,648	1,979	22,829	9,011	6,725	49,404	25,300	20,359
5.1	1.1	0.6	6.2	1.3	0.7	8.3	3.3	2.5	18.0	9.2	7.4
12.25	**2.72**	**1.50**	**14.83**	**3.20**	**1.73**	**20.00**	**7.89**	**5.89**	**43.28**	**22.16**	**17.83**
2.89%	**0.64%**	**0.35%**	**3.50%**	**0.75%**	**0.41%**	**4.72%**	**1.86%**	**1.39%**	**10.21%**	**5.23%**	**4.21%**
1.40	**0.31**	**0.17**	**1.69**	**0.36**	**0.20**	**2.28**	**0.90**	**0.67**	**4.94**	**2.53**	**2.04**
81,673	18,161	10,011	98,856	21,305	11,555	133,320	52,625	39,277	288,521	147,754	118,898
5.98	5.57	4.44	7.19	6.67	5.27	9.89	9.63	8.15	21.55	21.58	18.91
4,785	3,059	1,626	5,769	3,662	1,915	8,008	5,849	4,032	17,609	13,908	10,744
4.8	3.1	1.6	5.8	3.7	1.9	8.0	5.8	4.0	17.6	13.9	10.7
3.25%	2.75%	2.19%	3.20%	2.71%	2.15%	3.35%	3.01%	2.72%	3.44%	2.95%	2.84%
0.80	0.55	0.37	0.80	0.55	0.36	0.81	0.61	0.49	0.82	0.64	0.57
141.04	105.47	69.94	173.09	128.52	84.00	229.30	184.59	140.31	490.48	449.08	359.14

Bag size [kg]	N-content [g/kg]	P-content [g/kg]	K-content [g/kg]	P_2O_5-content [g/kg]	K_2O-content [g/kg]
25.00	460.00	0.00	0.00	0.00	0.00
25.00	0.00	0.00	415.00	0.00	500.00
25.00	130.00	55.90	166.00	130.00	200.00
2.00	260.00	180.00	330.00	418.60	397.60
25.00	130.00	0.00	381.80	0.00	460.00
10.00	170.00	129.00	124.50	300.00	15.00
25.00	59.00	45.00	252.00	104.65	303.61
25.00	150.00	64.50	124.50	150.00	150.00
40.00	240.00	270.00	300.00	627.90	361.40
1 litre	96.00	63.00	32.00	146.51	38.55
25.00	0.00	0.00	420.00	0.00	506.00
2.00	27.00	17.00	31.00	39.53	37.35
25.00	120.00	51.60	141.10	120.00	170.00

4.13 Capital costs calculation method

The CAPEX mainly consists of the following costs (Wellinger & Wagner, 2013):

1. Capital costs for the AD plant (reactors and machineries): We calculated the capital costs according to similar cases and expert interviews. The main units of the costs are:
   - Plant property: 15 %
   - Technical equipment: 10 %
   - Digestion plant: 55 %
   - Design: 10 %
   - Construction management and start-up costs: 10 %

   The total price was based on 6,636 SCR/m^3 of AD plant volume requirement (ZWHA lecturers, 2018).

2. Combined Heat and Power (CHP) Generator: Based on Deublein & Steinhauser (2011) we assumed 900 US$/kW and multiplied this amount with the estimated power of each case of each storyline.

3. A dewatering plant is needed for the separating of liquid (for liquid fertilizer) from the solid (for BSF and landfill cover) digestate. An average estimation of costs for a Belt Press (screw filter press for de-watering) that is running at full capacity (16 m^3/hour) (Belt Press KD 11–1600, Danish Wastewater Equipment) is US $80,000 per machine. For the scenario with a Q_{out} that exceeds 250 m^3/day, and the calculation for the capital costs include two Belt Presses.

4.14 Operation and maintenance cost calculation method

We calculated the O&M for the AD plant (labour, utilities, consumption, and maintenance) and the OPEX for final products production (electricity production, de-watering processes, fertilizers, BSF and landfill cover) as follows:

1. **Labour:** An initial need of international expertise was considered. During the first two years, we included the costs for capacity building in the calculation. Therefore, for the first two years, the salaries are based on four different levels of expertise. Maximum salary of 1,264 000 SCR/year (80,000 euros per year, based on the average German manager salary) at the top level and a drop of 1/3 for the level below was assumed. From the third year on, the four salary levels were adapted to the local ones and the salary starts from a minimum salary of 5,000 SCR/month for the lowest level (corresponding to the minimum local salary), and it increases with 1/3 per level also in this case. The number of employees needed for running the plant is based on literature research and then adapted to the plant volume (see Appendix 7.7 for the details).

2. **Utilities consumption:** The method followed was based on defining the main costs, which for an AD plant are assumed to be electricity and water consumption. The use costs are based on local prices (see details in the Appendix 7.7)

3. **Maintenance:** For the first and the second year 10% of the annual total CAPEX were added as maintenance costs and 20% for the following years.

4. **Electricity production:** We assumed production costs of 0.013 US$/kWh for OPEX. This value was then multiplied with the expected electricity production (kWh over the whole year) as presented in Section 2.8. We verified these values by using the online convertor method: http://www.energyinternational.co.uk/CHPCalculator1.htm

5. **Dewatering processes:** The respective costs include the separation process of digestate into the liquid and solid part, including the labour that is required for running the process. Three mechanics are needed to run the dewatering machine at full capacity and for maintenance. We define the salary of a mechanic to be at 7,500 SCR/month. The electricity demand for the running the Belt press is neglected for simplification.

6. **Fertilizer production:** We expect that a general labor force is sufficient for the production of one ton of liquid and solid fertilizer. Salary costs for general labor is set to 5,000 SCR/month.

7. **BSF production:** we consider two general labor force costs per ton processed BSF and 105 kWh electricity demand per ton (Mertenat, 2018). The percentage of heat which can contribute to the evaporation of remaining water was calculated as follows:

$$\textit{Fertilizer production potential covered by heat (\%)} = \frac{\textit{MJ heat needed to evaporate excessing water}}{\textit{MJ heat produced by AD}}$$

For simplification, the potential additional electricity demand to evaporate remaining water - which cannot be evaporated by heat - was not taken into the calculation.

8. **Landfill cover production:** Post-composting treatment costs for landfill cover are expected to range around 8 US $ per ton digestate, already including labor costs (Golkowska).

4.15 Revenue calculation method

Lastly, we assessed and calculated the revenues for all the possible profitable products:

1. **Electricity:** The gross revenues from electricity are based on a sales price of 2 SCR/kWh, which is a comparable price to the actual market prices. This, however, assumes that the electricity can be sent to the common grid and sold to Public Utilities Corporation (PUC) for a price similar to the one they incur in their own electricity production.

2. **Fertilizers, BSF and post-composted digestate for landfill cover:** We compared these revenues with costs paid for locally used fertilizers, high-protein animal feed ingredients, and coral sand, respectively. The products are sold as a substitution product in the local market with local prices. If product amounts exceeded local demand, it was assumed that the remaining amount was sold on international markets. Therefore, revenues for each product were calculated as follows:

$$\textit{Revenues (SCR)} = \textit{Substitute price}\left(\frac{SCR}{t}\right) * \textit{price solid fertilizer (t)}$$

Table 4.9 presents all the assumptions behind the calculations of the production costs for the final products.

Table 4.9
Used parameters for calculating costs and revenues.

Parameter	Unit	Value	Source
Conversion US $ to SCR	No unit	13.5	Online converter
Urea retail price	SCR/t	14,000	Seychelles Agricultural Agency
Demand Urea in Seychelles	t/month	1.72	FAO
Urea characteristics N:P:K-ratio N-content P_2O_5-content K_2O-content	 g/kg g/kg g/kg	 34:0:0 340 0 0	Seychelles Agricultural Agency, personal communication
Fishmeal market price	SCR/t	15,582.5	Indian Ocean Tuna (IOT), Ferox Feed
Soybean meal import price	SCR/t	6,463	Ferox Feed
BSF export price	SCR/t	23,000	EAWAG
Demand Pig meal Broiler meal Layer meal	%	23 26 51	Ferox Feed
Percentage of Soybean meal in: Pig meal Broiler meal Layer meal	%	 16.0 26.0 21.6	Ferox Feed
Percentage of Fishmeal in: Pig meal Broiler meal Layer meal	%	 2.5 6.0 10.0	Ferox Feed
Price coral sand	SCR/t	1,350	Internet: average of amazon prices
Demand coral sand	t/month	800	LWMA
Demand animal feed	t/month	1,000	Ferox Feed

4.16 Cost/ Benefits estimation

Plant Property	Land and building	15%
Technical Equipment	Front loader, compost filter, etc.	10%
Digestion Plant	Material and Equipment	55%
Design	Detail engineering	10%
Construction Menagement and Start-Up	Personnel cost	10%
	AD plant total CAPEX	**100%**
	CHP total CAPEX	
	Centrifuge CAPEX	
	Total SCR	

Capital costs
Operational costs

	Amount n°/unit	External price SCR/unit	Local price SCR/unit	External/ local
Leader (°n)	1/plant	1,264,000.00	202,500.00	**0.13**
Drivers (°n)	1/1,000 m^3	842,666.67	135,000.00	**0.13**
Mechanics (°n)	1/1,000 m^3	90,000.00	90,000.00	**1.00**
Sorters (°n)	1/1,000 m^3	60,000.00	60,000.00	**1.00**

Labour costs

By Unit we mean plant or 1,000 m^3. The final number was subsequently multiplied times number of plants or multiples of 1,000 m^3.

Running costs/utilities costs

- **Electricity consumption:** The tariffs are 16.65 SCR/KVA for power consumption and 3.79 SCR/kWh for energy consumption, which correspond to the highest tariffs for commercial consumption. For the former, no literature value for AD plant was found so the latter was doubled. The KVA is Kilo Volt Ampere and is the unit that represents the real (more than what is actually consumed) electricity consumption. This is higher than the real consumption because of oscillations, hence losses, caused by the transport of the electricity from point A to point B.

- **Water consumption:** an average consumption of 15 m^3/month was accounted and the corresponding local tariff for water (19.4 SCR/month*m^3) and sewerage (12.25 SCR/month*m^3) charge was applied. This on the assumption that additional water needed for the system load dilution will be taken from the wastewater treatment plant (WWTP) effluent (sludge from the sewage) and not from drinking water.

Revenues

Table 4.10
Production costs and revenues for storyline 1.

	2022			2042		
	Max	Ave	Min	Max	Ave	Min
Liquid Fertilizer						
Production t/year	16,630	26,330	30,198	16,630	26,330	30,198
Operational costs Mio.SCR/year	7	11	13	7	11	13
Revenues Mio.SCR /year	8	13	15	8	13	15
Solid Fertilizer						
Production t/year	27	30	30	27	30	30
Operational costs Mio.SCR /year	0.011	0.013	0.013	0.011	0.013	0.013
Revenues Mio.SCR /year	0.013	0.015	0.015	0.013	0.015	0.015
Black Soldier Flies						
Production t/year	4,287	4,800	4,836	4,287	4,800	4,836
Operational costs Mio.SCR /year	1	1	1	1	1	1
Revenues Mio.SCR /year	2	2	2	2	2	2
Landfill cover						
Production t/year	241	270	272	241	270	272
Operational costs Mio.SCR /year	0.2	0.2	0.2	0.2	0.2	0.2
Revenues Mio.SCR /year	0.3	0.4	0.4	0.3	0.4	0.4
Electricity						
Production GWh/year	7.4	2.1	1.1	7.4	2.1	1.1
Production Cost Mio.SCR/year	1.3	0.4	0.2	1.3	0.4	0.2
Revenues Mio.SCR /year	14.8	4.1	2.3	14.8	4.1	2.3
Total						
Operational costs Mio. SCR /year	10	13	14	10	13	14
Revenues Mio. SCR /year	25	19	19	25	19	19
Net Costs Mio. SCR/year with export	–15	–6	–5	–15	–6	–5
Operational costs Mio.SCR /year	3	2	2	3	2	2
Revenues Mio. SCR /year	17	6	5	17	6	5
Net Costs Mio. SCR /year without export	–14	–5	–3	–14	–5	–3
% Reduction of Revenues without export	8%	29%	43%	8%	29%	43%

Table 4.11
Production costs and revenues for storyline 2.

