ANALYSIS ON WASTE COLLECTION IN THE PERIPHERY OF SÃO TOMÉ CITY: LESSONS TO BE APPLIED IN AFRICAN CITIES

Projeto Bairro Limpo / Luxan non limpo
São Tomé e Príncipe

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LEIGOS PARA O DESENVOLVIMENTO

CAMÕES INSTITUTO DA COOPERAÇÃO E DA LINGUA PORTUGAL
MINISTÉRIO DOS NEGÓCIOS ESTRANGEIROS

Introduction

- The city of São Tomé is the capital and main city in the island republic of **São Tomé e Príncipe** (in the African Gulf of Guinea). The city is located in the north east coast of São Tomé island and its population is estimated in 80,000 inhabitants.
- As usual in other African cities, the population of São Tomé has been growing at a fast rate: from 50,000 in 2000 to an expected 100,000 in 2030.
- This fast growing rate is due to the global process population migration from rural to urban areas.
- As a negative consequence of this population growth, the city is not able to provide services like waste management to residents, especially those in peripheral areas.

**Maps adapted from OpenStreetMap and OpenTopoMap*

Current situation of waste management in São Tomé

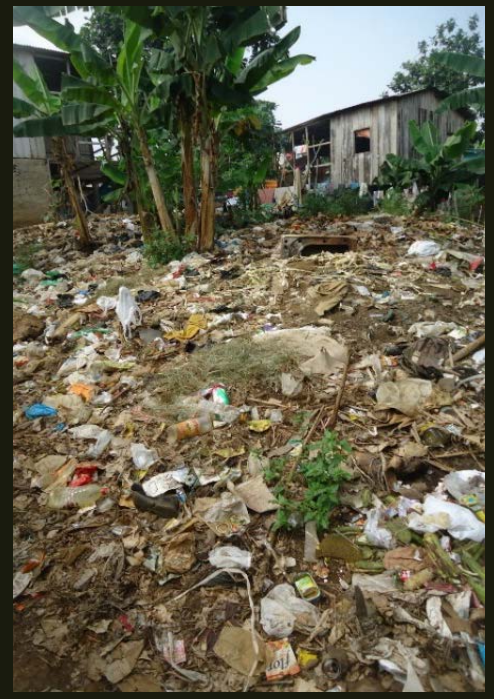
- Only the central, most urbanised area of the city has an organised waste collection, managed by a private company operating waste containers and collection vehicles with compactor.
- Some neighbourhoods are regularly served by a municipal collection van, with personnel who manually load the waste brought by residents along the streets.

Current situation of waste management in São Tomé

- All waste collected through the organised collection systems ends up in a massive landfill located in the outskirts.
- This landfill is not managed in a controlled and safe manner, so that the surrounding population is exposed to the pollution of water, soil and atmosphere.
- Moreover, the landfill is running out of space due to constant arrival of waste and no alternative for waste deposition in envisioned in the near future.

Current situation of waste management in São Tomé

- In the peripheral neighbourhoods where an organised waste collection scheme does not exist, the uncontrolled deposition of waste in the surrounding environment is the usual practice. Piles of waste are thus scattered everywhere, always near of the dwellings were they come from.
- Burning waste is also a usual practice, either for eliminating the volume of waste deposed or for recovering of valuable materials (i.e. metal wires).



Project description

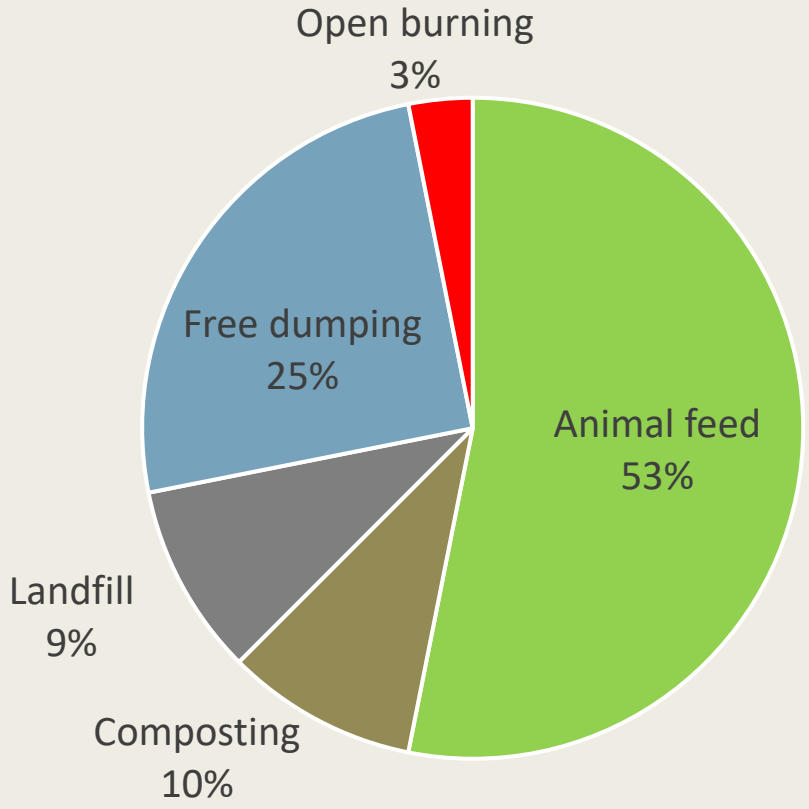
- Within the context previously explained, the project Bairro Limpo / Luxan non limpo (“clean neighbourhood”) was developed by a group of associations representing the residents of Boa Morte neighbourhood, in collaboration with the Portuguese NGO “Leigos para o Desenvolvimento” and with the technical assistance of the Polytechnic Institute of Coimbra.
- Boa Morte is one of the residential areas in the periphery of the city which are not served by the organised waste collection services, in spite of its proximity to the landfill.

