AN ANALYSIS OF SOLID WASTE MANAGEMENT SYSTEM IN THIRUVANANTHAPURAM MUNICIPAL CORPORATION

PROJECT RECYCLE

A Fellowship Programme in R
at FOSSEE, IIT - Bombay
by
Team BitPlease
Tech Department of Sahridaya

TEAM MEMBERS

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OUR MOTIVE

- To do an analysis of inflow and outflow of solid waste, and to identify gaps in the existing system.
- To generate a mathematical model for an optimal waste management system.
- To use the model for easy implementation in other districts by simple input of basic parameters.

SOLID WASTE

Solid waste is the unwanted or useless solid materials generated from human activities in residential, industrial or commercial areas.

1

Non-biodegradable

2

Biodegradable (our focus)

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SOLID WASTE MANAGEMENT IN INDIA

- Waste management rules in India are based on the principles of "sustainable development", "precaution" and "polluter pays".
- With rapid urbanisation, the country is facing massive waste management challenge.

According to a report by DownToEarth magazine,

- Urban population - 377 million in 7,935 towns
- Generated Municipal Waste - 62 million tonnes (MT)
- Waste collected - 43 MT
- Waste treated - 11.9 MT
- Waste dumped in landfill sites - 31 MT

WASTE MANAGEMENT SYSTEMS

- CENTRALISED – The waste is collected and dumped into open landfills that continue to be filled up past their life expectancy and carrying capacity.

- DECENTRALISED - A decentralised system follows the ‘Proximity Principle’, meaning the waste is treated as close to the place of generation as possible.

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SOLID WASTE MANAGEMENT IN THIRUVANANTHAPURAM MUNICIPAL CORPORATION

- Thiruvananthapuram Municipal Corporation (TMC) has been promoting decentralized solid waste management system and on-site management of biodegradable discards since 2013.
- Material Recovery Facilities (MRF), set up at ward level, are sheltered spaced for storing non-biodegradable discards in a segregated, clean & dry manner.
- Aerobic bins can be used to convert biodegradable waste into compost, which can then be used for soil conditioning for farming and gardening.
- 4ft x 4ft x 4ft Ferro-cement structure
- Lack of land and increasing population density.
- Overflow system

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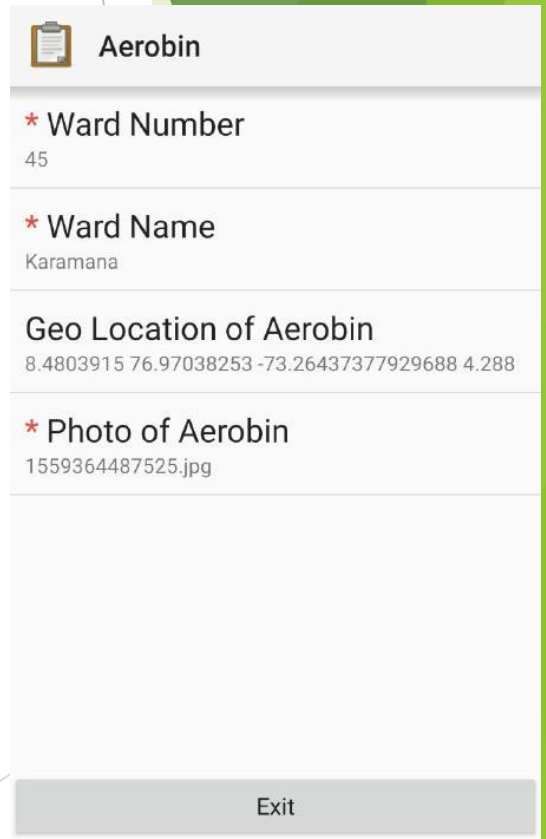
SCOPE OF STUDY

- Type of waste – Bio-degradable solid waste
- Area under study – Thiruvananthapuram Municipal Corporation (214.86 sq. km, 100 wards)

DATA COLLECTION PROCESS

- Meeting with Health Inspector (H.I.) of TMC office.
- Visiting Office of H.I.s in each ward, collecting data about waste management.
- Collecting inflow and outflow of existing Aerobic bins (or Aero bins).
- Geotagging and recording the information of each Aero bin location using Open Data Kit (ODK).



OUR GITHUB REPOSITORY

All the data collected and the data analysed by us can be found in our Git repository : https://github.com/sahridhaya/Recycle

LIBRARIES USED IN R

- ggplot2
- tidyverse
- graphics
- stats
- plotrix

ORGANISATIONS WE COLLABORATED WITH

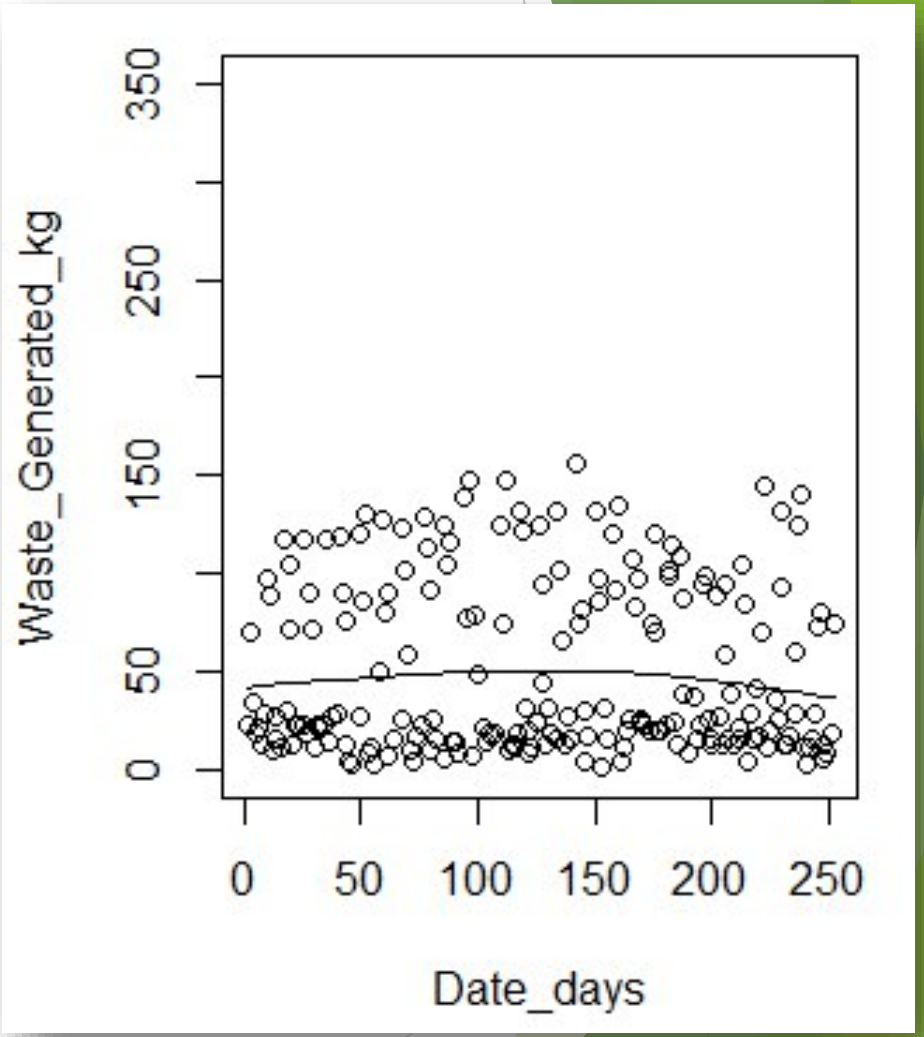
- Thiruvananthapuram Municipal Corporation
- Thanal
- RecycleBin, TVM