	2022			2042		
	Max	Ave	Min	Max	Ave	Min
Liquid Fertilizer						
Production t/year	22,494	34,007	49,906	21,636	33,614	46,240
Operational costs Mio.SCR/year	9	14	19	9	14	21
Revenues Mio.SCR /year	14	22	31	15	23	33
Solid Fertilizer						
Production t/year	33	43	47	32	41	44
Operational costs Mio.SCR /year	0.014	0.017	0.018	0.014	0.018	0.020
Revenues Mio.SCR /year	0.022	0.027	0.029	0.022	0.029	0.031
Black Soldier Flies						
Production t/year	5,280	6,889	7,534	5,190	6,510	6,984
Operational costs Mio.SCR /year	1	2	2	1	2	2
Revenues Mio.SCR /year	2	3	3	2	3	3
Landfill cover						
Production t/year	297	387	424	292	366	393
Operational costs Mio.SCR /year	0.2	0.2	0.2	0.2	0.2	0.2
Revenues Mio.SCR /year	0.4	0.5	0.5	0.4	0.5	0.6
Electricity						
Production GWh/year	12.0	2.7	1.5	13.7	2.9	1.6
Production Cost Mio.SCR/year	2.1	0.5	0.3	2.4	0.5	0.3
Revenues Mio.SCR /year	24.1	5.3	3.0	27.4	5.8	3.2
Total						
Operational costs Mio. SCR /year	13	16	22	13	17	23
Revenues Mio. SCR /year	41	31	37	45	32	40
Net Costs Mio. SCR/year with export	–28	–14	–15	–32	–15	–17
Operational costs Mio.SCR /year	4	2	2	4	3	3
Revenues Mio. SCR /year	26	8	6	30	9	7
Net Costs Mio. SCR /year without export	–23	–6	–4	–26	–6	–4
% Reduction of Revenues without export	19%	59%	75%	18%	57%	75%

Table 4.10
Production costs and revenues for storyline 3.

	2022			2042		
	Max	Ave	Min	Max	Ave	Min
Liquid Fertilizer						
Production t/year	26,041	41,069	56,882	29,310	40,998	53,437
Operational costs Mio.SCR/year	12	17	22	11	17	24
Revenues Mio.SCR /year	19	27	35	17	27	37
Solid Fertilizer						
Production t/year	38	49	52	44	53	55
Operational costs Mio.SCR /year	0.018	0.022	0.023	0.016	0.020	0.022
Revenues Mio.SCR /year	0.029	0.035	0.036	0.025	0.032	0.034
Black Soldier Flies						
Production t/year	6,158	7,790	8,395	7,090	8,456	8,842
Operational costs Mio.SCR /year	2	2	2	2	2	2
Revenues Mio.SCR /year	3	3	3	2	3	3
Landfill cover						
Production t/year	346	438	472	399	476	497
Operational costs Mio.SCR /year	0.2	0.3	0.3	0.2	0.2	0.3
Revenues Mio.SCR /year	0.5	0.6	0.7	0.5	0.6	0.6
Electricity						
Production GWh/year	12.3	2.7	1.5	14.8	3.2	1.7
Production Cost Mio.SCR/year	2.2	0.5	0.3	2.6	0.6	0.3
Revenues Mio.SCR /year	24.5	5.4	3.0	29.7	6.4	3.5
Total						
Operational costs Mio. SCR /year	17	20	25	15	20	27
Revenues Mio. SCR /year	47	36	42	50	37	45
Net Costs Mio. SCR/year with export	–30	–16	–17	–34	–17	–18
Operational costs Mio.SCR /year	4	3	3	4	3	3
Revenues Mio. SCR /year	28	9	7	33	10	7
Net Costs Mio. SCR /year without export	–24	–6	–4	–28	–7	–5
% Reduction of Revenues without export	23%	61%	75%	18%	58%	75%

4.17 Seychelles Fishing Authority (SFA) Mariculture Masterplan

The last storyline is based on the interview with the SFA. The Mariculture Masterplan aims at producing 100,000 t of fish per year by 2030. Since roughly a third of the processed fish mass ends up as waste (IOT, 2018), this means a huge quantity of potential feedstock for the AD plant. The Seychelles Mariculture Masterplan anticipates turning the produced fish waste into fertilizer (Lesperance, personal communication, 2018), which would be entirely possible with an AD plant. In addition, feed pellets would be needed for the growing fish, which speaks in favor of BSF larvae.

According to Mr. Lesperance, two laboratories plus two hatcheries should be running by 2019. The pilot project is comprised of a production of 200 t per year. The Masterplan plans to grow different species, of which 80 % should consist of

Table 4.11
Production costs and revenues for storyline 4.

	2022			2042		
	Max	Ave	Min	Max	Ave	Min
Liquid Fertilizer						
Production t/year	114,524	145,009	178,396	44,070	58,937	75,030
Operational costs Mio.SCR/year	18	25	31	48	60	74
Revenues Mio.SCR /year	26	35	45	68	87	106
Solid Fertilizer						
Production t/year	138	158	157	60	70	72
Operational costs Mio.SCR /year	0.025	0.029	0.030	0.058	0.066	0.066
Revenues Mio.SCR /year	0.036	0.042	0.043	0.082	0.094	0.094
Black Soldier Flies						
Production t/year	22,084	25,209	25,172	9,524	11,251	11,551
Operational costs Mio.SCR /year	3	3	3	6	7	7
Revenues Mio.SCR /year	4	4	4	6	6	6
Landfill cover						
Production t/year	1242	1418	1416	536	633	650
Operational costs Mio.SCR /year	0.3	0.3	0.4	0.7	0.8	0.8
Revenues Mio.SCR /year	0.7	0.9	0.9	1.7	1.9	1.9
Electricity						
Production GWh/year	20.0	7.9	5.9	43.3	22.2	17.8
Production Cost Mio.SCR/year	3.5	1.4	1.0	7.6	3.9	3.1
Revenues Mio.SCR /year	40.0	15.8	11.8	86.6	44.3	35.7
Total						
Operational costs Mio. SCR /year	25	29	36	62	72	85
Revenues Mio. SCR /year	71	56	62	163	139	150
Net Costs Mio. SCR/year with export	−46	−27	−26	−101	−67	−65
Operational costs Mio.SCR /year	6	5	5	14	12	11
Revenues Mio. SCR /year	44	21	17	94	52	44
Net Costs Mio. SCR /year without export	−38	−16	−13	−80	−41	−33
% Reduction of Revenues without export	17%	40%	52%	20%	39%	49%

fin fish species such as red snappers, jack fish and groupers. The remaining 20 % should be covered by crabs, sea urges, oysters, and others. "The worst-case storyline release rates of fish feces and food pellets [...] were based on a total of 236 kg of feces produced and 671 kg of wasted food per ton of fish production. For every model storyline, approximatively 85 % of the initial food or feces release settled to the seafloor within the time-window of the simulation. The remaining 15 % fraction is expected to be further advected and dispersed in the water column without having any significant impact on the marine environment" (Golder Associates, 2016). For simplicity, the feces and fodder wastes are hence not included in our storyline. However, they could be a very good input to the AD plant, and should be considered when the project is implemented.

Appendix 5 Waste treatment II: Incineration

5.1 Expert interviews

Table 5.1
List of all interviewed experts.

Interviewee	Position/profession	Organization/company
Governmental Seychelles		
Alain de Comarmond	Principal Secretary Environment	Ministry of Environment, Energy and Climate Change (MEECC)
Flavien Joubert	CEO	Landscape Waste Management Agency (LWMA)
Tony Imaduwa	CEO	Seychelles Energy Commission (SEC)
Guilly Moustache	Principal Officer	Seychelles Energy Commission (SEC)
Cynthia Alexander	Principal Officer	Seychelles Energy Commission (SEC)
Private Enterprises (Waste)		
Maurice Waldner	Principal Secretary Environment	Ministry of Environment, Energy and Climate Change (MEECC)
Alfred Sigg	Principal Secretary Environment	Ministry of Environment, Energy and Climate Change (MEECC)
Romano Wild	Managing Director	Incineration plant in Horgen (Switzerland)
Private Enterprises (others)		
Lekha Nair		Seychelles Pension Fund
Cliff Gonzalves	Consultant	AAI Enterprise Pty Ltd
Research Institutions		
Dr. Melanie Haupt	Postdoctoral Researcher	ETH Zurich

5.2 Location analysis

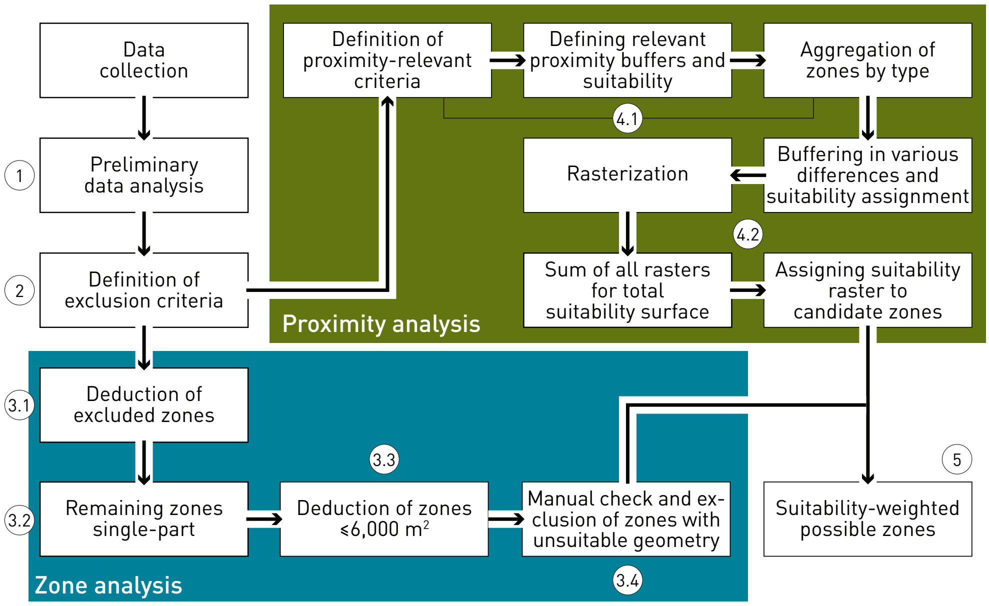


Figure 5.1
Overview of the spatial data processing procedure. The data is analysed in two separate procedures, zone analysis (blue) and proximity analysis (green), whereof the results are combined for interpretation.

1. We assessed the collected geodata by analysing the metadata. An overview of the data can be found in appendix 6.5.

2. Exclusion criteria: A zone was excluded either because technical characteristics (e.g. rivers, roads, wetlands) or legal considerations (e.g. national parks, protected areas, danger zones) prohibit the construction of an incineration plant. Additionally, areas which we deem as unfit to support such a facility are excluded (e.g., commercial zones, mixed zones, tourist sites), as based on our knowledge about spatial planning or on the results obtained from the acceptancy survey (e.g. residential zones, see Section 3.3). The excluded layers are presented in appendix 6.5.

3. 4 steps of zone analysis
   a) We subtracted zones fulfilling the above-mentioned exclusion criteria (point 2) from the overall island area. Moreover, we buffered geodata available in the form of line features (e.g. rivers) by 5m.[1]
   b) Multi-part features were transferred to single-part.[2]
   c) We removed all zones smaller than 6.000 m^2. This minimal size was determined by comparing plants of different sizes and verified by an informal discussion with waste a management expert (Haupt, personal communication, 12.07.18).
   d) Manual analysis of the remaining zones and removal of unfit geometries (not approx. rectangular shape, diameter less than 30 m).

4. Proximity analysis
   a) The base data for the proximity analysis consists of zones, in whose vicinity an incineration plant is not accepted either by public opinion (see Section 3.3) or due to ecological concerns. We generated buffers in three different distances around the layer features.[3] The distances are set based on varying suitability numbers (see Table 5.2) and vary from layer to layer. Additionally, buffer zones from the land-use plan were also assigned with a suitability value.[4]
   b) We rasterized the different suitability layers, for which we chose a raster of 5 m. This size ensures resourceful computing while retaining a large enough resolution for location analysis. The different raster layers then are summed up to give an overall suitability layer.