- The main goal of the project is to put into practice a regular scheme of waste collection, totally managed by the group of residents, self-sufficient from a financial point of view and with a low carbon footprint without compromising the efficiency of the service.
- An additional goal of the project is also to promote cleaner forms of waste treatment: home-composting and basic recycling.

Current situation of waste management in São Tomé

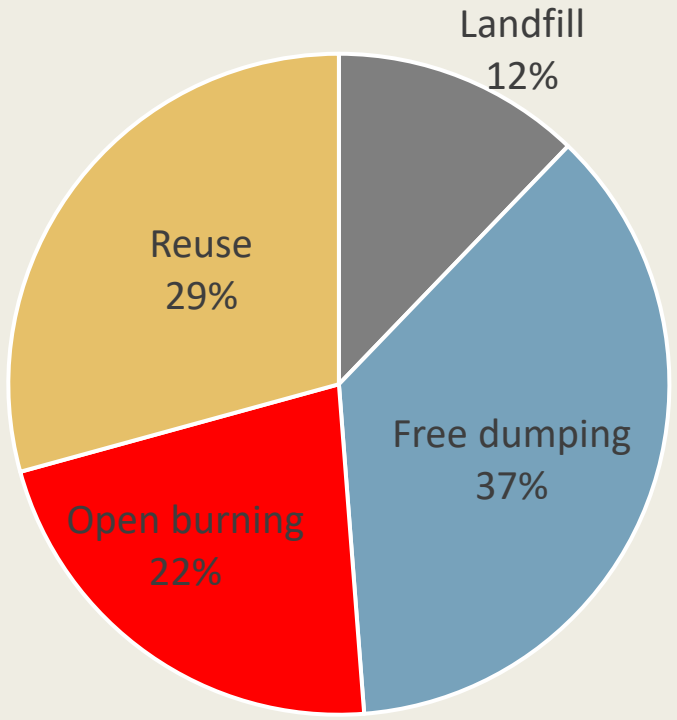
- A survey was made in the neighbourhood to confirm their waste management practices:

“Wet” wastes = biowaste (% answers)



Answers: 38

“Dry wastes” = non-biowaste (% answers)