DATA PROCESSING

- Digitizing of ledger book data using LibreOffice Calc.
- Importing the data into R in Comma-separated values (csv) format and analysing.
- Exporting data collected using ODK into (csv).
- Importing the data to QGIS and processing.
- Generating a mathematical model with the help of all the collected data.

ANALYSIS OF CURRENT WASTE GENERATION

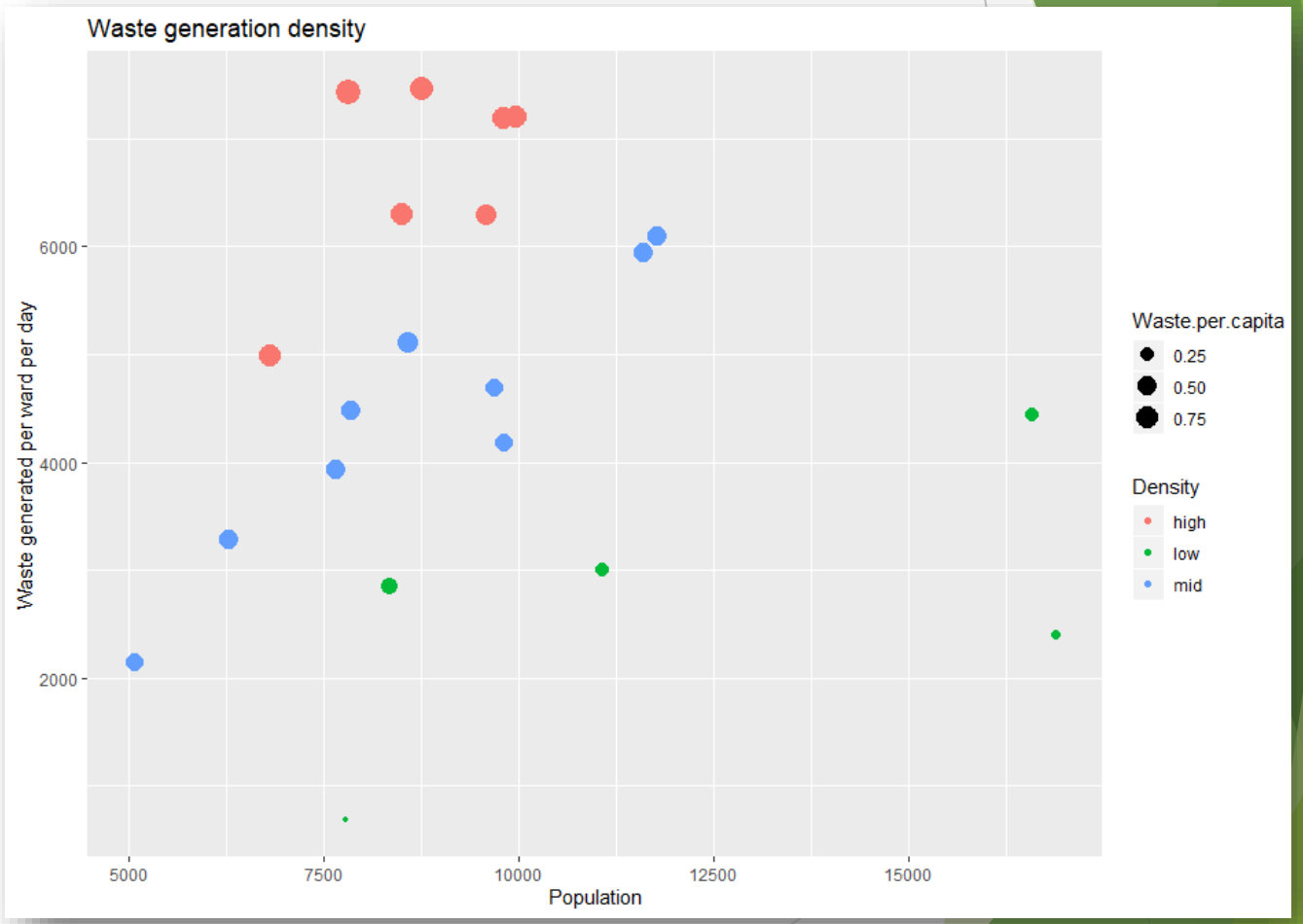
Data collection process



Data Representation

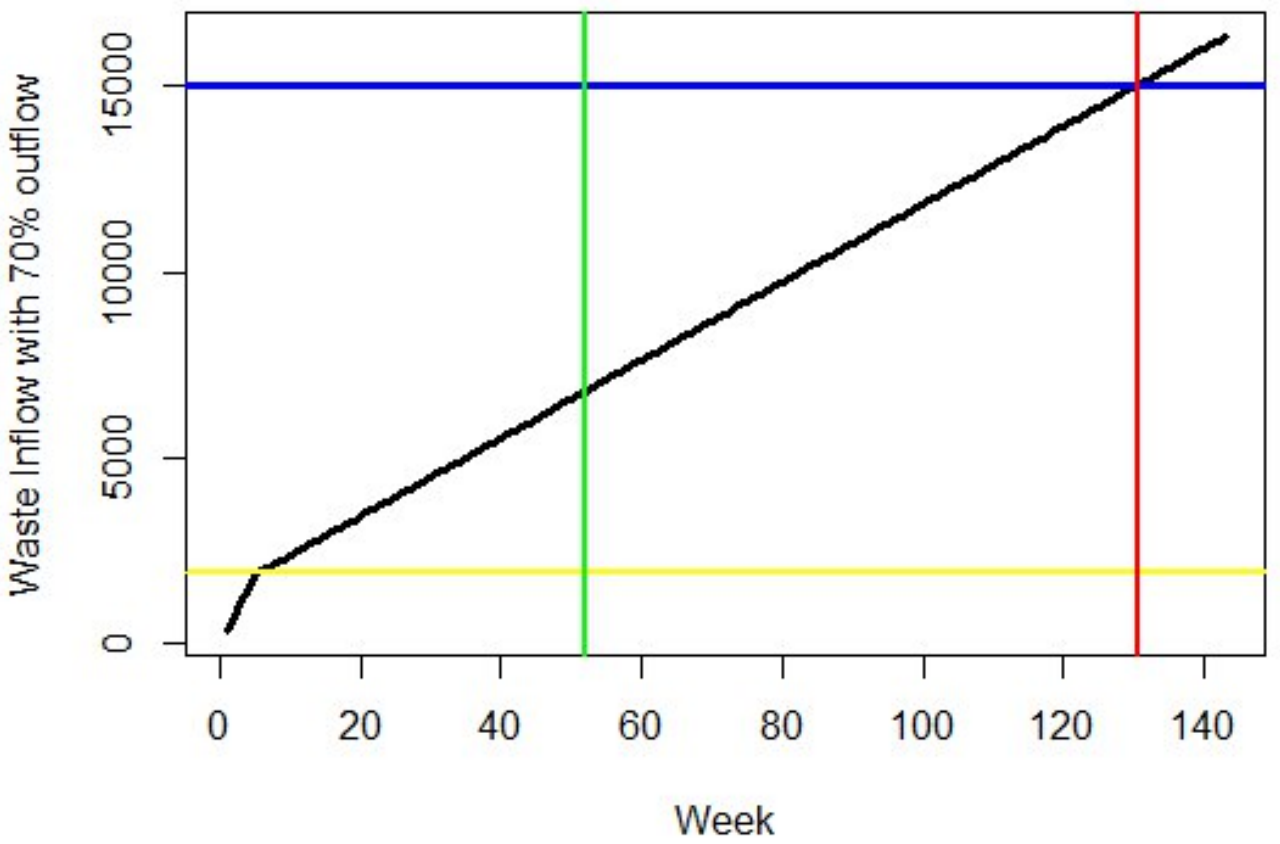
WASTE GENERTION DENSITY

Ward	Population	Waste generated	Waste per capita	Density
Vattiyoorkavu	9967	7200	0.722384	high
Ulloor	11599	5940	0.512113	mid
Palayam	5069	2148	0.423752	mid
Medical College	6817	4986	0.731407	high
Manacaud	7853	4476	0.569973	mid
Jagathy	8348	2850	0.341399	low
Sreekaryam	11782	6096	0.517399	mid