5. By combining the two analyses, the suitability per possible zone can be calculated. The applied suitability values use in the proximity analysis can be found in Table 5.2 .

1 The buffer size was estimated based on the measurement of 5 sample rivers (downstream) on aerial imagery of Mahé. Includes embankments.

2 The term multi-part and single-part refer to the topology of a GIS-feature. Multi-part features consist of multiple polygons but are counted just as one entity. Because multi-part features are misleading for the location analysis, they were transformed to single-part features, where every entity counts as a separate feature.

3 The different sub-layers of the zoning plan are combined by purpose (e.g. all residential areas), so the buffers are generated around the zone layers and not the zoning sub-types.

4 Next to the buffers around the proximity-relevant zones, costs were also assigned to the buffer zones from the land use plan. Buffer zones are defined as "Areas between core protected areas and the surrounding landscape or seascape which protect the network from potentially damaging external influences and which are essentially transitional areas" (Ministry of Environment Energy and Climate Change Seychelles (MEECC) (2013). "Seychelles Protected Areas Policy," Mahé, Seychelles.Buffer areas do not prohibit construction legally, although the construction of an incineration plant within this area is deemed ecologically and spatially unsuited in these areas. However, considering the limited land resources on Mahé, they may have to be used. Because these areas are not suited well, they were fitted with a cost of 20.

Table 5.2
Definition of the suitability values used in the proximity analysis.

Placing an incineration plant at this location will lead to…	Assigned suitability value
Strongly negative impacts	100
Intermediate negative impacts	50
Slightly negative impacts	20
Minimal negative impacts	10
Neutral / no impacts	0
Minimally beneficial impacts	–10
Slightly beneficial impacts	–20
Intermediate beneficial impacts	–30
Strongly beneficial impacts	–50

5.3 Survey about social acceptance

All information is confidential and will only be used in aggregated form!

Gender
☐ Male ☐ Female

Age
☐ 18 - ☐ 18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56-65 ☐ 65 +

Household income
☐ < 5000 RS ☐ 5000-10'000 RS ☐ 10'000-20'000 RS ☐ > 20'000 RS ☐ I don't know

Educational background
☐ Primary ☐ Secondary ☐ Post-secondary (A levels) ☐ University

Where do you live?

Do you know what happens to the waste after having placed it in the bin?

How effective is the Seychelles waste management?
☐ No idea
☐ Not effective
☐ Fair
☐ Effective
☐ Very effective

What do you think would be a possible/preferable solution for waste in Seychelles? Why?

Do you know what an incineration plant is? If yes, can you explain the principle?
☐ Yes ☐ No

An incineration plant burns unrecyclable waste. It simultaneously produces energy (electricity and heat) and cleans the gases generated by the combustion. Incineration reduces the waste volume by 70-80%.
Do you think an incineration plant would be a good investment? Why? Why not?

Do you think an incineration plant will cause…			
Much noise	☐ Yes	☐ No	☐ No idea
Stinky odour	☐ Yes	☐ No	☐ No idea
Decrease / reduce air quality	☐ Yes	☐ No	☐ No idea
Produce renewable energy sources	☐ Yes	☐ No	☐ No idea
Solve the waste problem in Seychelles	☐ Yes	☐ No	☐ No idea

If an incineration plant was to be built close to your residence, what would be your concerns?

Do you think household should pay for waste disposal?
☐ Yes ☐ No

Why do you think so?

How much would you be willing to pay per month for sustainable waste disposal?
☐ 25 RS ☐ 50 RS ☐ 100 RS ☐ 200 RS ☐ 500 RS ☐ more

Do you think people who produce more waste should also pay more?
☐ Yes ☐ No

Why do you think so?

5.4 Overall criteria assessment

Table 5.3
Overview of criteria according to (Rand, Haukohl, & Marxen, 2000). Rows in green have aspects considered in our study, rows in blue are not part of the current study.

Importance	Criteria
Institutional	
mandatory	A solid waste management system, comprising a controlled and well-operated landfill, has been functioning well for a number of years.
mandatory	Solid waste collection and transportation (municipal and industrial solid waste) are managed by a limited number of well-regulated/controlled organization(s).
mandatory	There are signed and approved letters of intent or agreements for waste supply and energy sale.
mandatory	Consumers and public authorities are able and willing to pay for the increased cost of waste incineration.
mandatory	Authorities are responsible for controlling, monitoring, and enforcing operations.
mandatory	A public guarantee is available for repayment of capital costs and operation costs.
strongly advisable	The authorities responsible for control, monitoring, and enforcement are independent of the ownership and operation of the plant.
strongly advisable	Skilled staff for plant operation is available to the plant owner at affordable salaries. Otherwise, there must be long-term reliable operation and service contracts.
preferable	The waste management authority owns the incineration plant.
Waste as Fuel	
mandatory	The average annual lower calorific value must be at least 7 MJ/kg and must never fall below 6 MJ/kg in any season.
strongly advisable	Forecasts of waste generation and composition are established on the basis of waste surveys in the catchment area of the planned incineration plant. This task must be carried out by an experienced (and independent) institution.
strongly advisable	Assumptions regarding the delivery of combustible industrial and commercial waste to an incineration plant should be founded on an assessment of positive and negative incentives for the various stakeholders to dispose of their waste at the incineration facility.
strongly advisable	The annual amount of waste for incineration should not be less than 50,000 tons, and the weekly variations in the waste supply to the waste incineration plant should not exceed 20 percent.
Incineration Economy	
mandatory	There must be a stable planning environment with predictable prices of consumables, spare parts, disposal of residues, and sale of energy. Furthermore, the capital costs (large share of foreign currency) must be predictable.
mandatory	The financing of the net treatment cost must ensure a waste flow as intended in the overall waste management system. Consequently, the tipping fee at the waste incineration plant must be lower or at least correspond to the tipping fee at the landfill site. Willingness and ability to pay must be thoroughly addressed.
mandatory	Foreign currency must be available to purchase critical spare parts.
strongly advisable	When surplus energy is to be used for district heating, the incineration plant must be located near an existing grid to avoid costly new transmission systems.
preferable	To be economically feasible, the individual incineration units should have capacities of at least 240 t/d (10 t/h), and there should be at least two separate units.
preferable	If a regular market for sale of hot water (district heating or similar) or low-pressure steam is present, the plant should be based on sale of heat only. This is preferable both in terms of technical complexity and economic feasibility. A certain extent of cooling to the environment during the warm season may be preferable to costlier solutions.

Table 5.3
Continued

Importance	Criteria
	Project cycle
mandatory	A skilled independent consultant with experience from similar projects should be employed at an early stage.
mandatory	To avoid conflicts, the public should be involved and informed during all phases but especially in the planning phase (feasibility assessment and project preparation phase).
	Incineration technology
mandatory	The technology should be based on the mass burning principle with a movable grate. Furthermore, the supplier must have numerous reference plants in successful operation for a number of years.
mandatory	The furnace must be designed for stable and continuous operation and complete burnout of the waste and flue gases (CO<50 mg/Nm^3, TOC<10 mg/Nm^3).
mandatory	The flue gases from the furnace must be cooled to 200°C or lower before flue gas treatment.
mandatory	The flue gas cleaning equipment must be at least a two-field ESP (basic emission control, dust<30 mg/Nm).
mandatory	A controlled landfill must be available for residue disposal. Full leachate control must be exercised at the landfill.
strongly advisable	The annual amount of waste for incineration should not be less than 50,000 metric tons and the weekly variations in the waste supply to the waste incineration plant should not exceed 20 percent.
strongly advisable	Municipal solid waste incineration plants should be in land-use zones dedicated to medium or heavy industry.
strongly advisable	The stack should be twice the height of the tallest building within 1.0 km, or at least 70 meters high.

5.5 Proximity analysis

The suitability raster produced by the proximity analysis (see Figure 5.2) shows that the suitability values for an incineration plant tend to be highest within densely populated residential areas, for instance in Victoria, Beau Vallon or Port Launay. This effect is even reinforced in these cities due to their proximity to the National Park. As expected, costs decrease in areas around current landfills and in areas near services. Based solely on the chosen criteria, the area around the current landfill is well suited for an incineration plant. Another area which would also be interesting is in Anse Royale. However, the centrality of this location would not be as suitable as in Providence.

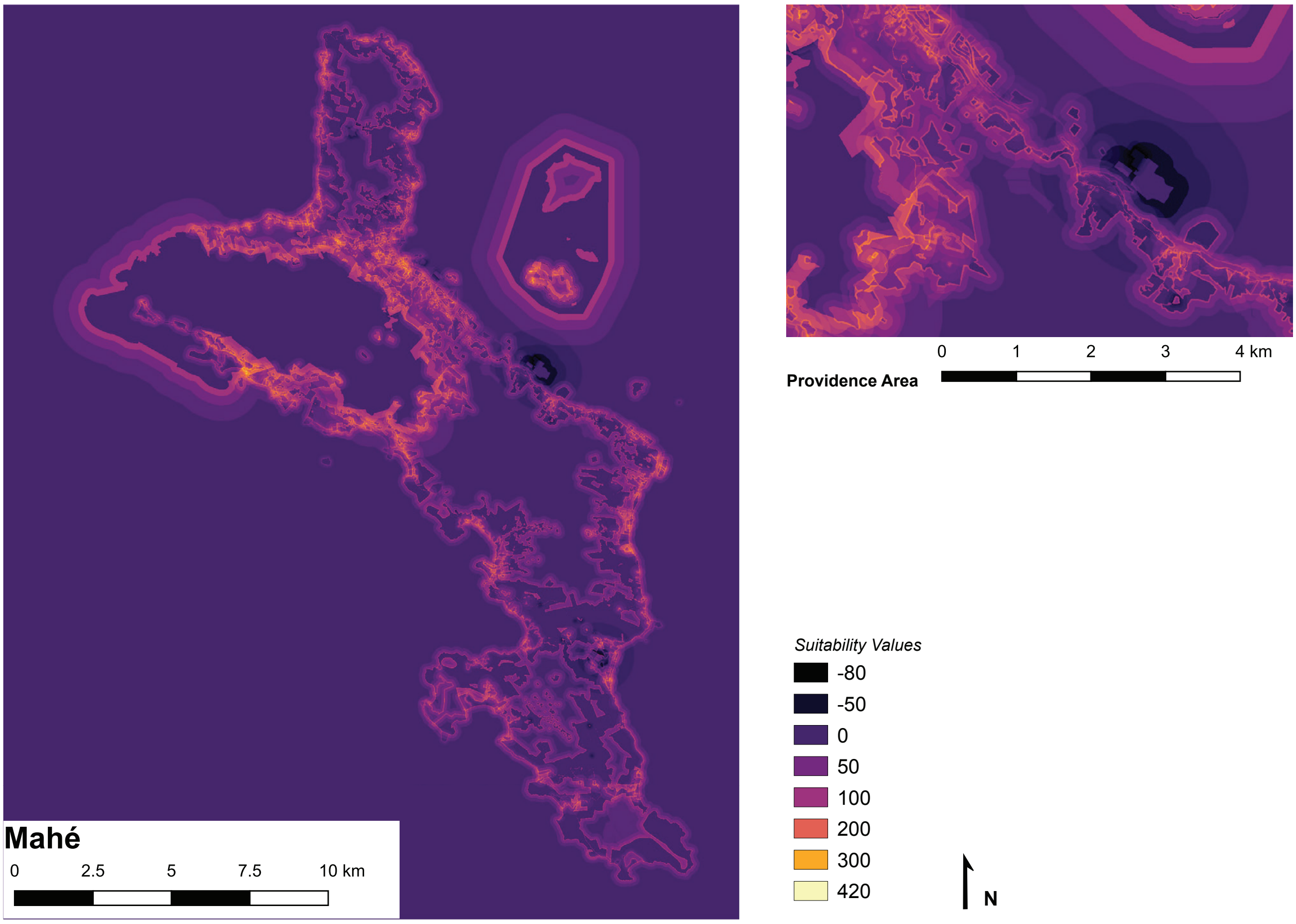


Figure 5.2
Suitability value raster produced by the proximity analysis.