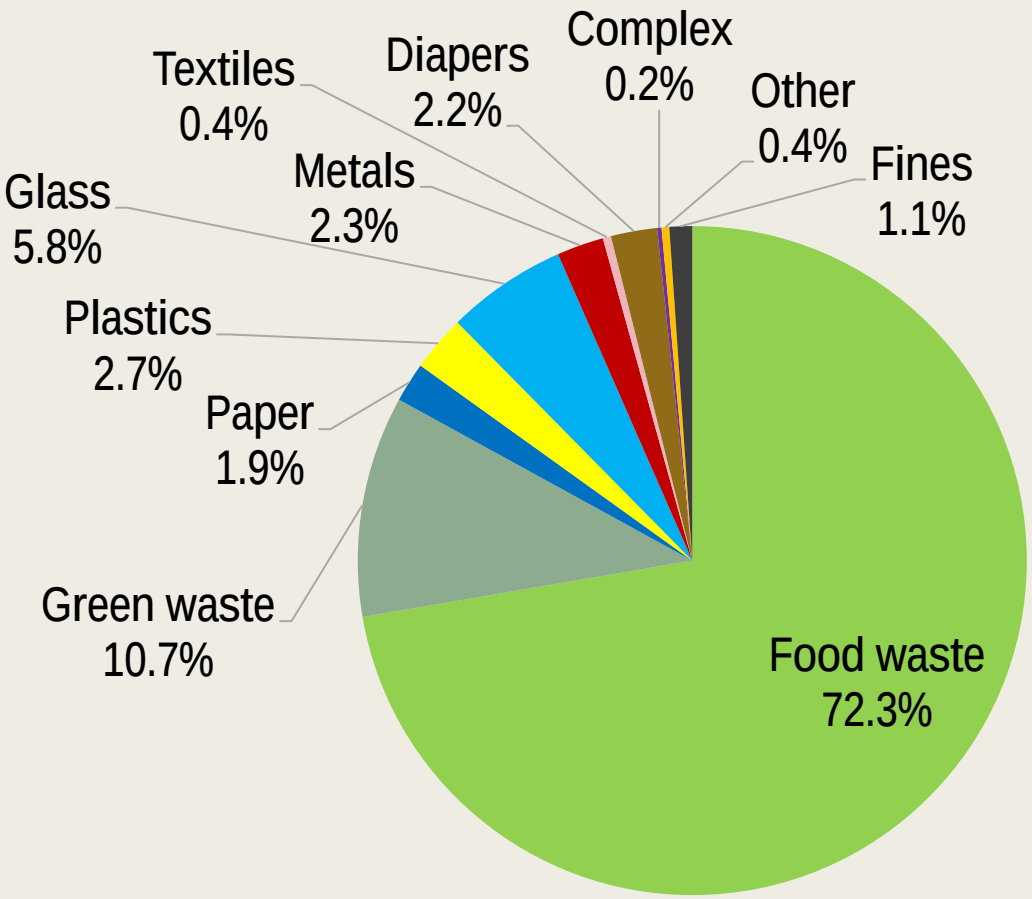


Answers: 52

Quantification of waste generation

- The amount of waste generated by a sample of families was monitored (weighted) during 1 week.
- Results:
  - Biowaste: **0.40 ± 0.26 kg·person^{-1}·day^{-1}**
  - Non-biowaste: **0.10 ± 0.08 kg·person^{-1}·day^{-1}**
  - Total: **0.50 kg·person^{-1}·day^{-1}**
  - *Total Monday–Friday: 0.43 kg·person^{-1}·day^{-1}*
  - *Total in weekends: 0.60 kg·person^{-1}·day^{-1}*

Waste characterisation



*Total sample weight: **220 kg**

Looking for a feasible collection system

- Waste collection solutions implemented in São Tomé – as in other cities of developing countries – have been hampered by a mix of inadequate technical choices and inefficient financial management.
- Complex equipment (vehicles, compactors, bins), often imported from foreign countries, show a poor performance in this context, due to a combination of:
  - Difficult terrain (most secondary roads are not paved), with increased attrition.
  - Harsh climate conditions (high temperatures accelerate corrosion).
  - Lack of technical support: difficulties to obtain spare parts and low experience for maintenance and repairs.
- **Conclusion:** A feasible solution for waste collection in São Tomé should therefore be based in locally accessible technology, adapted as much as possible to the local conditions, easy to operate and maintain.

Looking for a feasible collection system

- In the financial perspective, waste management is typically affected by insufficient funding. The necessary investments in equipment and personnel rely often on external donations received through development aid programmes. However, these programmes tend to be abandoned once the external funding has finished.
- The payment of waste fees by citizens is not generalised, and anyway the less favoured population is not willing to afford them: other harmful but inexpensive alternatives such as dumping and burning household waste are preferred.
- As a consequence, only the central, most urbanised areas of the city are served by the organised collection schemes, since it is there where high-income population and companies able to pay fees are concentrated, and where collection is easier due to a more defined urban infrastructure. Peripheral and less developed areas remain ignored by the responsible authorities.
- **Conclusion:** although external contributions remain essential for making important investments, it is necessary to implement a payment system of waste fees, with the goal of at least support the operating costs of a waste collection system; otherwise any new attempt to establish such a system will likely fail.
- The collection of fees should be necessarily based on those population sectors which actually are able to pay, with special focus on companies. This group should indeed subsidise the service provided to the rest, less favoured population (at least for the first moment).

Looking for a feasible collection system

- In view of the context referred, the vehicle chosen corresponds to a motor tricycle (powered by a gasoline engine with 150 cm^3).
- This type of vehicle is very common in the country (and the particular model chosen is widely distributed), therefore local mechanic technicians have enough experience to perform repairs, and supply of spare parts is also not difficult.
- Moreover, since its technology is not complex, the maintenance tasks are not complicated to perform.
- Even though the size of wheels is small, the vehicle is capable to move along unpaved and narrow roads, where other larger vehicles would not be able to circulate, or only with great difficulty.

Looking for a feasible collection system

- However, the main disadvantages of this kind of vehicle refer to the limited loading capacity:
  - The maximum payload is 600 kg (including the driver), but for optimal performance it should not be greater than 300 kg.
  - However, the most restrictive constraint is the volume capacity of the loading compartment: it was measured as **0.64 m³**.
  - Assuming 100 kg/m³ as the specific weight of waste, this corresponds to **64 kg**.
  - According to the experimental data previously collected, 64 kg would be the weight of waste produced by 128 persons, or approximately 25 households.

