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Optimising Waste Collection with AI -
creating a robust approach

QUICKLY (WASTE COLLECTION IN SINGAPORE)

›› SINGAPORE IS SMALL BUT DENSE

›› LANDFILL ISLAND!

›› 7 DAYS A WEEK COLLECTION + 1 X WEEK- RECYCLABLE COLLECTION)

›› VERY LOW COST (R80 PM PER HOUSEHOLD, R300 PER LARGE LANDED HOUSES)

›› LOW COSTS BECAUSE OF DENSITY

›› HIGHEST COMPONENT DISPOSAL (COSTS R900 PER TON)

›› FACES SAME STRUGGLES ARE EVERYWHERE ELSE!

WASTE COLLECTION SYSTEMS ARE UNDER PRESSURE

1 FRAGILE **2** BECOMING MORE COMPLEX **3** STRUGGLES WITH CHANGE

CONFIDENTIAL

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R7.3 billion (€500 million)
2010 waste management bill
Source: National Treasury (2011).

CONSEQUENCES OF SUDDEN CHANGES TO THE SYSTEM

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›› **Waste is not collected**

›› **Costs a lot and money to fix**

›› **Trial-and-error approach to attempt to fix it**

HOW TO DEAL WITH THESE CONSEQUENCES

›› **Rely on (very) experienced personnel**

›› **Take lessons from other municipalities**

›› **Higher consultants / throw money at the problem**

›› **Ignore-it / hope it goes away**

ALTERNATIVES