5.6 GIS data overview

Table 5.4
GIS data overview.

Layer	Sub-Layer	Description	Data source	Exclusion_criteria	Aggregated Layer
bs_island		Islands	MLUH/ Centre for GIS		
bs_district		Districts	MLUH/ Centre for GIS		
bs_subdistricts		Subdistricts	MLUH/ Centre for GIS		
sv_parcel		All parcels	MLUH/ Centre for GIS		
sv_buildings		Building footprints	MLUH/ Centre for GIS		
env_river		All rivers	MLUH/ Centre for GIS	1	
env_wetland		Waterbodys and swamps (on islands)	MLUH/ Centre for GIS	1	
env_protected_area			MLUH/ Centre for GIS	1	ProtectedAreas_MultiBuffer
env_danger_zones			MLUH/ Centre for GIS	1	
tt_road		Road network, classified	MLUH/ Centre for GIS		
cd_da_office			MLUH/ Centre for GIS		
pl_planzone			MLUH/ Centre for GIS		
pl_reclamation_guidelines			MLUH/ Centre for GIS		
aerial_photo			MLUH/ Centre for GIS		
env_shoreline_ranking			MLUH/ Centre for GIS		

Table 5.4
Continued

Layer	Sub-Layer	Description	Data source	Exclusion_criteria	Aggregated Layer
mc_police_station			MLUH/ Centre for GIS		
pl_place_of_worship			MLUH/ Centre for GIS		
he_medical_facility			MLUH/ Centre for GIS		
pl_financial_facility			MLUH/ Centre for GIS		
edu_educational_facility			MLUH/ Centre for GIS		
pl_proposed_planzone	Land use plans		MLUH/ Centre for GIS		
	A1	Crop Production (some mixed with small animal husbandry)	MLUH/ Centre for GIS	1	
	A2	Livestock Production	MLUH/ Centre for GIS	1	
	B1	Roads	MLUH/ Centre for GIS	1	
	B2	Transport Facility (car park, bus depot, bus stop)	MLUH/ Centre for GIS	1	
	B3	Ports, marinas, fishermen landings, jettys, quays, boat shelters	MLUH/ Centre for GIS	1	
	B4	Airport/Airfield	MLUH/ Centre for GIS	1	
	B5	Telecommunication (Masts, Ground stations etc.)	MLUH/ Centre for GIS		
	C1	Commercial	MLUH/ Centre for GIS	1	
	C2	Commercial & Offices	MLUH/ Centre for GIS	1	
	C3	Commercial & Residences	MLUH/ Centre for GIS	1	CommercialMixed_MultiBuffer
	C4	Market	MLUH/ Centre for GIS	1	
	C5	Warehouse and Stores	MLUH/ Centre for GIS	1	
	C6	Offices	MLUH/ Centre for GIS	1	
	C7	Mixed Use (Urban)	MLUH/ Centre for GIS	1	CommercialMixed_MultiBuffer
	C8	Mixed Use (Sub-Urban)	MLUH/ Centre for GIS	1	CommercialMixed_MultiBuffer
	D1	Unallocated/Reserved Land	MLUH/ Centre for GIS		
	E1	Diplomatic Representation	MLUH/ Centre for GIS	1	
	F1	Forest Reserve	MLUH/ Centre for GIS	1	
	I1	Small Industry	MLUH/ Centre for GIS	1	
	I2	Medium-sized Industry	MLUH/ Centre for GIS	1	
	I3	Heavy Industry	MLUH/ Centre for GIS	1	
	O1	Public Buildings	MLUH/ Centre for GIS		
	O2	Police/Court House/Security Services/SPDF	MLUH/ Centre for GIS	1	
	O3	Fire Brigade	MLUH/ Centre for GIS	1	
	O5	MNA Offices	MLUH/ Centre for GIS	1	
	P1	National Park	MLUH/ Centre for GIS	1	
	P2	Marine or Terrestrial Reserve	MLUH/ Centre for GIS	1	

Table 5.4
Continued

Layer	Sub-Layer	Description	Data source	Exclusion_criteria	Aggregated Layer
	P3	Wetland, Marshes, Mangrove	MLUH/ Centre for GIS	1	WetlandsBeaches-Parks_MultiBuffer
	P4	Protected Beach front/coast-line	MLUH/ Centre for GIS	1	WetlandsBeaches-Parks_MultiBuffer
	P6	Green Space/Beach park/ Gardens	MLUH/ Centre for GIS	1	WetlandsBeaches-Parks_MultiBuffer
	P7	Buffer Zones	MLUH/ Centre for GIS		
	R0	Very Low density residential & Tourism	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R1	Very low density Residential	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R10	Temporary workers accomo-dation	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R2	Low density Residential	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R3	Low Density Residential & Agriculture	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R4	Low residential & Tourism	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R5	Medium density Residential	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R6	Medium density Residential & Agriculture	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R7	Medium Residential & Tour-ism	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R8	High Density Residential	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	R9	Housing Estate	MLUH/ Centre for GIS	1	Residential_Multi-Buffer
	S1	Medical Facilities	MLUH/ Centre for GIS	1	Services_Multi-Buffer
	S2	Old age homes/Day care Centers	MLUH/ Centre for GIS	1	Services_Multi-Buffer
	S3	Educational Facilities	MLUH/ Centre for GIS	1	Services_Multi-Buffer
	S4	Church/Cemetery/Religious infrastructure	MLUH/ Centre for GIS	1	Services_Multi-Buffer
	S5	Sport Facilities	MLUH/ Centre for GIS	1	
	S6	Cultural Facilities	MLUH/ Centre for GIS	1	Services_Multi-Buffer
	T1	Hotels, Guesthouse, Self-Ca-tering Accommodation	MLUH/ Centre for GIS	1	Tourism_Multi-Buffer
	T2	Tourism sites	MLUH/ Centre for GIS	1	Tourism_Multi-Buffer
	U1	Water Reservoir/Water Plant	MLUH/ Centre for GIS		Utilities_Multi-Buffer
	U2	Powerplant/Sub-Station	MLUH/ Centre for GIS		Utilities_Multi-Buffer
	U3	Sewage Plant	MLUH/ Centre for GIS		Utilities_Multi-Buffer
	U4	Landfill	MLUH/ Centre for GIS		Landfill_Multi-Buffer

Table 5.5
Buffer distances and costs of analysed GIS layers. The buffer distances show the distance of the three buffer layers from the original layer, which is then assigned with a suitability value.

Layer Name	Layer sub-types	Buffer	Data source	Exclusion_ criteria	Aggregated Layer
Com-mercial Mixed	Commercial & Residences, Mixed Use (Urban), Mixed-Use (Sub-Urban)	20 / 100 / 200	Close proximity bothersome / noise impacts/ neighbour-hood factor	50 / 20 / 10	Especially bothersome if mixed with residential, though less residents involved.
Landfill	Landfill	200 / 500 / 1000	Transport costs in-crease with distance	-50 / –20 / –10	Proximity beneficial (landfill mining, disposal of bottom ash)
Protect-ed Areas	Protected Areas, National Parks	200 / 500 / 1000	Buffer zones around NPs, creation of tran-sitional areas (unsuit-ed)	100 / 50 / 20	Direct proximity ecolog-ically undesired, transi-tional areas.
Residen-tial	Very Low density residential (& Tourism), Low Density Residential (& Agriculture & Tourism), Medium Densitiy Residential (& Agriculture & Tourism), High Density Residential, Housing Estate, Temporary Workers Accom-modation	20 / 100 / 200	Close proximity bothersome / noise impacts/ neighbour-hood factor	100 / 50 / 20	High unacceptance with local population, "yes, but not in my back-yard"-effect
Services	Medical Facilities, Old age homes/Day care Centers, Ed-ucational Facilities, Church/ Cemetery/Religious infra-structure, Cultural Facilities	20 / 100 / 200	Close proximity bothersome / noise impacts/ neighbour-hood factor	50 / 20 / 10	High unacceptance with local population, "yes, but not in my back-yard"-effect
Tourism	Hotels, Guesthouse, Self-Ca-tering Accommodation, Tour-ism sites	20 / 100 / 200	Close proximity bothersome / noise impacts/ neighbour-hood factor,	100 / 50 / 20	May pose negative image for tourists, disruption of landscape
Utilities	Water Reservoir/Water Plant, Powerplant/Sub-Station, Sewage Plant	20 / 50 / 100	Synergy can be used reasonably within short distances (e.g. heat transfer)	–30 / –20 / –10	Use of technical syn-ergies (e.g. access to electricity grid, desalina-tion plant)
Wetlands Beaches Parks	Wetland, Marshes, Mangrove, Protected Beach front/coast-line, Green Space/Beach park/Gardens	20 / 50 / 100	Structural safety buff-er, eyesight	50 / 20 / 10	Direct proximity ecolog-ically undesired, higher structural costs due to unstable ground.

5.7 Survey results about social acceptance

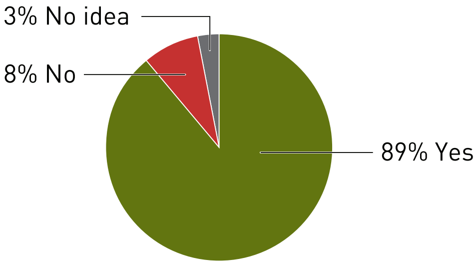


Figure 5.3
Opinion whether investing in an incineration plant would be preferential.

5.8 Overall feasibility assessment

Table 5.6
Criteria mentioned by (Rand et al., 2000) and not assessed in our study.

Criteria	Our knowledge/opinion
There are signed and approved letters of intent or agreements for waste supply and energy sale.	Legislation in preparation.
Solid waste collection and transportation (municipal and industrial solid waste) are managed by a limited number of well-regulated/controlled organization(s).	Partially fulfilled. Collection and transportation of waste to the landfill works, however number of contracts is enormous, leading to lack of control.
Authorities are responsible for controlling, monitoring, and enforcing operations.	Theoretically fulfilled.
A public guarantee is available for repayment of capital costs and operation costs.	No research output.
The waste management authority owns the incineration plant.	Inconclusive, we recommend that government should have ownership.
Forecasts of waste generation and composition are established on the basis of waste surveys in the catchment area of the planned incineration plant. This task must be carried out by an experienced (and independent) institution.	Partially fulfilled. Consequent continuation of data collection/monitoring needed.
There must be a stable planning environment with predictable prices of consumables, spare parts, disposal of residues, and sale of energy. Furthermore, the capital costs (large share of foreign currency) must be predictable.	Partially fulfilled. Should be assessed in more detail in a specific tender.
The financing of the net treatment cost must ensure a waste flow as intended in the overall waste management system. Consequently, the tipping fee at the waste incineration plant must be lower or at least correspond to the tipping fee at the landfill site. Willingness and ability to pay must be thoroughly addressed.	Not fulfilled to our knowledge, but highly necessary.
Foreign currency must be available to purchase critical spare parts.	No research output.
A skilled independent consultant with experience from similar projects should be employed at an early stage.	Company with long-lasting experience and similar projects recommended.
The flue gases from the furnace must be cooled to 200°C or lower before flue gas treatment.	No research output.
The stack should be twice the height of the tallest building within 1.0 km, or at least 70 meters high.	Recommended. Check civil aviation regulations. Normally flue gases do not impair flight traffic.

Appendix 6
Financial mechanisms: Money flows

6.1 Expert interviews

Table 6.1
List of all interviewed experts.