Kazhakkuttam	16882	2400	0.142163	low
Sasthamangalam	9810	7182	0.73211	high
Thirumala	8750	7470	0.853714	high
Thiruvallom	16580	4446	0.268154	low
Vizhinjam	8498	6300	0.741351	high
Karamana	9810	4182	0.4263	mid
Fort	6296	3282	0.521283	mid
Nemom	8576	5112	0.596082	mid
Kudappanakkunnu	9576	6300	0.657895	high
Nanthancode	9677	4692	0.484861	mid
Sreekandeswaram	7661	3936	0.513771	mid
Kadakampally	11075	3006	0.271422	low
Poonthura	7825	7434	0.950032	high
Chalai	7788	684	0.087827	low



WASTE INFLOW AND OUTFLOW WITH WEEKS

- Waste deposited in aerobic bin per ward
- Outflow starts
- End of existing data
- Overflow limit
- Week at overflow



Average No of bins in one MRF = 10
Average Capacity of 1 bin = 1.5 T

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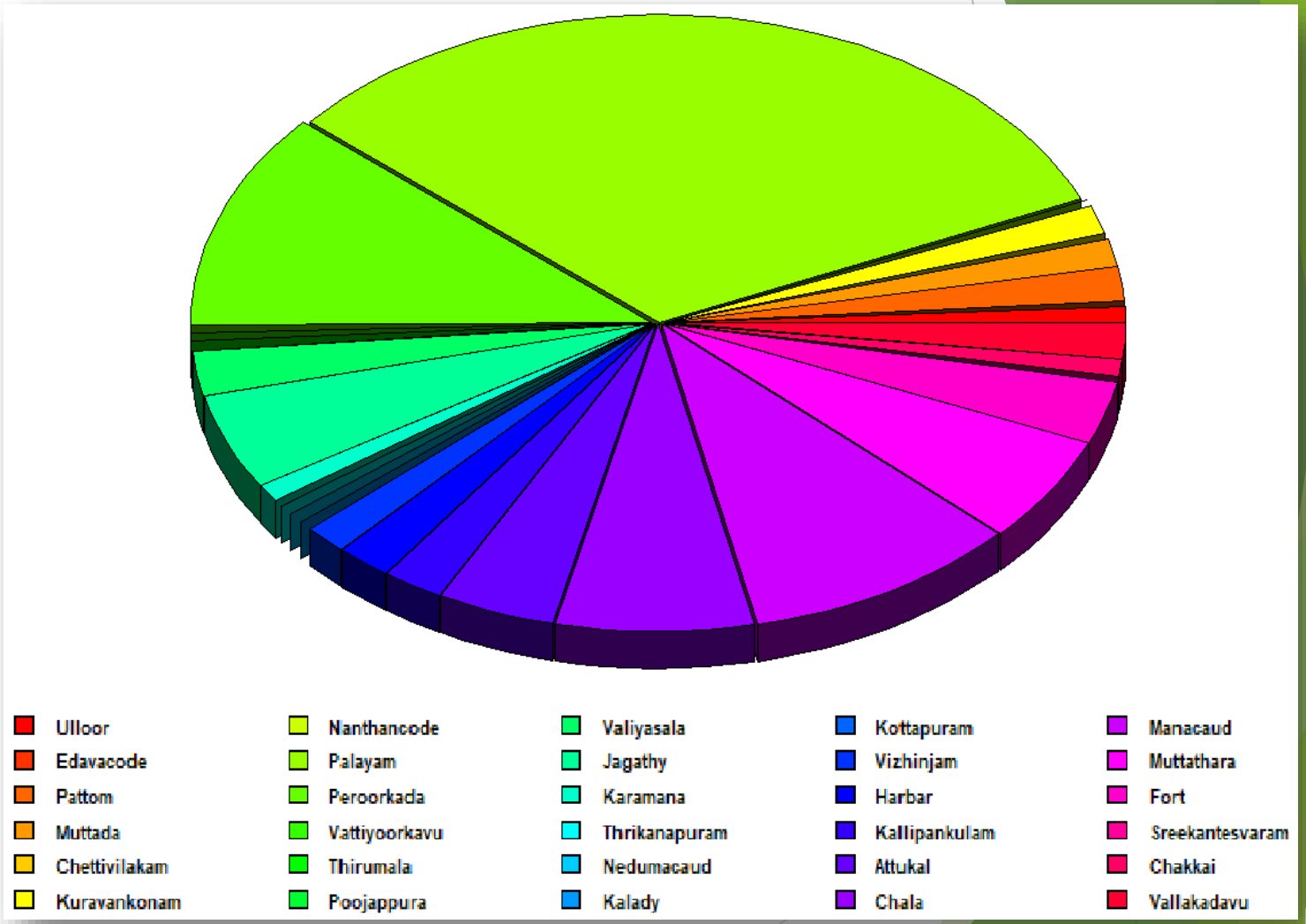
WASTE PROCESSING CAPABILITY