›› **Get ahead of it**

›› **Invest time and resources now**

›› **Leverage new technology**

›› **DIGITISATION for better planning**

DIGITISATION OF WASTE MANAGEMENT
PLANNING & OPTIMISATION PLATFORM

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1

2

3

WASTE COLLECTION DATA

DIGITAL TWIN

WASTE COLLECTION SYSTEM

Collector's Data

Open & Waste Labs Data Sets

Diagnostics of existing system

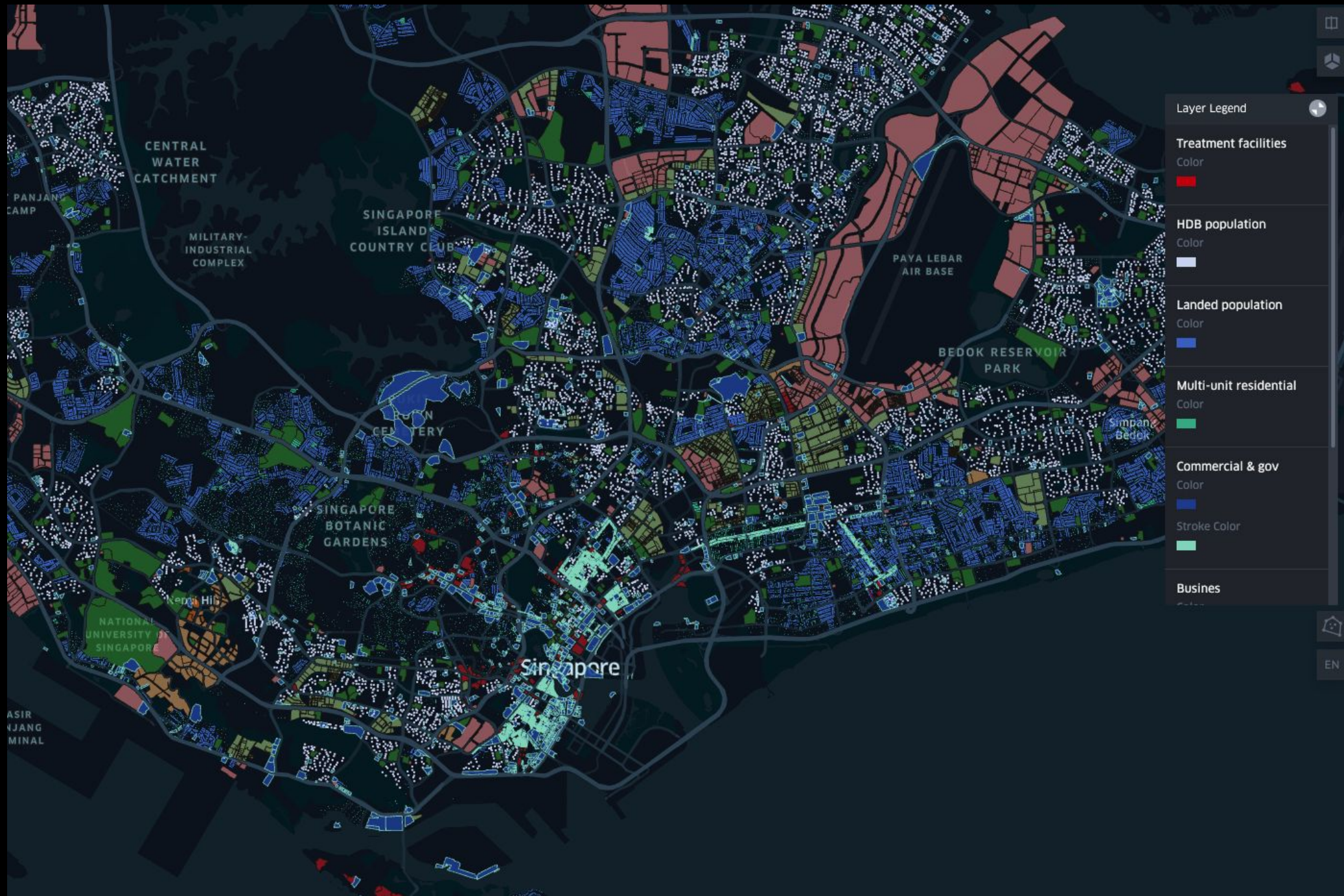**Planning for different scenarios**

Optimisation of the system

INPUT DATA

>> **GPS data of the vehicles -** *common*

>> **Load-cells (tracking amount collected) -** *rare*

>> **Daily and landfill weighbridge data -** *fairly common*

>> **Synthetic population -***rare (South Africa is an exception)*

>> **Building data -** *fairly common*

>> Whatever is available really

RESULTS- what comes out of it

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›› **Exposes weaknesses in current system (overutilized crews, equipment, etc)**

›› **Detailed scenario simulation and comparison:**
How many trucks do you need under different conditions.

›› **Optimisation: prescriptive, shows how many vehicles are needed, their routes and schedules, and prioritised collections**