Interviewee	Position/profession	Organization/company
Governmental Seychelles		
Alain de Comarmond	Principal Secretary Environment	Ministry of Environment, Energy and Climate Change (MEECC)
Fredrick Kinloch	Director waste management	
Arthur Berta	Consultant	
Flavien Joubert	CEO	Landscape Waste Management Agency (LWMA)
Rahul Mangroo	Deputy CEO	
Lemmy Payet	Consultant	
Karine Bonnelame	Financial controller	
Maria Jannie	Coordinator	Waste Management Fund (WMF) & Environmental Trust Fund (ETF)
Dwight Stravens	Acting Chief Procurement Officer	Procurement Oversight Unit (POU)
Private Enterprises (Waste)		
Davis Uzice	CEO	STAR and Wastea
Patrick Lablache	CEO / Private Waste Collector	3AM Services
Private Enterprises (others)		
Cliff Gonzalves	Consultant	AAI Enterprise Pty Ltd
Jean Weeling-Lee	Managing Director	Corvina Invest. Co Ltd
Other Organisations		
Dr. Marie-Therese Purvis	Chairperson, Board of Directors	Sustainability for Seychelles (S4S)
Jack Esparon	Ex-Operations supervisor STAR	

6.2 Waste types and tipping fees

Table 6.2
List of all interviewed experts.

Class	Waste type	Description	LWMA Tariff	STAR Additional Tariff (collection, use of weighbridge or others)
1	Municipal and commercial	Waste collected by STAR from households (collection is subsidized) and business premises that have a contract with the LWMA (collection is partially subsidized)	Free	
2	STAR's private clients	Hotels and stores that have a direct contract with STAR (not subsidized)	50 SCR/ton	
3	Green waste	Biodegradable waste	Free	
4	Liquid waste	Part of the liquid waste is landfilled, part is treated by PUC (Public Utilities Corporation)	140 SCR/ton	
5	Mixed from private trucks	Waste from collectors other than STAR	Below 1 ton: 50 SCR Above 1 ton: 100 SCR/ton	
6	Scrap metal	Metal deposited in a specific area of the landfill	Free	
7	Putrescent waste	Expired goods and abattoir waste	1,000 SCR Administrative fee (valid for one month)	431 SCR/ton 1,050 SCR/load to dig a hole
7	Putrescent waste	Expired goods and abattoir waste	1,000 SCR Administrative fee (valid for one month)	
8	Waste oil	Part of the oil waste is accepted by PUC. Kitchen oil, grease trap and hydraulic oil that is collected is exported by STAR.	0.5 SCR/liter	1,200 SCR/liter Collection service and export
9	Construction and demolition	Waste from construction and demolition sites	Below 1 ton: 50 SCR Above 1 ton: 100 SCR/ton	
10	Inert	Mainly glass. Discarded at the Anse Royal landfill	200 SCR/ton Landfilling 1,000 SCR/truck load Administrative fee	345 SCR For use of weighbridge at providence
11	Hazardous	Different type of hazardous waste, including asbestos. Discarded at the Anse Royal landfill	800 SCR/ton 1,000 SCR/truck load Administrative fee	At Providence: 1204 SCR/ton At Anse Royal with use of weighbridge at Providence: 345 SCR
12	Special	Medical waste	Free	1,204 SCR/ton for collection

Table 6.3
New waste classification scheme suggested by the waste management authorities.

Class	Waste type	Description
1	Bio	Biodegradable waste from gardens and parks, as well as domestic and commercial food waste
2	Putrescible	Waste containing organic matter that is liable to become putrid, such as offal
3	Plastic	Plastic waste
4	Inert	Waste that has no active biological or chemical properties, such as sand
5	Construction	Solid components from construction, demolition or refurbishment of buildings
6	Glass	Glass waste
7	Paper and board	Paper, board and other constituents that cannot be easily removed such as coatings, and spiral bindings
8	Metal	Metallic waste
9	Electronic	Electrical and electronic equipment
10	Sludge and liquid	Liquid or muddy substances
11	Special	Industrial oils, tires and hazardous waste
12	Residual	Any waste not included in the above specifications
13	Residual from waste treatment	Waste resulting of a treatment and not included in the above specifications
12	Special	Medical waste

6.3 Expenses and revenues

Table 6.4
Expenses and revenues of the WMS.

Expenses	SCR
MEECC: Salary	4,759,000
MEECC: Goods and services	2,372,610
LWMA: Collection Municipal	14,045,629
LWMA: Collection Commercial	15,300,000
LWMA: Landfilling	18,810,949
WMF: Redeem centres	7,537,691
WMF: Administrative	2,397,043
ETF: Projects	1,643,545
Total	**66,866,468**
Revenues	**SCR**
MoF: Landfill tipping fees and commercial waste collection	17,709,644
ETF: 15.1% of fee in water bill	1,376,457
ETF: Fees for littering	267,088
WMF: Levy share (Retained redeem centres)	7,537,691
WMF: Levy share (Administrative)	2,397,043
Total	**29,287,924**
Net expenses	**37,578,544**

Table 6.5
Calculation of per capita costs of the WMS.

National level		Mahé	
Expenses	**SCR**	**Expenses**	**SCR**
MEECC: Salary	4,759,000	LWMA: Collection Municipal	14,045,629
MEECC: Goods and services	2,372,610	LWMA: Collection Commercial	15,300,000
WMF: Redeem centres	7,537,691	LWMA: Landfilling	18,810,949
WMF: Administrative	2,397,043		
ETF: Projects	1,643,545		
Revenues	**SCR**	**SCR**	
ETF: 15.1% of fee in water bill	1,376,457	MoF: Tipping fees and commercial waste collection	17,709,644
ETF: Fees for littering	267,088		
WMF: Levy share (Retained redeem centres)	7,537,691		
WMF: Levy share (Administrative)	2,397,043		
Population			
Population Seychelles	946,000	Population Mahé	818,000
Per capita cost (Mahé)			**44.76**

Table 6.6
Revenues and expenses of the ETF in 2017, that are relevant for the WMS. Source: ETF.

Revenues	SCR
Out of court settlement	267,088
15 % of Levy PUC water bill	1,376,457
WMF: Redeem centres	7,537,691
WMF: Administrative	2,397,043
Total	**1,643,545**
Expenses	**SCR**
LWMA	164,916
Project Cleaning Environment	4,175
Removal Debris (illegal dumping)	1,500
Providence Landfill	378,000
Scrap Metal	508,600
School waste project	176,776
Waste Sorting Project	409,578
Total	**1,643,545**

Table 6.7
Expenses of the WMF in 2017. Source: WMF.

Revenues	SCR
Retained by redeem centres	7,537,691
Administrative cost	318,280
Operating Cost (transportation)	2,078,763
Total	**9,934,734**

Table 6.8
Calculation of the amount retained by the redeem centres and the amount the fund should retain, according to the levy system model. Source of the flow WMF to redeem centres: WMF

	PET	Cans	Total
WMF to redeem centres	17,303,472.00	12,406,039.00	
Levy model: WMF to redeem centre	0.65	0.70	
Levy model: retained redeem centre	0.15	0.20	
Levy model: retained WMF	0.05	0.30	
Total retained redeem centres	**3,993,108.92**	**3,544,582.57**	**7,537,691.49**
Total WMF should retain	**1,331,036.31**	**5,316,873.86**	**6,647,910.16**

6.4 Current state of the WMS policies

There are three main plans that set the vision and strategies of the WMS in the Seychelles: The Solid Waste Master Plan, the Solid Waste Policy, and the LWMA Strategic plan. The Master Plan describes the long-term vision for waste management. At a second level, the Policy establishes the guiding principles and expected outcomes of different actors of the system. At a third level, the LWMA strategic plan, sets clear performance standards and targets of the Agency.

The three plans of the waste management sector are in different stages of development. The last Master Plan is outdated since 2010 and the development of a new one is in an early phase. The Waste Management director of the MEECC stated that he is writing the terms of reference for the document. Based on that, the European Union will finance the plan drafting by consultants. The Solid Waste Policy, which will be valid from 2018 to 2023, was developed with the help of the United Nations Development Programme (UNDP) and is in process of approval by the cabinet of ministers. The LWMA strategic plan is valid up to 2020.

6.5 Details of the tender process

The Procurement Oversight Unit is responsible for checking that the tender conforms to the Procurement act. If this is the case, the Procurement Oversight Unit approves it and sends it back to the responsible organization. The Procurement oversight unit nominates a part of the Independent evaluation committee.

The Independent evaluation committee is responsible to evaluate the bidders and give a list with their recommendations. The committee is set up by CEO of the organization launching the tender and the Procurement oversight unit. But the organization launching the tender cannot participate in the committee. However, a member of the organization (e.g. deputy) is responsible for organizing the meetings and clarify questions about the tender document. This person cannot vote as member of the committee.

The approval authorities can accept or reject the list of bidders proposed by the independent evaluation committee. However, the approval authorities cannot recommend somebody else, they can only accept or reject the list.

Depending of the value and the type of the tender, the approval authorities may vary (Table 6.9). They can be the CEO/head of the organization issuing the Tender (in the case of waste collection: the CEO of the LWMA), one of the Independent procurement committees, or for larger contract the National tender board. There are five different Independent Procurement Committees, the usual composition of the committee is 1/3 from the public sector and 2/3 from the private sector. The National Tender Board is considered to be an independent entity. The CEO of the board is nominated by the President. The other seven members are nominated for a duration of three years by various entities (e.g., professional organizations, chamber of commerce, and association of NGOs). The members are from the public and private sectors.

Table 6.9
Approval authorities dependent of the tender value and type. Adapted from the Procurement Oversight Unit website (http://www.pou.gov.sc/).

Type	Amount (SCR)		
Works	Up to 150'000	Above 150'000 to 750'000	Above 750'000
Goods & Services	Up to 100'000	Above 100'000 to 500'000	Above 500'000
Consultancies	Up to 50'000	Above 50'000 to 150'000	Above 150'000
Approved by	**Head of Organization (PS/CEO)**	**Independent Procurement Committees**	**National Tender Board**

If a bidder who was not elected disagrees with the outcome of the tender, s/he can challenge it. The unsatisfied bidder has 10 days to challenges the outcome and pays an administrative fee of 300SCR. The originating organization receives the challenge and has 10 days to accept or reject it. If it rejects it, the unsatisfied bidder can accept the rejection (in which case the contract is signed) or challenge the rejection. If the bidder challenges the rejection, it goes to the Review Panel (admin fee of 500SCR). The review panel has 30 days to take a decision. It can either reject the challenge (in which case the contract is signed), partially cancel the tender (if the tender consists of different contracts), or cancel the whole tender.

Appendix 7 Implementation of plans: Barriers and the way out

7.1 Expert interviews

Table 6.1
List of all interviewed experts.

Interviewee	Position/profession	Organization/company
	Governmental Seychelles	
Denis Matatiken	Special Advisor to the Minister	Ministry of Environment, Energy and Climate Change (MEECC)
Nanette Laure	Director General	
Arthur Berta	Consultant	
Flavien Joubert	CEO	Landscape Waste Management Agency (LWMA)
Tony Imaduwa	CEO	Seychelles Energy Commission (SEC)
	Private Enterprises (Waste)	
Davis Uzice	CEO	STAR and Wastea
Leeroy Ernesta	Owner	DE Recycling
Navin Naidu	Owner	Navin's Recycling Paper Industries
Patrick Lablache	CEO / Private Waste Collector	3AM Services
	Private Enterprises (others)	
Cliff Gonzalves	Consultant	AAI Enterprise Pty Ltd
Ian Charlette	Consultant	
Vanesa Quatre	Consultant	
	Other Organisations	
Dr. Marie-Therese Purvis	Chairperson, Board of Directors	Sustainability for Seychelles (S4S)
Lizanne Moncherry	Manager Tourism Office, Victoria	Seychelles Tourism Board

7.2 Basic Interview Guide

See next page.