- Ratio of amount of waste processed to the total amount of input waste.
- Each section in the chart represents a wards with similar ratio.
- Equation:

$$\text{Processing ratio} = \frac{\text{Waste processed / day}}{\text{Waste / ward / day}}$$

Where,

Waste / ward / day = Ward Population × 0.4 kg



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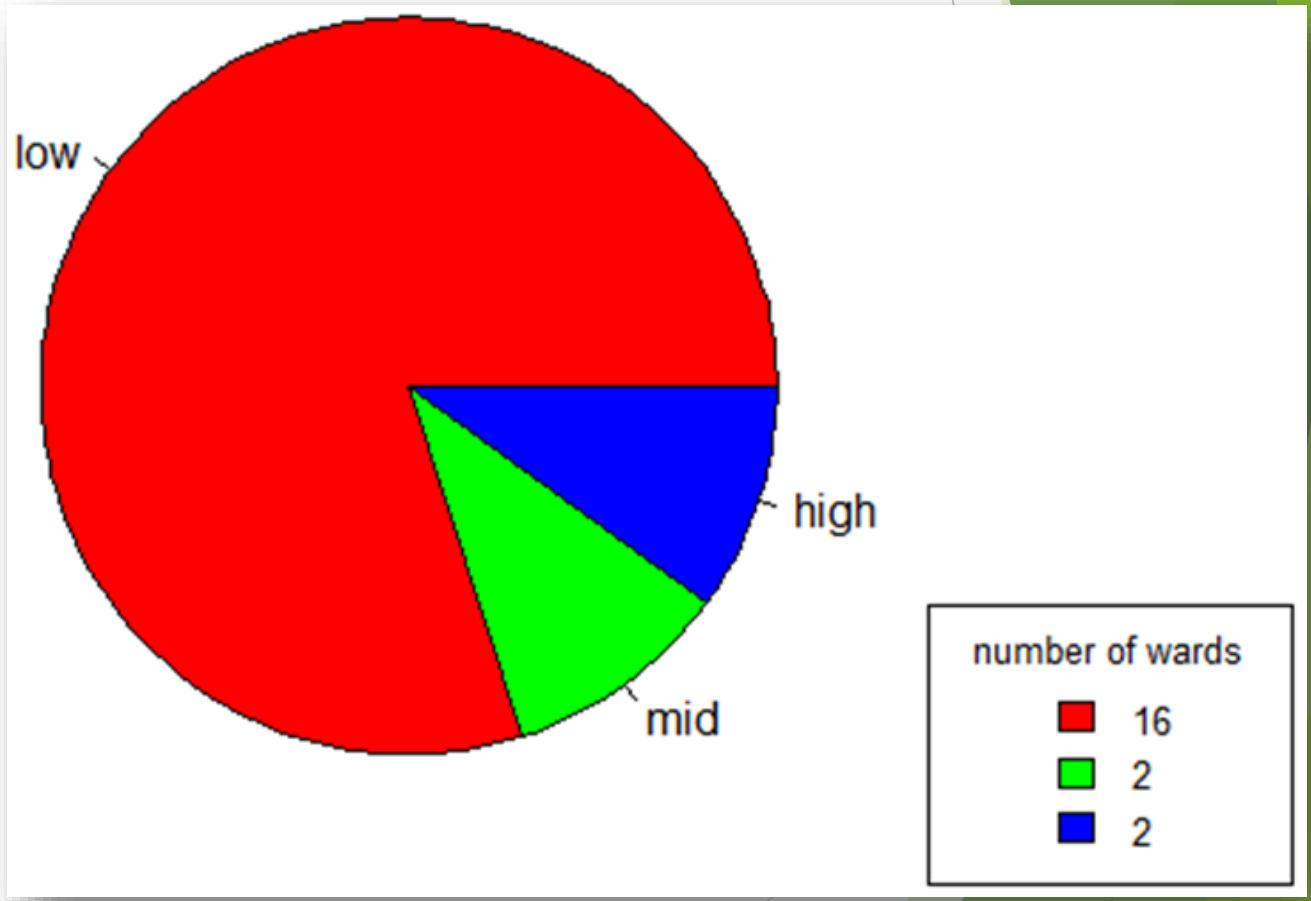
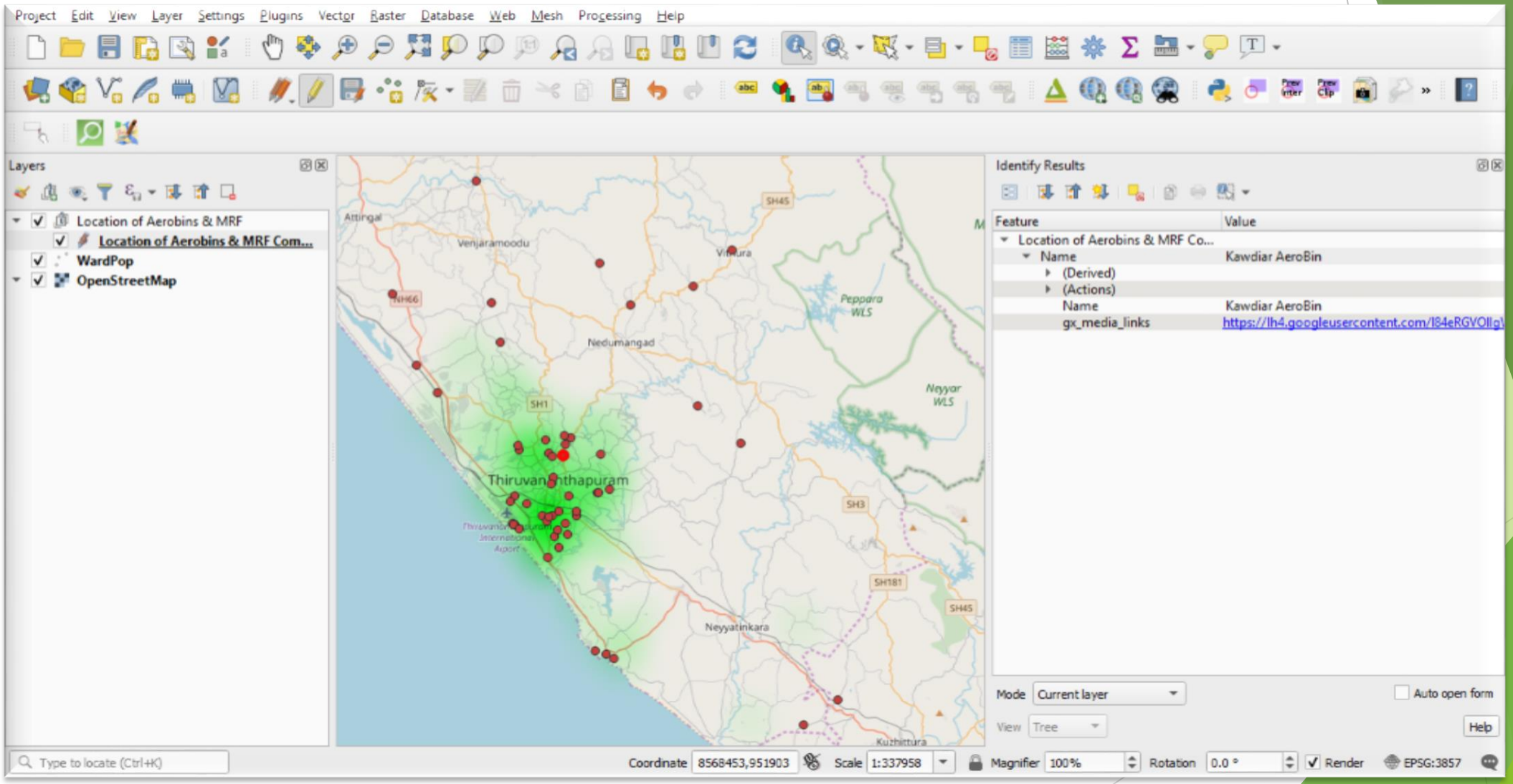
WASTE INFLOW FROM COLLECTED DATA