Layer Legend

Treatment facilities
Color

HDB population
Color

Landed population
Color

Multi-unit residential
Color

Commercial & gov
Color

Stroke Color

Busines

Cape Town

NEWLANDS
FOREST

BELLVILLE
MARSHALLING
YARD

DRIFTSANDS
NATURE
RESERVE

CAPE FLATS
WASTE WATER
TREATMENT
WORKS

RHEINMETA
DENEL
MUNITION
SOMERSET
WEST

04/12/20
07:32:21am — 09:17:24am

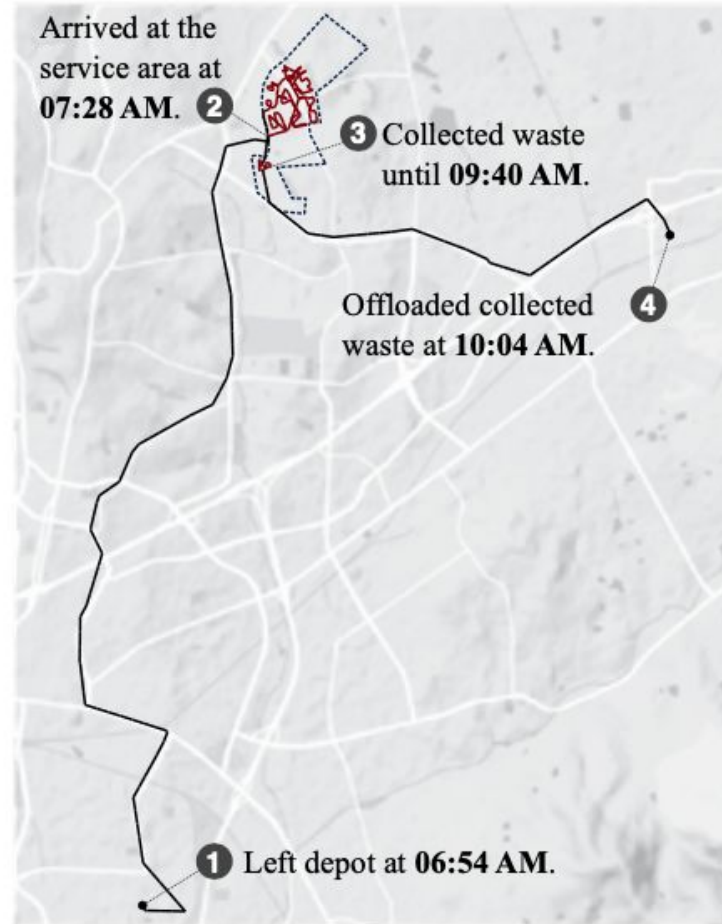t   Y Axis   1x

12   01 AM   02 AM   03 AM   04 AM   05 AM   06 AM   07 AM   08 AM   09 AM   10 AM   11 AM   12 PM   01 PM   02 PM   03 PM   04 PM   05 PM   06 PM   07

EN

FULL COLLECTION ROUTE

Collection beat

Collection travel

Landfill

Non-collection travel, to and from the beat, the landfill and the depot.

Vehicle depot

Complete route (06:54–12:51)

COLLECTION ROUTE SPLIT OVER ITS TWO SUB-ROUTES

Arrived at the service area at **07:28 AM.** ②

③ Collected waste until **09:40 AM.**

Offloaded collected waste at **10:04 AM.** ④

① Left depot at **06:54 AM.**

Sub-route 1 (06:54–10:04)

⑥ Collected waste until **12:05 PM.**

Arrived at the service area at **10:25 AM.** ⑤

Offloaded collected waste at **12:25 PM.** ⑦

⑧ Arrived back at depot at **12:51 PM.**

Sub-route 2 (10:04–12:51)

VEHICLE ACTIVITY TIME-LINE OVER THE COURSE OF A DAY

At depot   Waste collection   At landfill   Waste collection   At landfill At depot

① ②   ③   ④ ⑤   ⑥   ⑦ ⑧

6:54 7:28   9:40 10:04 10:25   12:05 12:25 12:51
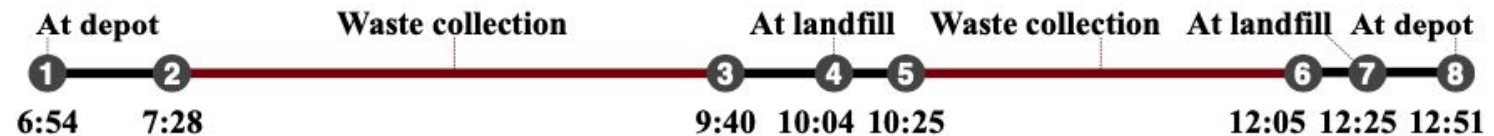
COSTING PER VEHICLE TYPE & ACTIVITY

On average, it took **6.1 hours** to complete the collection route.

On average, **4.1 hours** was spent collecting waste. The rest was spent outside the service area.

On average, the vehicle travelled **79 km** to complete the collection route.