<table>
<tr><td colspan="2">Start:
● Greetings/Thank you for allowing me to conduct an interview with you!
● Introduce ourselves
● Explain why you are here
● Goal of the study and of the interview with this person
● Remarks on recording/Start:
○ May I record our conversation? This is just for the purpose of transcription and it will be deleted afterwards. You can stop the interview at any time, and if you want to exclude parts of the conversation form the analysis, please let me know.
○ Confidentiality: what is written can't be traced back. Please let us know during the interview, if we need to be careful with certain information.
○ Do you have any questions? If you're fine, I will start the recording.</td></tr>
<tr><td>Main Questions and Sub-Questions</td><td>Category</td></tr>
<tr><td>A lot of strategies and plans exist ... Why are plans not implemented?
- What are the main obstacles for the implementation of plans?
- The knowledge of what needs to be done is existing, why is it not done?
- So you named XY as a reason, what is the (underlying) problem of XY?
- ...</td><td>All</td></tr>
<tr><td>From a literature-review we often found that the reason for a lack or failure of implementation of plans is due to the larger setting/environment, i.e.
- neglection of cultural values of the community
- uncertain/unsecure political environment
- uncertain/unsecure socio-economic environment
- Conflicting goals and priorities (personal/between departments)
- lack of commitment of decision makers/lack of political will
- lack of trust
    - by public in government
    - among key players
    -
...What do you think about that, in regard to the waste management plan XY?</td><td>Context</td></tr>
<tr><td>From a literature-review we often found that the reason for a lack or failure of implementation of plans is due to issues with the organizational structure of the implementation process, i.e. ...
- inefficient bureaucracy
- inadequate organizational structure
- unclear allocation of responsibilities
- corruption
- lack of agreement between processes, work systems, organisational strategies
- intransparency (among key players)

...What do you think about that, in regard to the waste management plan XY?</td><td>Structural</td></tr>
<tr><td>From a literature-review we often found that the reason for a lack or failure of implementation of plans is due to issues with content of the plans, i.e. ...
- too little focus on implementation in the plan
- unrealistic plan
- too ambitious plan
- unclear targets in the plan

...What do you think about that, in regard to the waste management plan XY?</td><td>Content</td></tr>
<tr><td>From a literature-review we often found that the reason for a lack or failure of implementation of plans is due to issues in the operational dimension of the plans, i.e. ...
- resource limitation
    - too small budget
    - inadequate budget
    - lack of technology
    - inadequate technology
    - lack of number of working force
    - lack of adequate/skilled working force
- ineffective management
    - lack of responsibilities
- lack of monitoring/feedback-failure
- poor/improper communication towards key actors or among responsible departments

...What do you think about that, in regard to the waste management plan XY?</td><td>Operational</td></tr>
<tr><td colspan="2">End:
● Close the interview: Do you have anything to add?
● Do you have questions?
● Thank You! (Invitation to presentation/read report)</td></tr>
</table>

7.3 Working Schedule Stakeholder Workshop

Time	Content	Method	Name
0 (10)	Formal Introduction: Hello, tdCS18 introduce (name and position) goals schedule/process confidentiality	Presentation	MD
10 (5)	Introduction / Background	Presentation	JT
15 (5)	Personal list of reasons	silent Brainstorming	
20 (10)	Introduce dimensions and put up cards	one after the other	
30 (15)	Input from research must be reasons evt. public? addition deeper reasons finance input ...	(interactive) Presentation	SW / MC
45 (20)	Discussion	Facilitation	
65 (20)	Systematization / Diagram	Group work	MD
85 (15)	Break		
0 (10)	Group-Presentation of Diagrams	Presentation	JT
10 (15)	Discuss Diagrams - ownership	Facilitation, Conclusion	
25 (5)	Wrap-up of first part / Outlook second	Presentation of objectives	
30 (20)	Choose Reasons in own field of action. In groups of two, develop actions to overcome them. – Input on Actions (what works → positive!) – (incl. Finance money-flow/proportions/ instruments)	Group work with support of us	MD
50 (20)	Present and discuss actions	Facilitation	JT
70 (10)	Wrap-up	Presentation	SW
80 (Total: 175)	End		

7.4 Alphabetical list of barriers highlighted by the research team during the workshop

- Conflicting goals between actors
- Corruption and nepotism
- Lack of alignment
- Lack of economic incentives
- Lack of enforcement
- Lack of financial autonomy
- Lack of overview of financial system
- Lack of performance measures
- Lack of procedures
- Lack of political will
- Lack of public awareness
- Poor communication between key stakeholders
- Too much focus on initial cost rather than maintenance cost
- Unclear allocation of responsibilities

7.5 Action Guide, Stakeholder Workshop

Addressed reason (s)	
Short description of action and procedures	
Outcome	
Involved institutions and stakeholders	
Who is leading?	
Resources Needed	
Time frame of Action	
Indicators to measure and evaluate progress	

7.6 Question for Public Survey, English Version

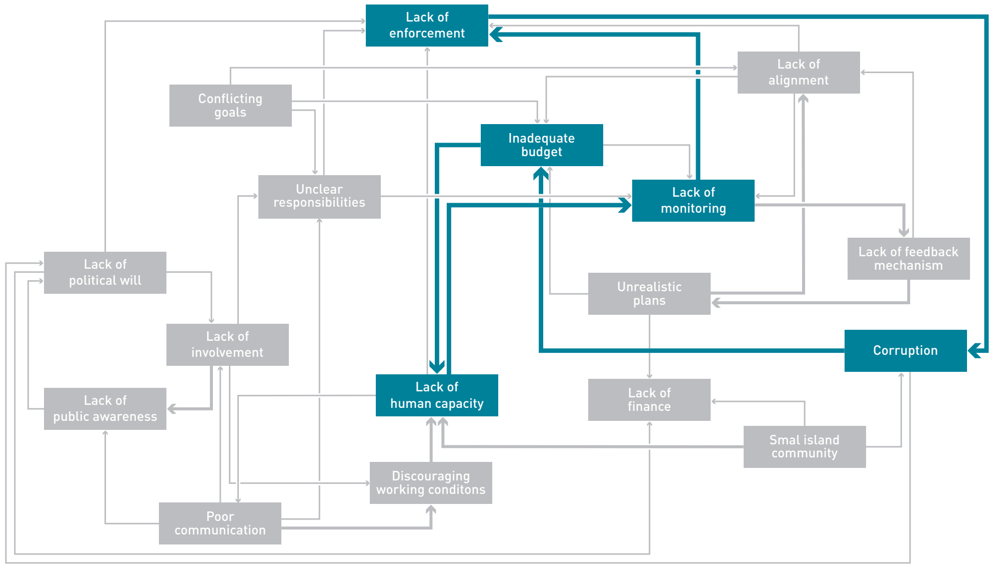
A recent study found several reasons why most plans regarding waste management in the Seychelles are not implemented. To what extent do you agree/disagree with the following reasons? (Reference to the study here....)
Mark only one per row

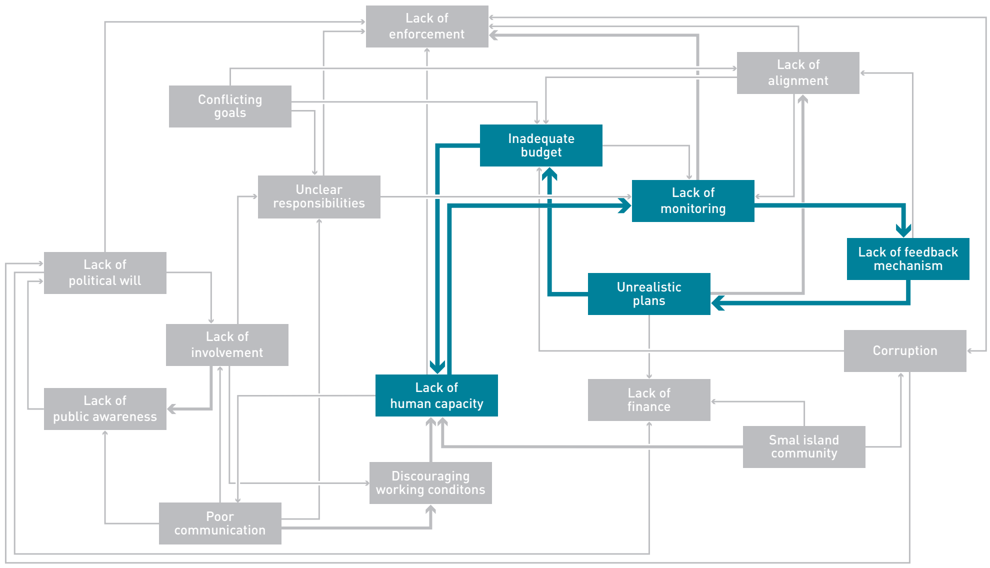
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	I don't know
Lack of public awareness						
Corruption						
Lack of skilled labour						
Lack of finances						
Lack of political will						
Inefficient organizational structures						
The plans are unrealistic						

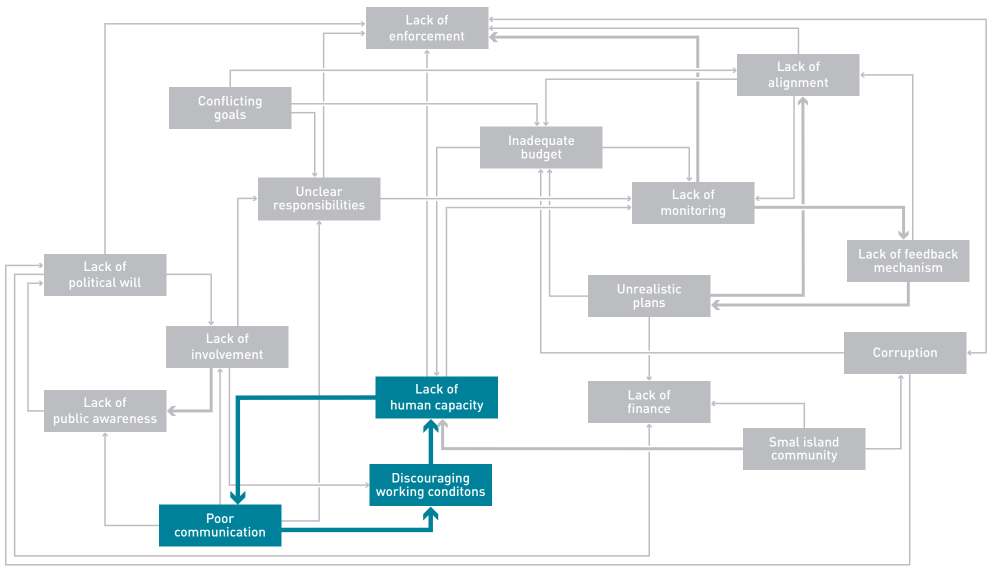
7.7 List of Barriers from Literature Review