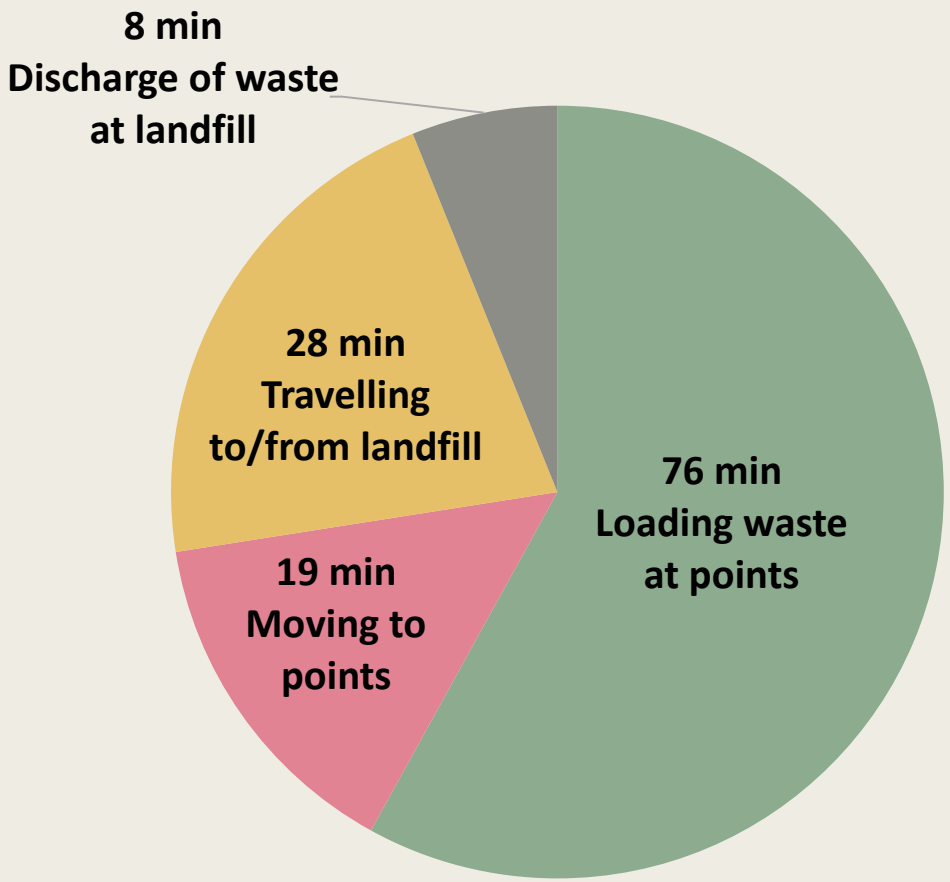
- This limited capacity may only be compensated if the final destination of waste is not far from the collection area, thus allowing more transportation trips without critically increasing fuel and time consumption.
- This is the case in the selected neighbourhood, since the landfill is only 1.5 km away from the starting point of collection.

Evaluation of sustainability

- The vehicle started to operate during the year 2020, serving initially 18 points of collection (including households, commercial establishments, a residence and waste bins in the street).

- Its performance was evaluated in order to determine how sustainable is this mode of collection.
- Geo-referenced recordings of the collection circuit were performed, in order to determine the parameters of operation.

Evaluation of sustainability



- Collection takes place 3 times per week on Monday, Wednesday and Friday
- Average distance travelled per day: 10.8 km
- No. trips to landfill: 2 or 3
- Average speed: 14 km/h
- Maximum speed: 44 km/h
- Average total time: **131 min**
- Average stop time: **4.2 min**

Most of the working time the vehicle is stopped.

Environmental evaluation: carbon footprint

- Fuel consumption per working day: **3 litres** (gasoline).
- Waste collected: **192 kg** (3 x 64 kg) per working day.

9.9 kg CO_2 / day

Performance indicators
14.3 L fuel / tonne collected
51.5 km / tonne collected
27.7 L fuel / 100 km

Environmental evaluation: carbon footprint

- Simulated comparison of different vehicles types:

- 70 kg CO_2 eq. per 1 t waste

- 36 kg CO_2 eq. per 1 t waste

- 24 kg CO_2 eq. per 1 tonne

The collection with motor tricycle might be environmentally acceptable, provided that collection points are not too distant.

Financial evaluation

Revenues (per month)		Costs (per month)	
Fees paid	1200 STN (49.0 EUR)	Fuel consumption	1170 STN (47.8 EUR)
		Maintenance	500 STN (20.4 EUR)
		Spare parts	140 STN (5.7 EUR)
		Insurance + taxes	160 STN (6.5 EUR)
		Other (clothes, phone, assistance)	449 STN (18.3 EUR)
Subtotal	1200 STN (49.0 EUR)	Subtotal	2419 STN (98.7 EUR)
Vehicle renting	2520 STN (102.9 EUR)	External costs	1332 STN (49.0 EUR)
TOTAL	3720 STN (151.9 EUR)	TOTAL	3751 STN (153.1 EUR)

*1 EUR = 24.5 STN (Exchange rate is fixed since 2018)

- Without the external revenues, the current financial structure is not sustainable.
- There are no personnel costs (salaries) in this model: the driver does this activity for free, provided that he can profit for using the vehicle the rest of time for other external professional activities at a low price (a kind of renting); the rest of tasks are assumed by the resident's association.
- The fee paid for each customer is 100 STN (4.08 EUR) per month. This is somewhat high for the domestic economy.