On average, **18 km** was travelled while collecting waste. The rest was spent travelling to and from the beat.
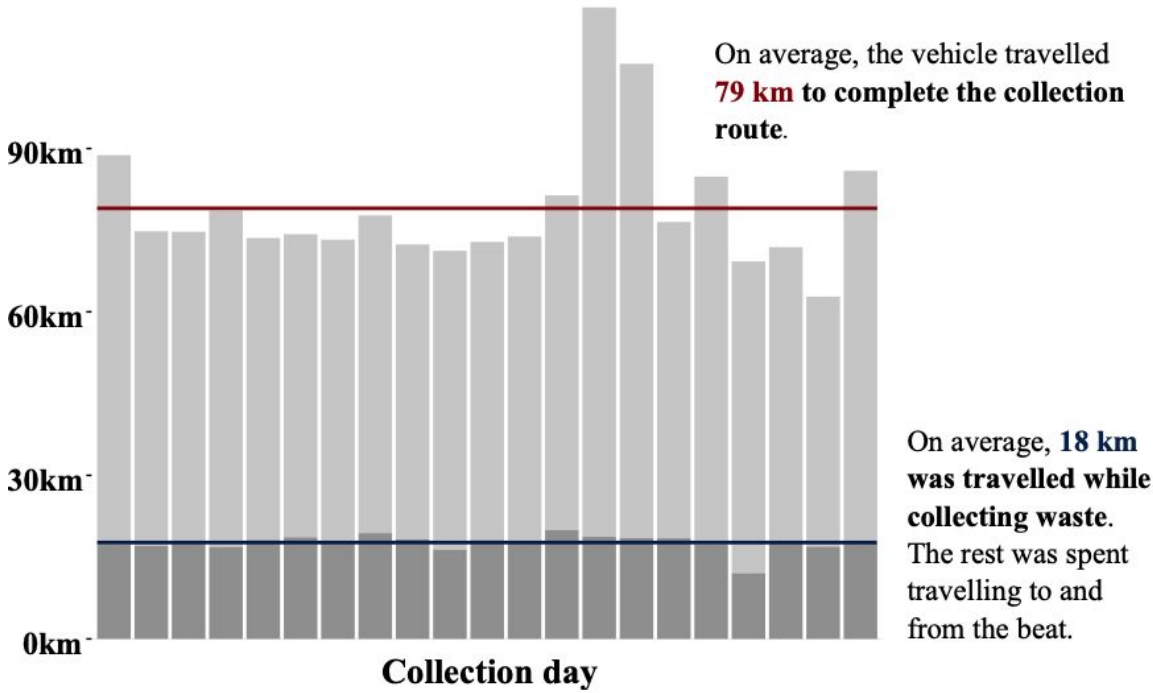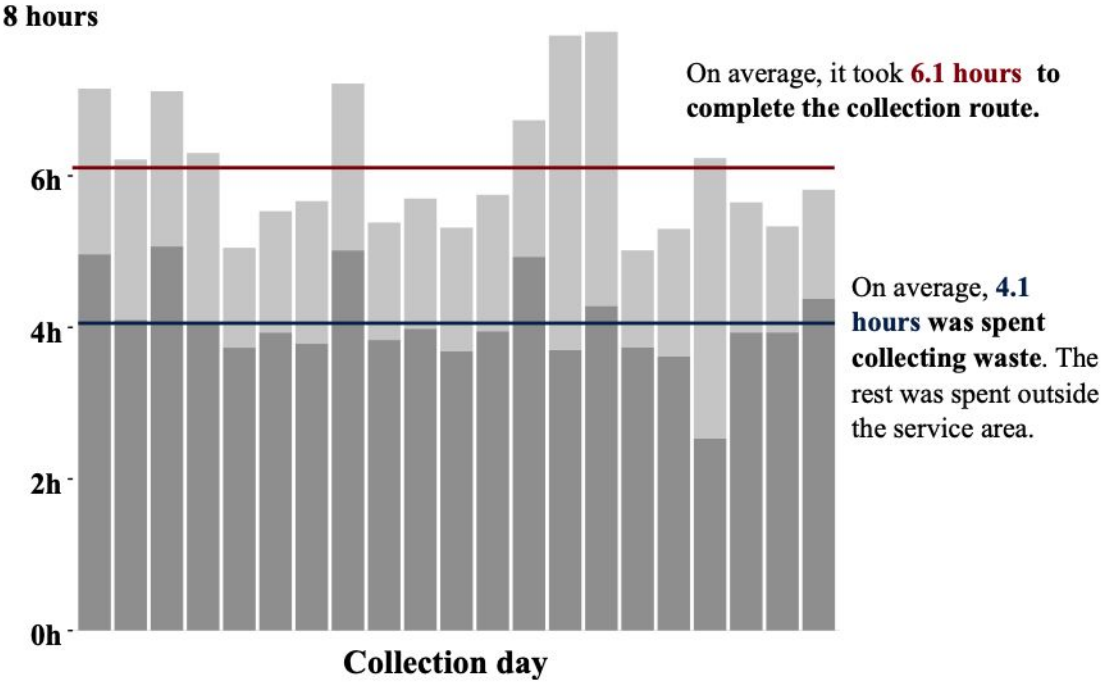
Resource planning