Average waste inflow rate per day

- Low – 0 to 50 kg
- Mid – 50 to 150 kg
- High – more than 150 kg

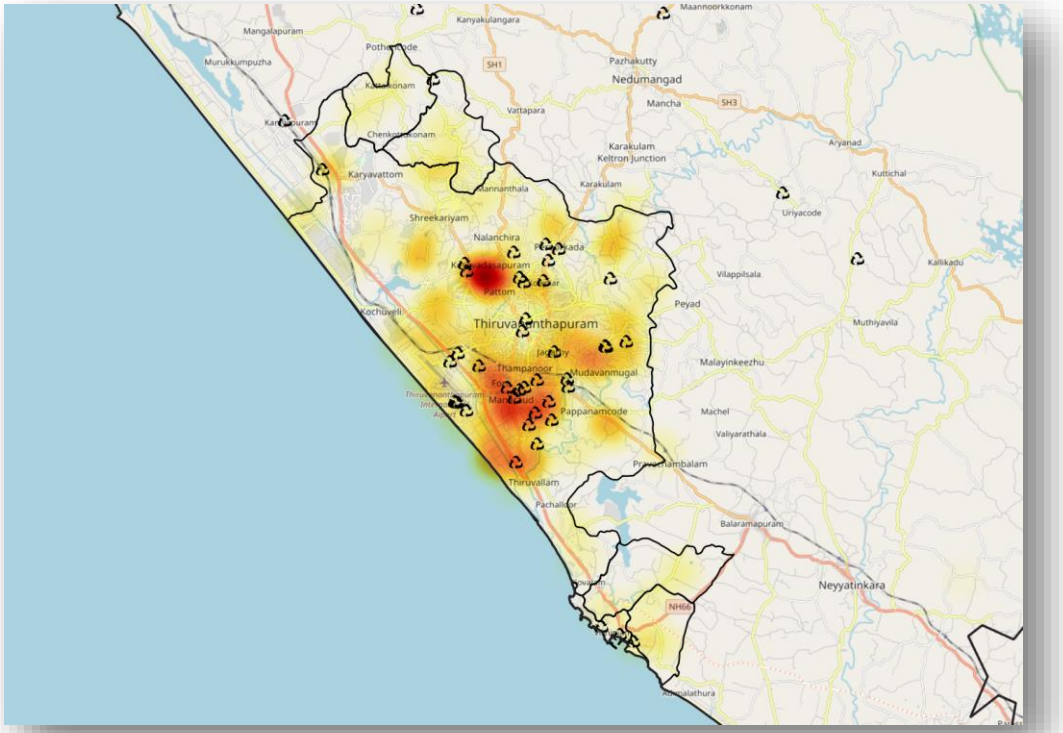


WORKING WITH QGIS 3.8

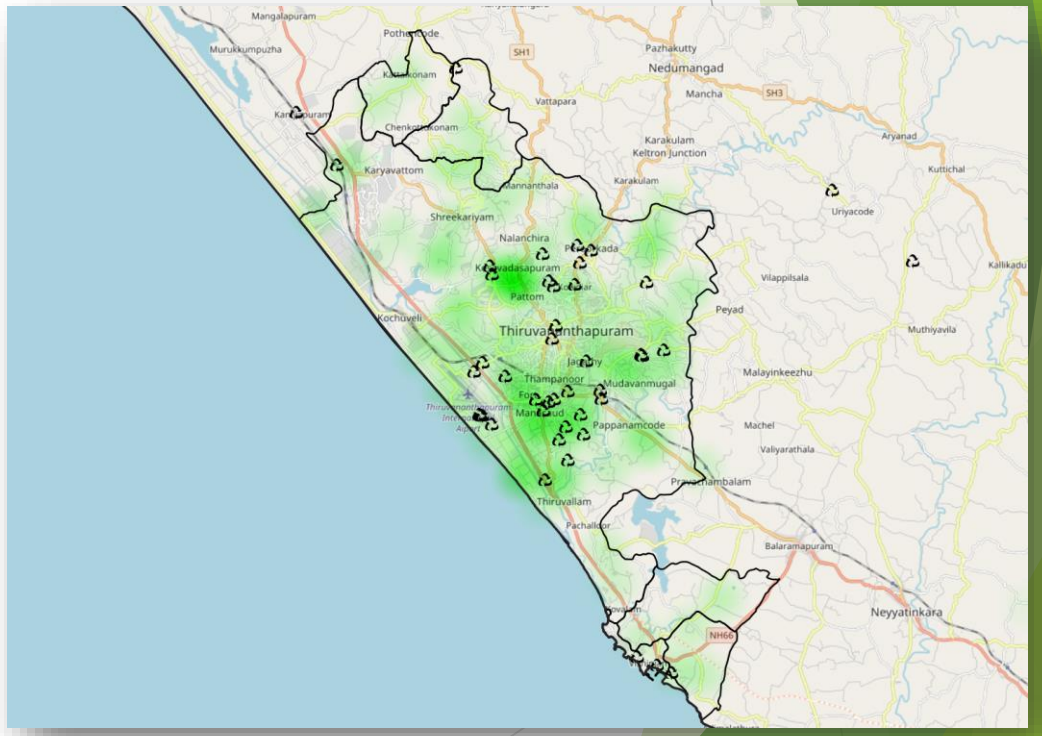


HEAT MAPS OF TMC

Population Density Map



Waste Generation Density



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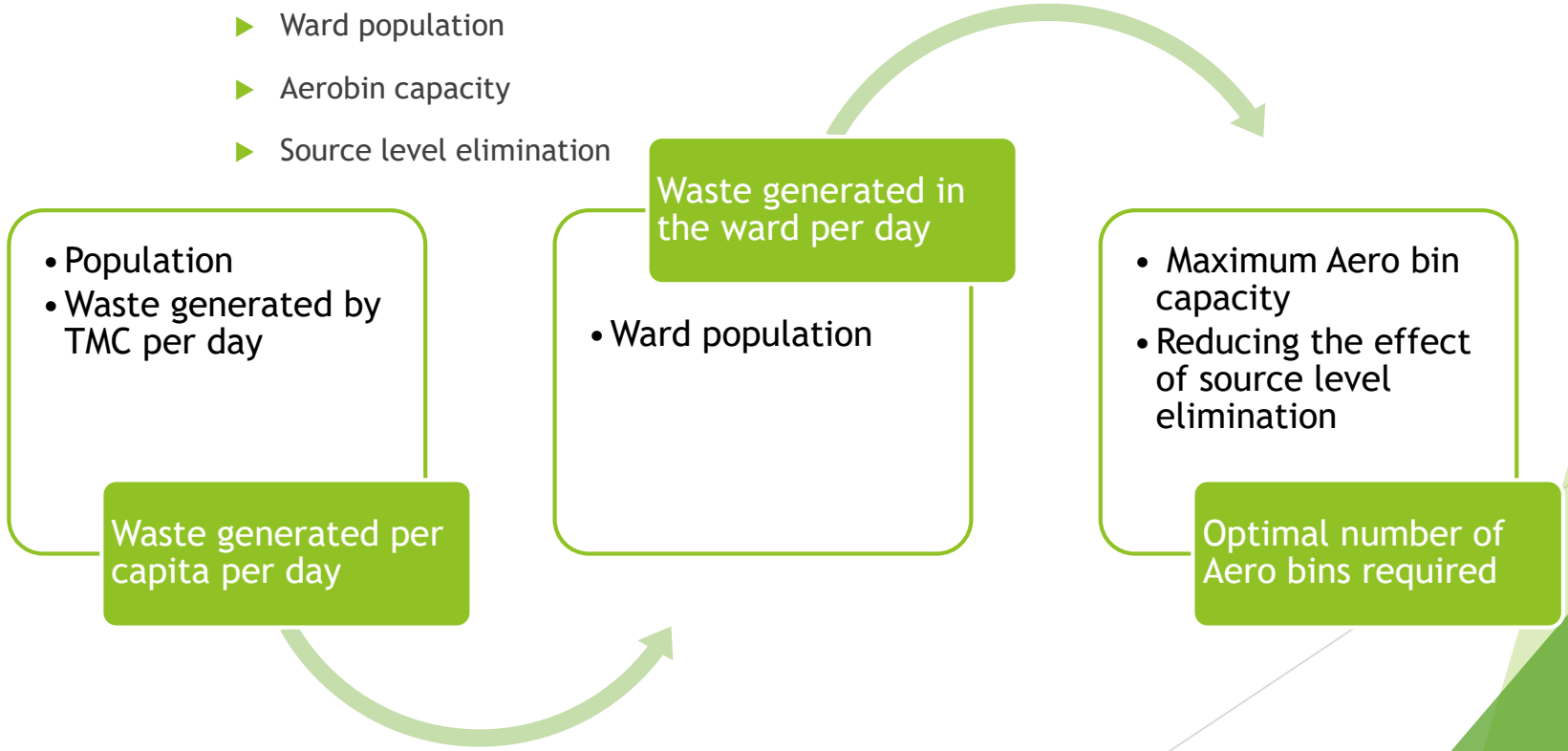
MATHEMATICAL MODEL

A. Optimal number of Aero bin units in each ward:-

- Basic parameters used :
  - City population
  - Waste generated by city
  - Ward population
  - Aerobin capacity
  - Source level elimination



R CODE OF THE MATHEMATICAL MODEL

```r
#total waste generated in TMC per day (60% of 353 tonnes)
Totwaste = 211800

PopData <- read.csv(file="C:/Users/hp/Desktop/WardPop.csv", header=TRUE, sep=",")

#TMC population
Pop = sum(PopData$Population)
Pop

#waste generated per capita per day
WasGen = Totwaste/Pop
WasGen

WG <- c()
#waste generated by wards per day
for (i in PopData[,1] ) {
  WG <- append(WG, (PopData[i,4] * WasGen))
  print(WG[i])
}

PopData$Waste.gnerated.by.ward <- WG
#write.csv(PopData,file =  "C:/Users/hp/Desktop/WardPop.csv")

#capacity of one aerobin location
Cap = 35*10

#Number of aerobins required (60% waste is dealt with at source level)
m <- c()
for (i in PopData[,1] ) {
  x = (WG[i]/Cap) * 0.4
  m <- append(m, round(x, digits = 0))
  print(m[i])
}

PopData$Required.number.of.bins <- m
PopData$Bins.to.be.constructed <- PopData$Required.number.of.bins - PopData$Existing.bins
#write.csv(PopData,file =  "C:/Users/hp/Desktop/WardPop.csv")

sum = 0
for (i in PopData[,1] ) {
  sum = m[i] + sum
}
sum
```