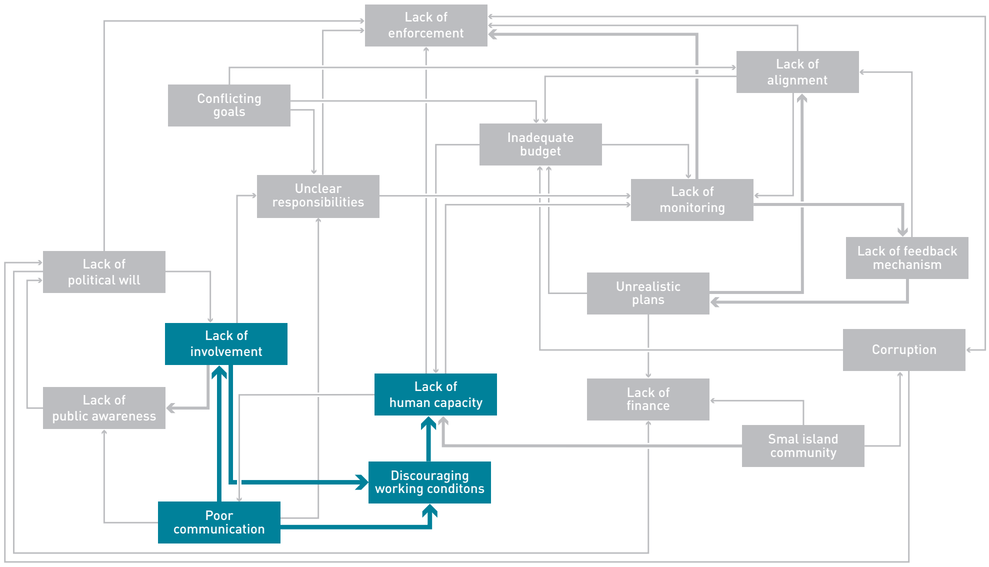
Operational Barriers	Literaure Source
Inadequate budget	Zurbrügg (2013)
Inadequate technology	Zurbrügg (2013)
Inefficient management	Kalali et al. (2011)
Lack of a feedback mechanism	SSDS 2012-2020 Ali & Khan (2006)
Lack of monitoring	Zurbrügg (2013)
Lack of skilled labour	Zurbrügg (2013) Kalali et al. (2011) Eckelman (2014)
Lack of technology	Zurbrügg (2013)
Limited financial resources	Zurbrügg (2013) Kalali et al. (2011) Eckelman (2014)
Poor communication among responsible departments	Kalali et al. (2011)
Poor communication towards key stakeholders	Kalali et al. (2011)
Tony Imaduwa	Zurbrügg (2013)
Content-related Barriers	
Too ambitious plans	Ali & Khan (2006)
Too little focus on implementation	Dine et al. (2016)
Unclear targets in plan	Kalali et al. (2011)
Unrealistic plans	Ali & Khan (2006)
Structural Barriers	
Corruption	Ali & Khan (2006)
Inadequate organizational structure	Zurbrügg (2013) Kalali et al. (2011)
Inefficient bureaucracy	Zurbrügg (2013)
Intransparency among key players	Zurbrügg (2013) Ali & Khan (2006)
Lack of agreement between processes, work systems, organizational strategies	Kalali et al. (2011)
Unclear allocation of responsibilities	Dine et al. (2016)
Contextual Barriers	
Conflicting goals and priorities between actors	Kalali et al. (2011)
Conflicting goals and priorities between departments	Kalali et al. (2011)
Lack of commitment of decision makers/lack of political will	Zurbrügg (2013) Kalali et al. (2011)
Lack of trust among key actors	Ali & Khan (2006)
Lack of trust by public in government	Ali & Khan (2006)
Neglection of cultural values in the community	Agamuthu et al. (2014)
Uncertain/unsecure political environment	Kalali et al. (2011)
Uncertain/unsecure socio-economic environment	Kalali et al. (2011)
Lack of public awareness	Zurbrügg (2013) Agamuthu et al. (2014)
Lack of legislative framework	Zurbrügg (2013) Terazono et al. (2005) Mohee et al. (2015)

7.8 Additional Feedback-Loops





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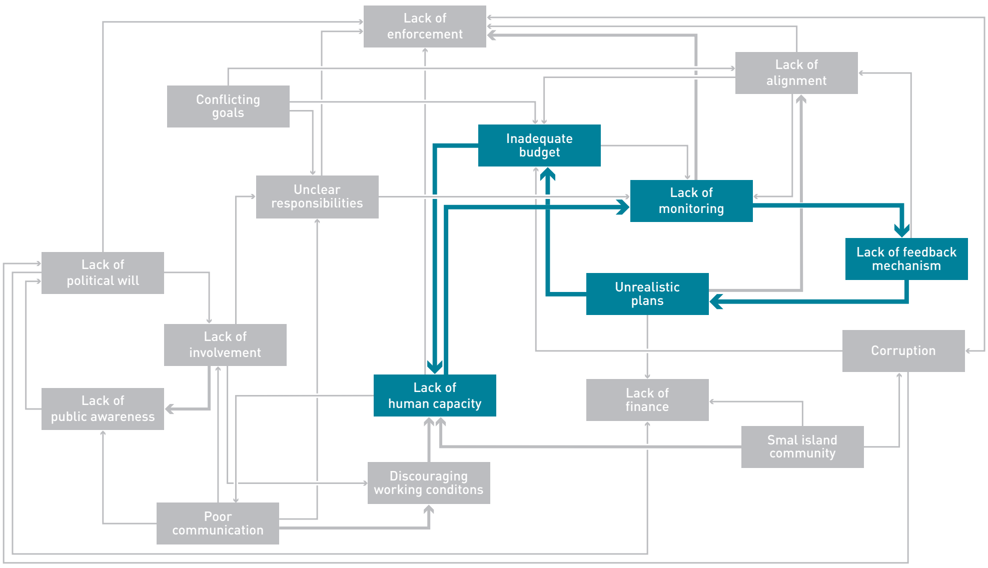
Smal island community
Discouraging working conditons
Poor communication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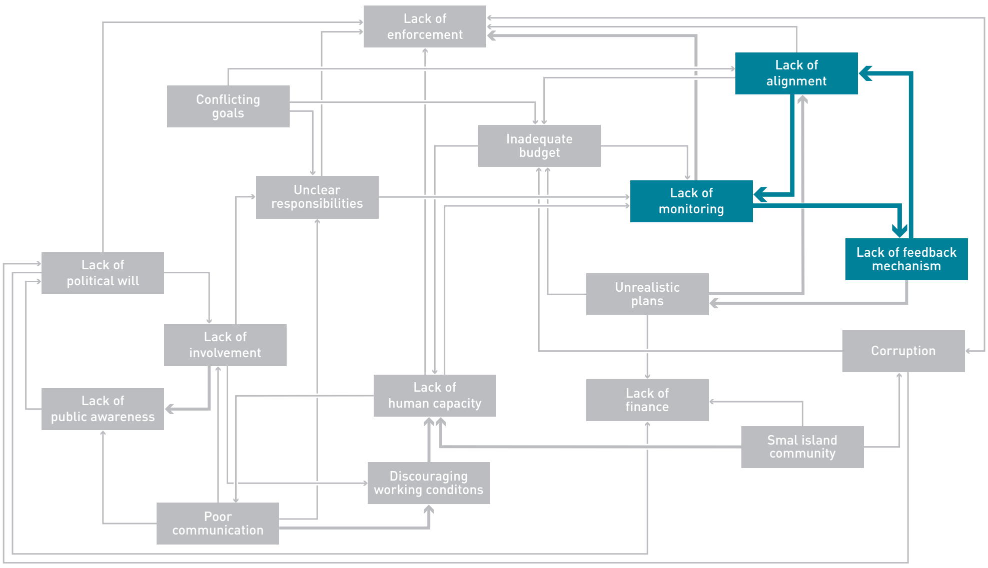
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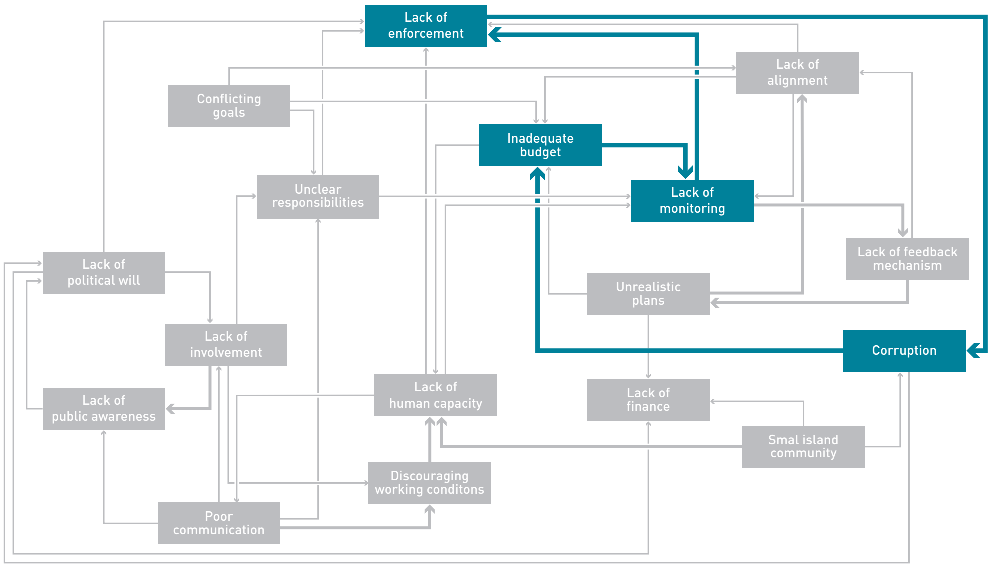
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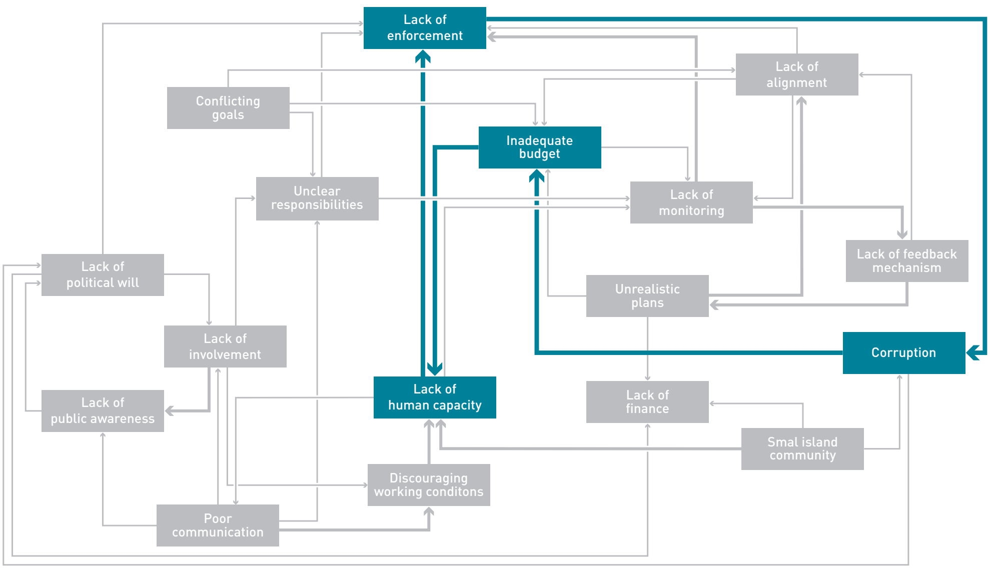
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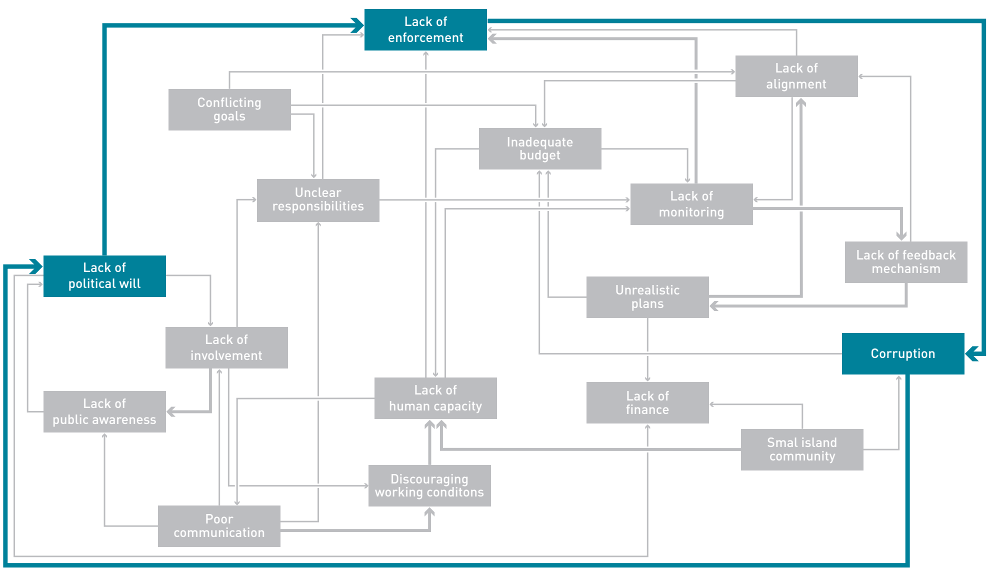
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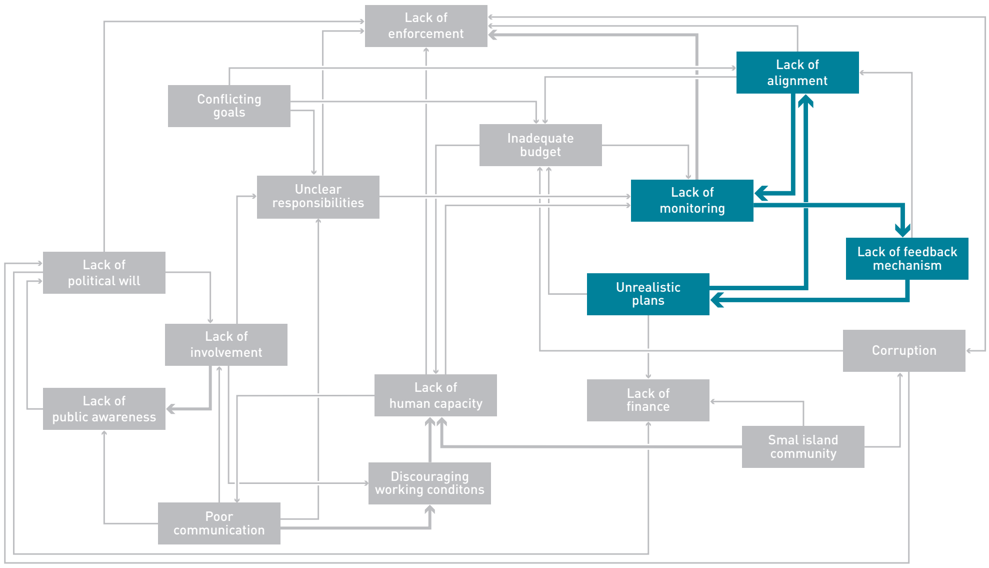