General waste and mixed recyclables collection

Document info

Area of interest:	Clementi, Singapore
Prepared by:	Waste Labs (wastelabs.co)
Prepared for:	Demonstration purposes
Contact:	info@wastelabs.co

Select scenario

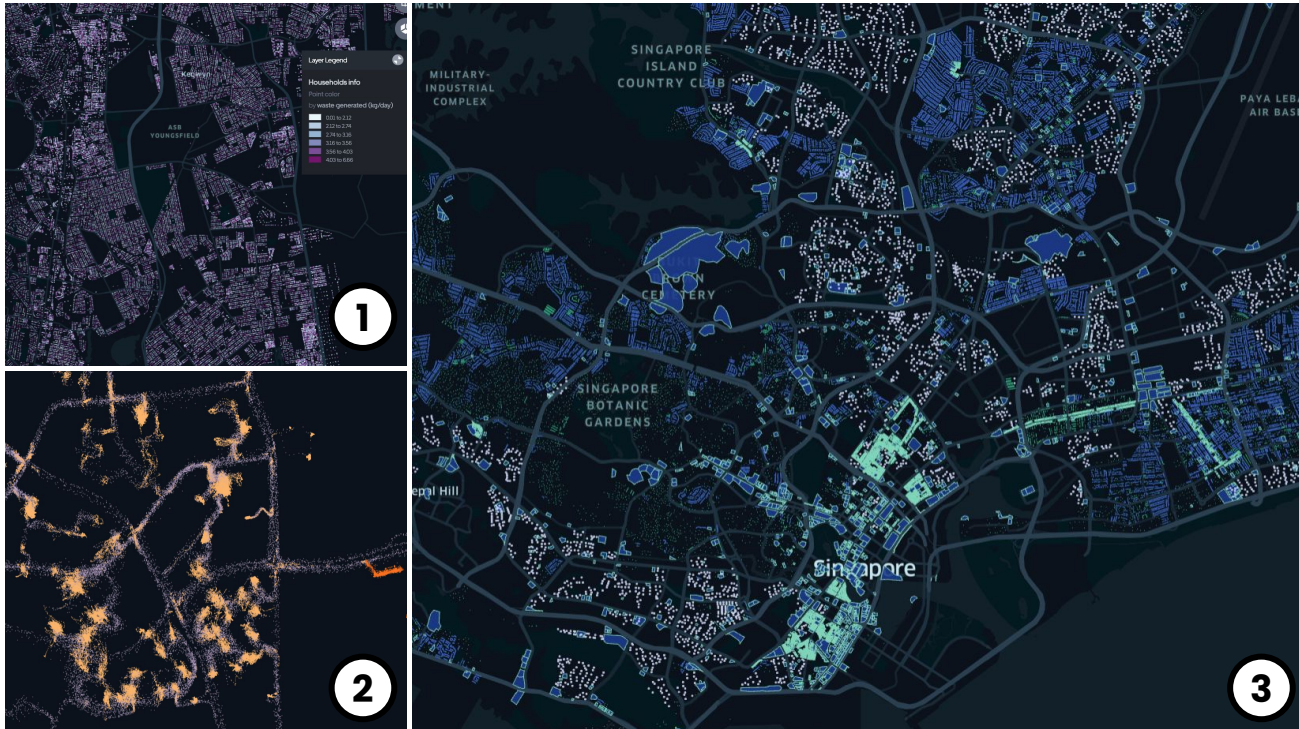| producer	mixed ▾
collection	refuse ▾

[Gen resource plan]

```
Checking inputs...
done
Converting inputs to string...
done
Writing instance to `scenarios/mixed_refuse.txt`...
done
scenarios/mixed_refuse_info_lists_pickled.dat found
scenarios/mixed_refuse_nn_list.dat found
scenarios/mixed_refuse_problem_info.dat found
scenarios/mixed_refuse_sp_data_full.dat found
Converted input data exist in `scenarios/`, proceeding to load data

Problem info supplied. Directly proceeding to solve problem.

Z: 118820      Savings: -45     Relocate arc 3 (R 0, T 1, P 8) before arc 8 (R 0, T 1, P 6)        relocate        Feasible moves
Z: 118806      Savings: -14     Relocate arc 12 (R 0, T 0, P 63) before arc 318 (R 0, T 0, P 57)       relocate        Feasible moves
Z: 118782      Savings: -24     Relocate arc 14 (R 1, T 0, P 60) before arc 214 (R 1, T 0, P 42)       relocate        Feasible moves
Z: 118692      Savings: -90     Relocate arc 17 (R 1, T 0, P 92) before arc 605 (R 1, T 1, P 32)       relocate        Feasible moves
Z: 118680      Savings: -12     Relocate arc 18 (R 1, T 0, P 1) before arc 168 (R 1, T 0, P 38)       relocate        Feasible moves
Z: 118365      Savings: -315    Relocate arc 20 (R 0, T 1, P 49) before arc 7 (R 1, T 1, P 45)       relocate        Feasible moves
Z: 118321      Savings: -44     Relocate arc 25 (R 0, T 1, P 29) before arc 267 (R 0, T 1, P 32)       relocate        Feasible moves
Z: 118139      Savings: -182    Relocate arc 27 (R 1, T 0, P 89) before arc 22 (R 1, T 1, P 43)       relocate        Feasible moves
Z: 117976      Savings: -163    Relocate arc 34 (R 0, T 0, P 17) before arc 234 (R 0, T 0, P 22)       relocate        Feasible moves
```

Layer Legend

Collection infrastructure
Color
🟥

all_pretty
Color
by Collection type
🟥 General refuse
⬜ Mixed recyclables
Stroke Color
by Collection type
🟥 General refuse
⬜ Mixed recyclables

HDB population
Color
🟦

Landed population
Color
🟦