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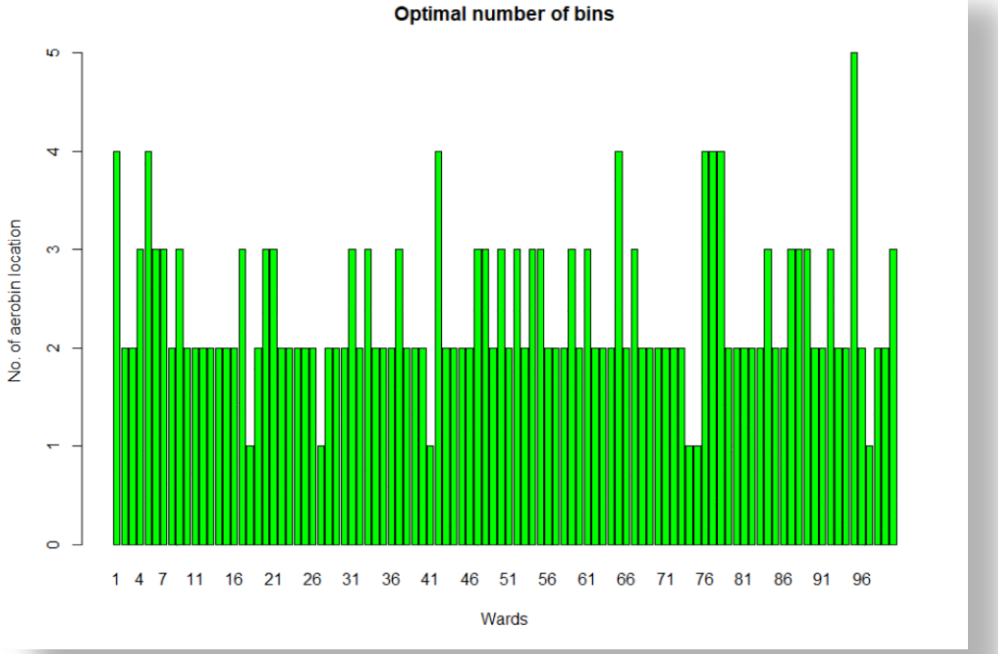
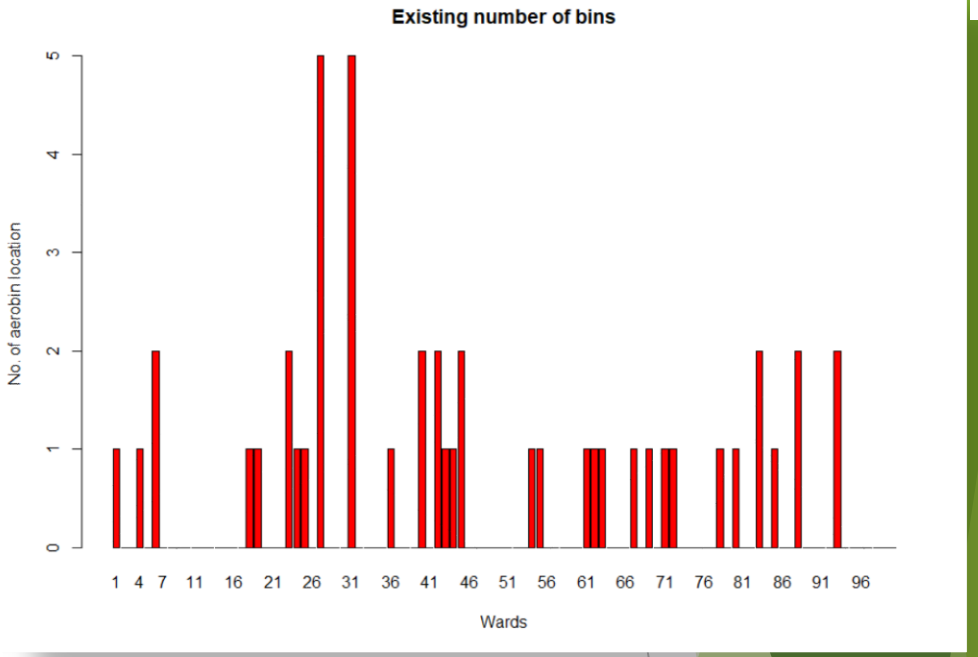
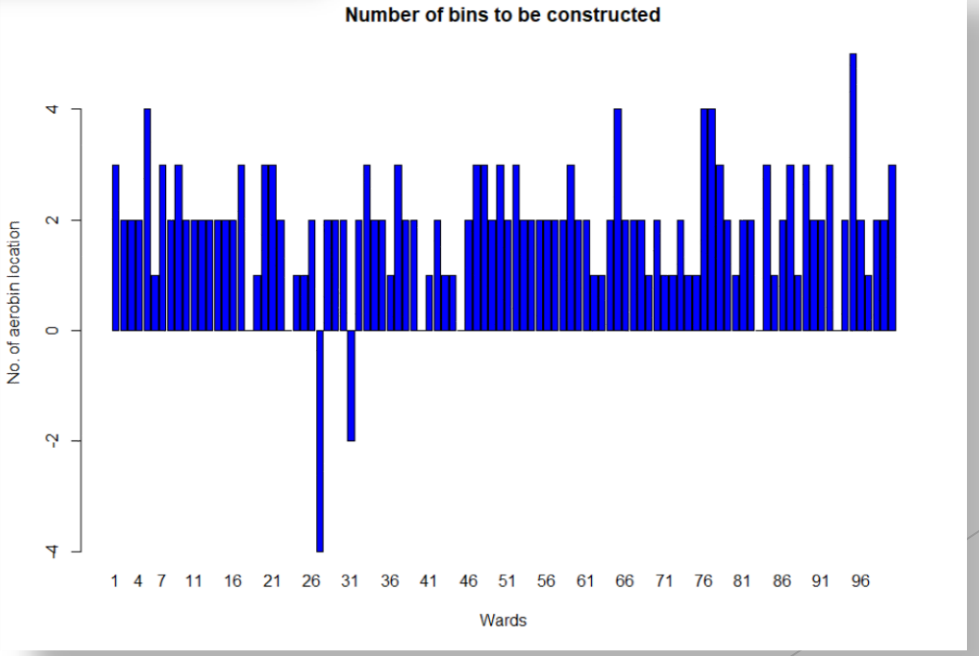