Simulation of future progress

- The system should be expanded in the near term within the limits of the neighbourhood, aiming at:
  - including a substantial part of the population.
  - optimising resources.
  - avoiding dependency on external factors.
- A simple linear model was developed to represent the future expansion, based on these assumptions:
  - On average, a household has 5 members, each producing 0.5 kg of waste daily.
  - During collection, the number of stops increases accordingly to the number of households served.
  - The journey duration and fuel consumed do not increase when new households are included, because it is considered that the collection route is not substantially altered.
  - For every 6 households included, a journey to the landfill (and back) is required.
  - Time required and fuel consumed increase accordingly to the number of trips to/from landfill.
  - For the sake of simplicity, other costs remain fixed (maintenance).

How is the variation of costs and revenues if more households join?

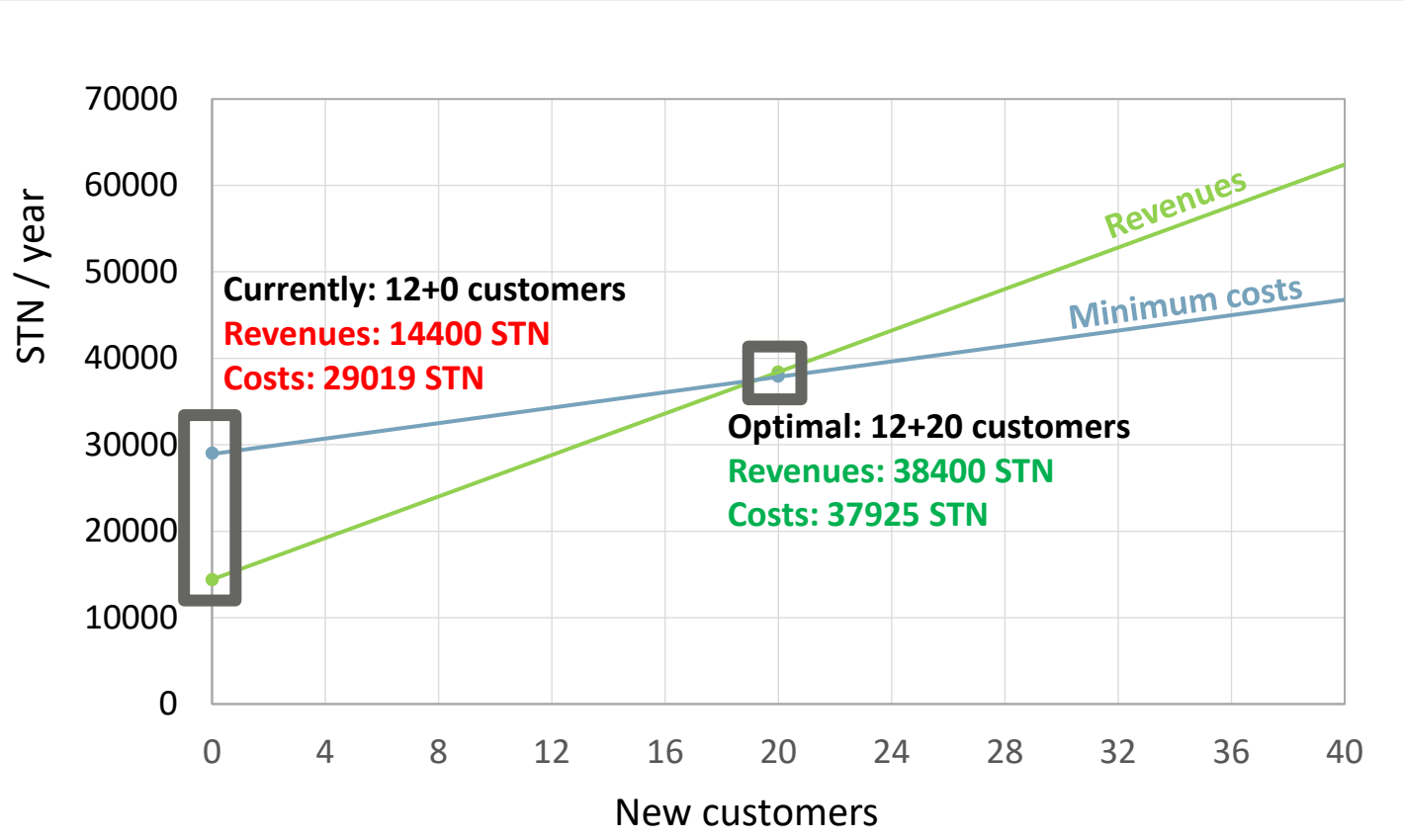
Simulation of future progress

- The minimum sustainability goal corresponds to support all expenses (operating costs) without any external contribution. This can only be accomplished when more customers (households or establishments) are incorporated to the collection service (because they are willing to pay for it).