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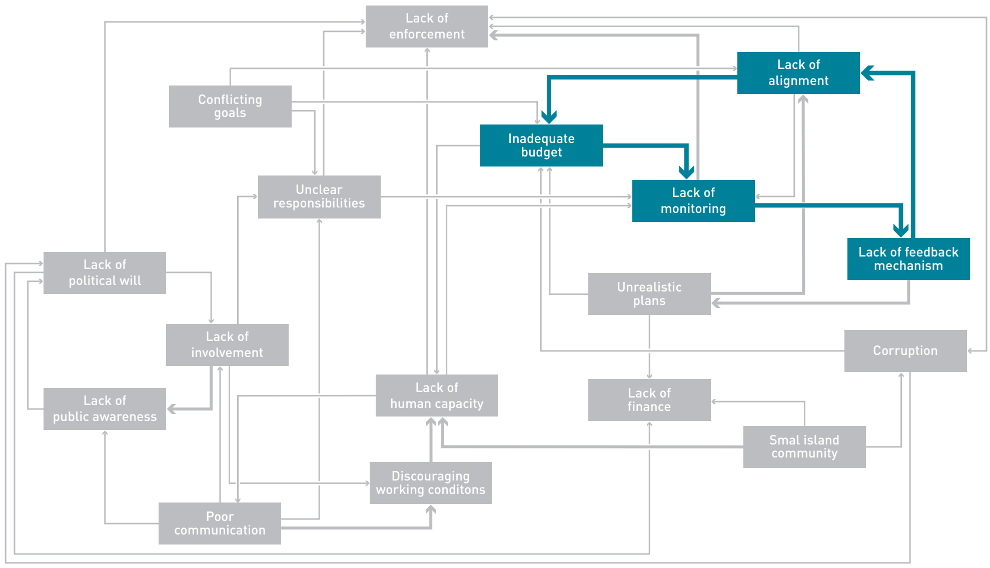

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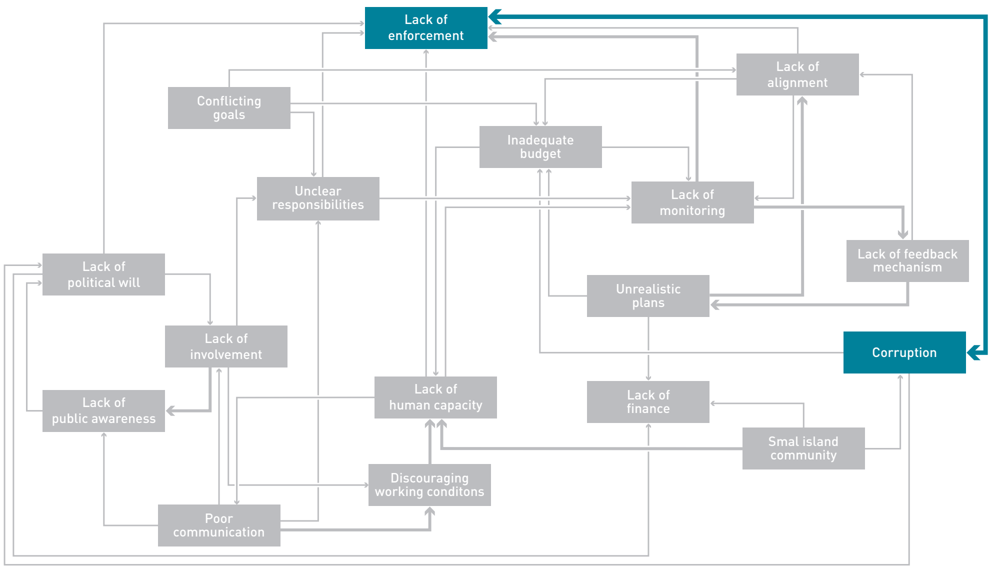

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Unrealistic plans
Lack of involvement
Corruption
Lack of human capacity
Lack of finance
Lack of public awareness
Smal island community
Discouraging working conditons
Poor communication

7.9 Data from Public Survey

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	I don't know	No answer
4	35	5	43	13	41	8
0	24	13	59	19	28	6
4	24	9	59	26	23	4
5	13	3	57	61	7	3
1	21	9	48	33	33	4
3	36	8	57	29	12	4
5	33	8	45	23	31	4

7.10 Proposed Actions from Stakeholder Workshop

Addressed reason (s)	Short description of action and procedures	Outcome	Involved institutions and stakeholders	Who is leading?	Resources Needed	Time frame of Action	Indicators to measure and evaluate progress
Lack of communication between stakeholders	Set / identify / agree on clear responsibilities between different stakeholders	Monitoring and evaluation mechanism in place	Ministry Civil Society LWMA, NGO's Public	LWMA	Budget / Human and Technical Experts	N/A	A monitoring and evaluation mechanism is put in place
Lack of monitoring	Ensure that plans include clear monitoring and evaluation mechanism	Implementation plan produced as per stakeholders responsibilities	N/A	N/A	N/A	N/A	Communication
Budget to implement plans	The need for the Parastatals to be financial Autonomy; Ministry of finance put in place the required mechanism	Financial regulation set; Autonomy of the different Agencies	Ministry of Finance Auditor General LWMA	Ministry of Finance	N/A	N/A	N/A
External Assistance (only money)	Clear budget along with targets; Sources of funding and link with local financing system	Financial plan that can be fitted into the annual budget	Finance Ministries Departments and Agencies	Ministry of Finance	Staff	3 years	N/A

Allocation of responsibilities	Having clear targets, timelines, actions required to achieve success; Draft of Assignment sheet; Crafting of SMART targets and Assigning to officer / works	System easy to understand, evaluate and enforce; Whole/Partial Achievement Indicators	HR, LWMA, MEECC	Third party without interest	Money, Time 1 or 2 skilled staff	1–2 years	Quarterly reports
Clear monitoring system for waste management plans	Link solid waste management plans to the Department & Agency Year plan and CEO's and other staff contracts; Set SMART targets; Retention to be based on performance of established indicators	Increased ownership of plans; Greater level of actions implemented	Department of waste management & related Agencies	N/A	N/A	N/A	N/A
Lack of human capacity for at high technical level	Avoid frequent movements of PS, CEO's, and other Senior officials; Ensure appointment of such persons based on merits other than political considerations; Regular training programme for technical persons in waste management as well as other areas of management	Improved management of services; Improved service delivery; Better implementation of plans	Cabinet ; Ministry of Environment, related Agencies Media , Civil Society	Ministry of Environment, UniSey, Guy Morel Institute, / ANHRD	N/A	N/A	N/A
Lack of manpower / capacity	Create a Waste management course at Unisey; Get more funding to create more post in Waste management department	We will be able to implement the targets and plan. 'deliver'	Ministry of Finance, Ministry of Education, Ministry of Human Resources, Ministry of Environment	Ministry of Human Resources, Ministry of Environment	Finance and Human Resources	throughout the years, every year	Beefed up' waste section

Lack of public awareness	Use the media to educate & inform the public on various waste management issues, projects and linkages with other relevant matters; Place sign boards to convey various consequences related to waste issues, sanctions for contravening waste related laws; Mobilize public for mass participation in cleaning activities	Engaged public; informed public; Less littering, (cleaner Seychelles)	MEECC, LWMA, NGO's, Media, Educational Institutions	MEECC and LWMA	Finance and Volunteers	This should be done continuously, throughout the year every year	Less illegal dumping, littering; More public participation
Unclear allocation of responsibilities	Sector plans and procedures, protocols; Legislation; Budgetary support; Political (Executive Directives)	Swifter and effective implementation of plans	Government, MDA's NGO's , Private sector	Government	Finance, Human Resources	N/A	N/A
Lack of Financing	Ensure well defined sectorial plans incorporated into SWM, National Development strategy, MTES, Annual action plans	Increase revenue streams in SWM (Waste management fund)s; More investment in infrastructure, Manpower Dev, HR Dev; More collaborations and partnerships; Incentives for private sector	Government and authorities, Civil society , Private sector, population at large	Government with support of legislative	Financial and Human Resources	N/A	N/A
Unclear allocation of responsibilities	Sector plans and procedures, protocols	N/A	N/A	N/A	N/A	N/A	N/A

USYS TdLab Transdisciplinary Case Study 2018

After transdisciplinary Case Study (tdCS) 2016, the topic of tdCS 2018 was again solid waste management (SWM) in the Seychelles.

SWM is an ongoing and significant challenge for the Seychelles. Landfilling is the currently employed waste management strategy for almost all waste classes. Waste generation has continuously increased over the last years, but landfill construction has not kept up with this increase. Recycling of PET, aluminium cans or scrap metal is in place, and these items feed into international waste streams.

The study focused on waste treatment options and related requirements, such as waste input (sorting), financial mechanisms and implementation measures.

The case study was split into seven groups to gain comprehensive and in-depth knowledge on the following investigated topics: Waste Collection and Sorting, Feasibility of Recycling, Hazardous Waste Flow, Anaerobic Digestion, Incineration, Financial Mechanisms and Implementation of Plans. The methods employed varied across groups and included literature reviews, semi-structured interviews, surveys, stakeholder workshops, multicriteria assessment, material flow analysis, asset dimensioning and cost analysis.

The study's results show the potential for expanding the recycling system to glass and organic materials, for example. Aside from landfilling, alternative treatments include AD of organic matter, which would produce energy and fertiliser. Our study has examined waste incineration as another form of waste treatment. Combustion substantially reduces the waste volume up to 80%, and heat can be used for electricity production (10–15% of the Seychelles' total energy production). However, these waste treatment options are only feasible and work efficiently if certain waste fractions are separated prior to or during collection. Separation is best done at the source. A consumer survey's results show that people seem prepared for such a sorting regime. However, apart from a handful of redeem centres that are widely spread over Mahé, no suitable sorting infrastructure is currently in place. Our study also shows that hazardous waste is one of the blind spots in waste management. An overview of hazardous waste is lacking, a gap that our study started to fill. No matter what new activities may be introduced, they all need meaningful political guidelines and regulations to ensure successful and sustainable implementation. This matter is all the more important because our study's results show that this was not the case in the past. However, there might be ways to overcome these barriers. An important prerequisite i this respect involves finances. The current financing system is rather complicated and consequently, not fully transparent. Overall, our study suggests an integrated waste management system of sorting, collection, recycling, treatment and dumping.

The case study involved 19 ETH master's students with diverse scientific backgrounds and 14 bachelor's students at the University of Seychelles. The research was conducted over six months, including a three-week field phase in the Seychelles. Researchers and teachers guided the students throughout the case study, supplemented by additional support from an advisory board of local experts. The students intensively engaged with numerous stakeholders from the government, public administration, the private sector and civil society.

This teaching-research course is the second tdCS as part of a collaboration agreement between the Transdisciplinarity Lab of ETH's Department of Environmental Systems Science and the University of Seychelles, as well as the Seychelles' Ministry of Environment, Energy and Climate Change.

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