Transfer station

Recycling Facility

Vehicle depot (option 1)

Vehicle depot (option 2)

Incineration plant

07/01/20
09:57:50am — 12:40:25pm

LAKESIDE GARDEN

ULU PANDAN WATER RECLAMATION PLANT

NGEE ANN POLYTECHNIC

INTERNATIONAL BUSINESS PARK

SINGAPORE POLYTECHNIC

Roches Hill

West COAST PARK

NATIONAL UNIVERSITY OF SINGAPORE

PULAU SERAYA

⏱ Time (cons dur)   〰 Y Axis   1x

AM   09 AM   10 AM   11 AM   12 PM   01 PM   02 PM   03 PM   04 PM   05 PM   06 PM   07 PM   08 PM

COVID: EXAMPLE

What happens when you lose too many resources?

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1 Synthetic population and waste generation rates (daily, per household)

2 Collection routes costing estimations based on GPS

3 Customer segmentation per collection cost

SCENARIO

›› **A portion of your collection crew is unavailable**

›› **Options: longer shifts for the rest**

›› **Options: reduce collection frequency**

›› **Options: stop collecting recyclables (if separately collected)**

›› **Options: prioritise certain collections (but who gets prioritised)**

›› **COMPLICATION: have to evaluate the above quickly**

RESULTS

	Week 1	Week 2	Week 3	Week 4
Waste uncollected				
Reduce collections	70t	140t	210t	280t
Stop recycling	20t	40t	60t	80t
Collection cost				
Reduce collections	R90'000	R95'000	R80'000	R85'000
Stop recycling	R110'000	R110'000	R110'000	R110'000

WHEN ARE THESE MODELS APPROPRIATE?

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›› **When there are sudden changes (need to plan contingencies very quickly)**

›› **When there are interdepencies (cost vs uncollected waste vs employee safety)**

›› **When staff haven't dealt with anything like this before (uncharted territories)**

CONCLUSION

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›› waste has lagged a bit with digitization, **BUT** it is now improving

›› you often DON'T need this kind-of technology, until you **REALLY** need it

›› waste collection systems are becoming more complex

›› the planning tools can help waste collectors and planners
(but it can't replace them)

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QUESTIONS?

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