No. customers	People included	Waste collected (kg)	Trips to/from landfill	Working time	Relative cost per 1 tonne collected
Current: 12 + 6 street bins	60	107	3	2h11min	1850 STN (75.5 EUR)
36	150	220	6	4h34min	1140 STN (46.5 EUR)
45	195	277	7	5h34min	990 STN (40.4 EUR)
54	240	333	8	6h45min	890 STN (36.3 EUR)

How many customers are necessary to achieve sustainability?

Costs/revenues comparison: **base scenario**

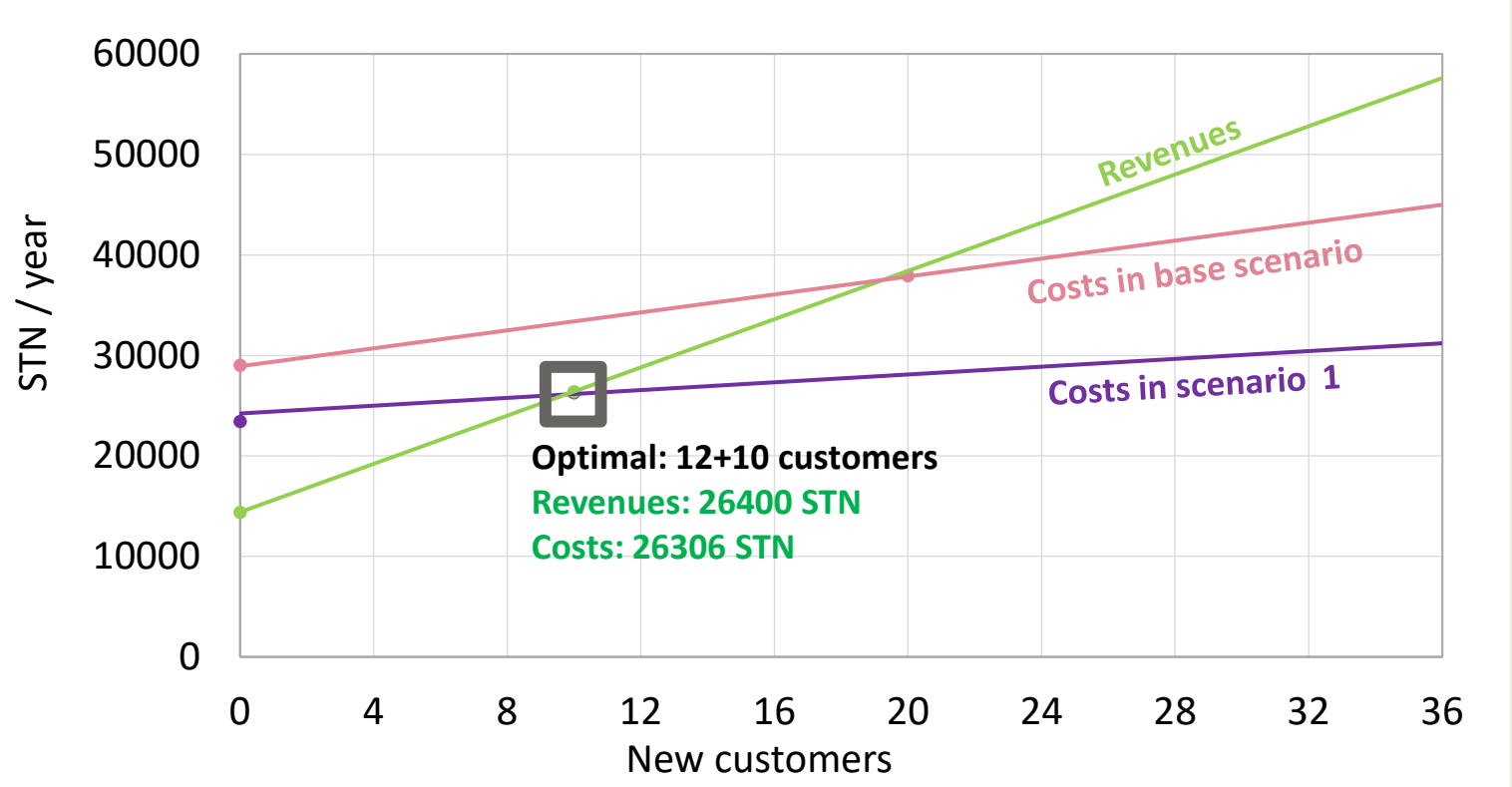


- Balance between revenues and costs reached with **32 customers**.
- All expenses (except salaries) are covered.

Required working time: **4h32min** (too much)

Costs/revenues comparison: **scenario 1**

- **<u>Improvements</u>:**
  - If more households are added to the collection route, then the waste will be more compactes and so the specific weight will always be around 100 kg/m³.
  - The loading capacity can reach 1 m³ by adding a rear wall 20 cm higher than the current one.
- **<u>Effect</u>: the trips to/from landfill will be reduced by ⅓.**

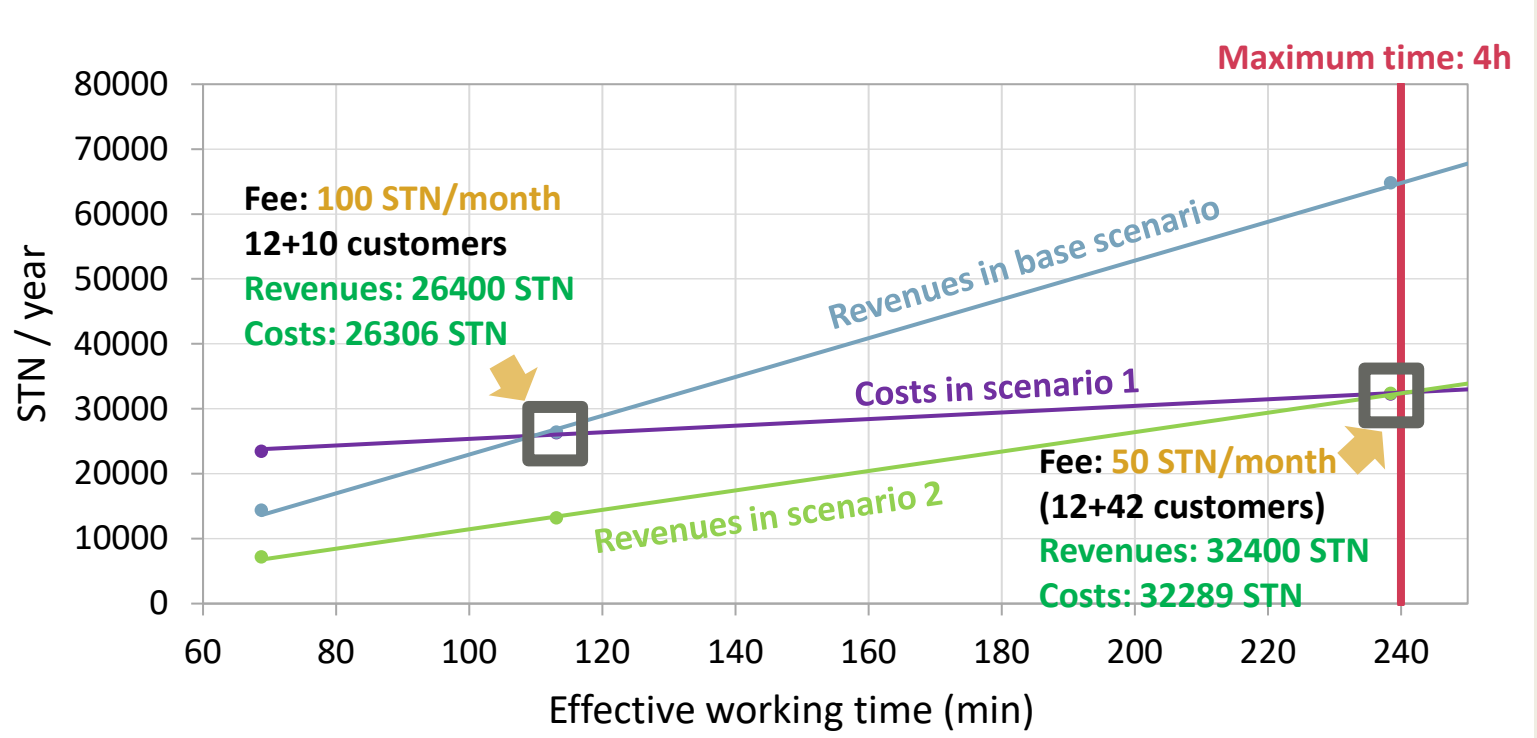


Required working time: **2h55min**

This leaves some further time available for resting pauses and auxiliary tasks.

Costs/revenues comparison: **scenario 2**

- **<u>Improvement</u>:**
  - Reduce duration of stops from 4.2 min down to 2 min, by establishing a tight collection schedule for every household.
  - Effective working time is fixed in 4 hours.



- **<u>Effect</u>: <u>productivity is increased so that the fee can be lowered</u>.**

Expanded scenario: adapted to separate collection

- With the introduction of composting, a separate collection scheme will be required, with specific collection days for each of both waste fractions *wet* and *dry.*
- Based on the previous results, an expansion of the model is proposed:
  - 4 working days per week instead of 3
  - 66 collection points served per working day (in conditions given by scenario 2)

Customer type	Fraction	Specific weight	Collection frequency	Monthly fee	No. customers	No. collections				
						Mon.	Tue.	Wed.	Thu.	Fri.
Household	Wet	200 kg/m³	2x week	50 STN	66	66			66	
	Dry	50 kg/m³	1x week				46			20
Home-composting household	Dry	50 kg/m³	1x week	20 STN	26					26
Commercial	Mixed	100 kg/m³	2x week	100 STN	20		20			20

Expanded scenario: adapted to separate collection

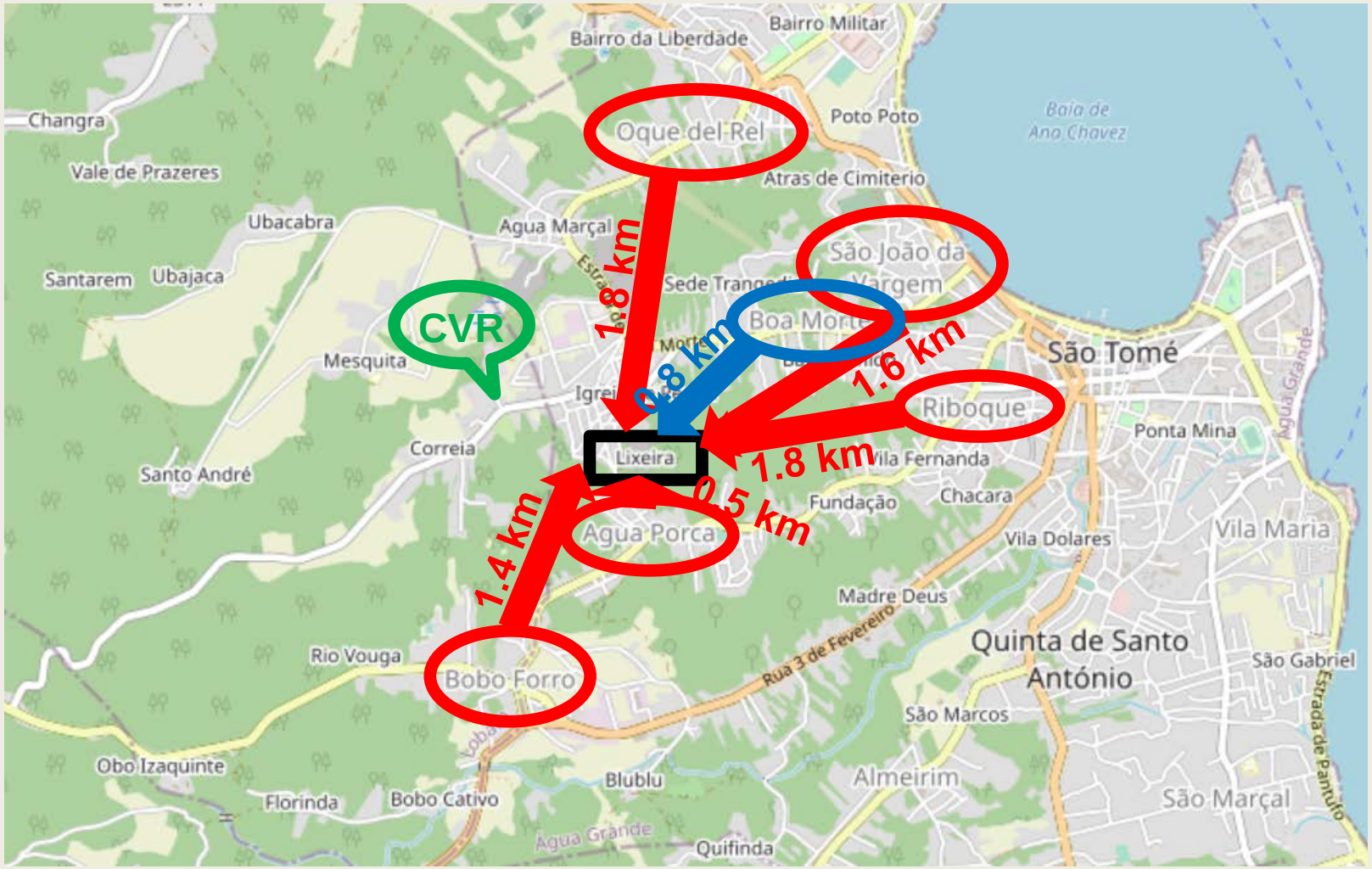
- Increased revenues would allow to pay a salary to the driver:

Annual revenues	Annual costs	Waste collected	Cost / waste collected
69840 STN (2838 EUR)	54529 STN (2226 EUR)	75.1 tonnes/year	730 STN (29.8 EUR)/tonne

- Further collection circuits may be established in the remaining time of the week still available. Consequently, the external renting of the vehicle would no longer make sense, but actually it is not anymore required once the sustainability has been achieved by own means.
- If all the available time is used for collection, then the difference between revenues and costs will be used for paying a full-time salary to the driver, who will become an employee.

Conclusions

- It has been demonstrated that a simple, self-sustained and effective waste collection system can be implemented in neighbourhoods of African cities where the collection distance is short.



- In the case of São Tomé, at least the townships which lie closer to the landfill and/or composting centre could benefit from such a system.
- In further areas, an interaction with the municipal waste service collection will be necessary in order to operate such small-scale schemes.

Conclusions

- Small-scale, low-tech and community based waste collection schemes may well be more effective and sustainable for waste collection in developing areas than expensive and highly complex massive systems.
- In opposition to developed countries, labour costs are low when compared with management costs of machines. Moreover, generation of local employment has a relevant social value in the less favoured neighbourhoods.

THANK YOU!

And special greetings to Boa Morte local community and team of Leigos para o Desenvolvimento!