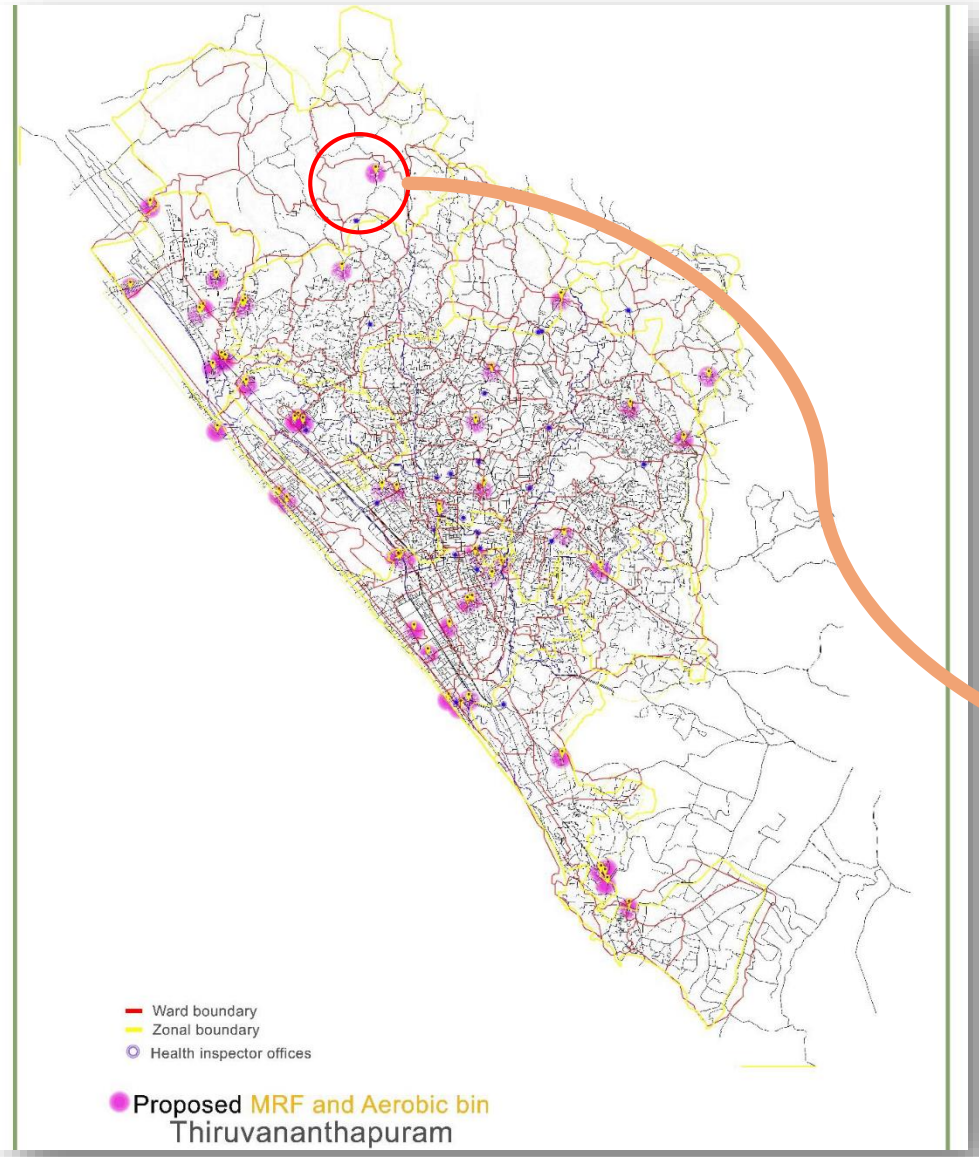


Optimal value = 236 bins

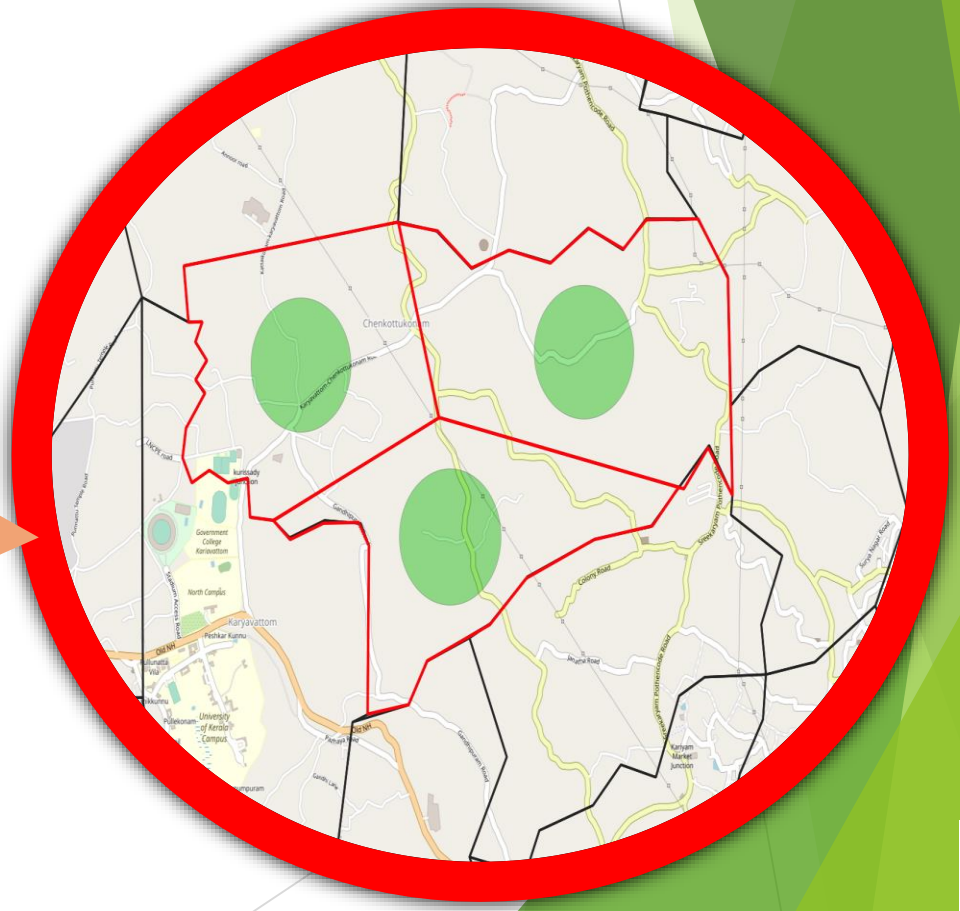
Current value = 47 bins



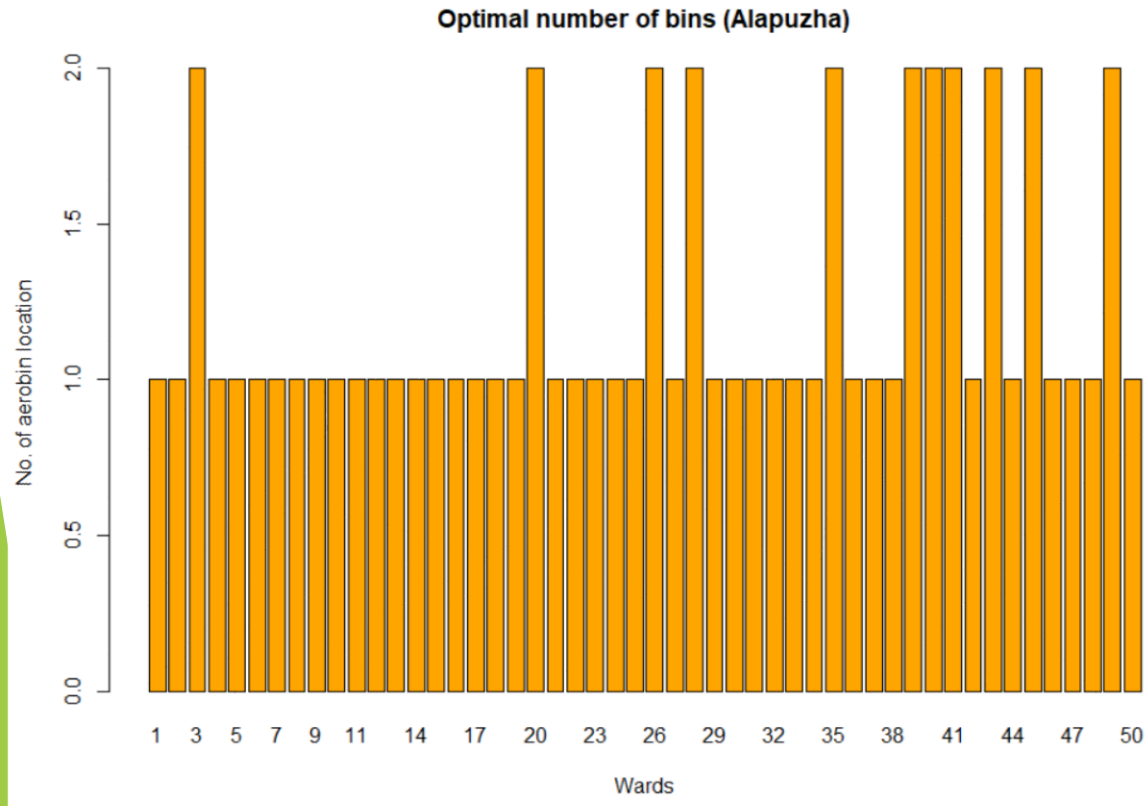
B. Proposed location of Aero bin units in each ward:-

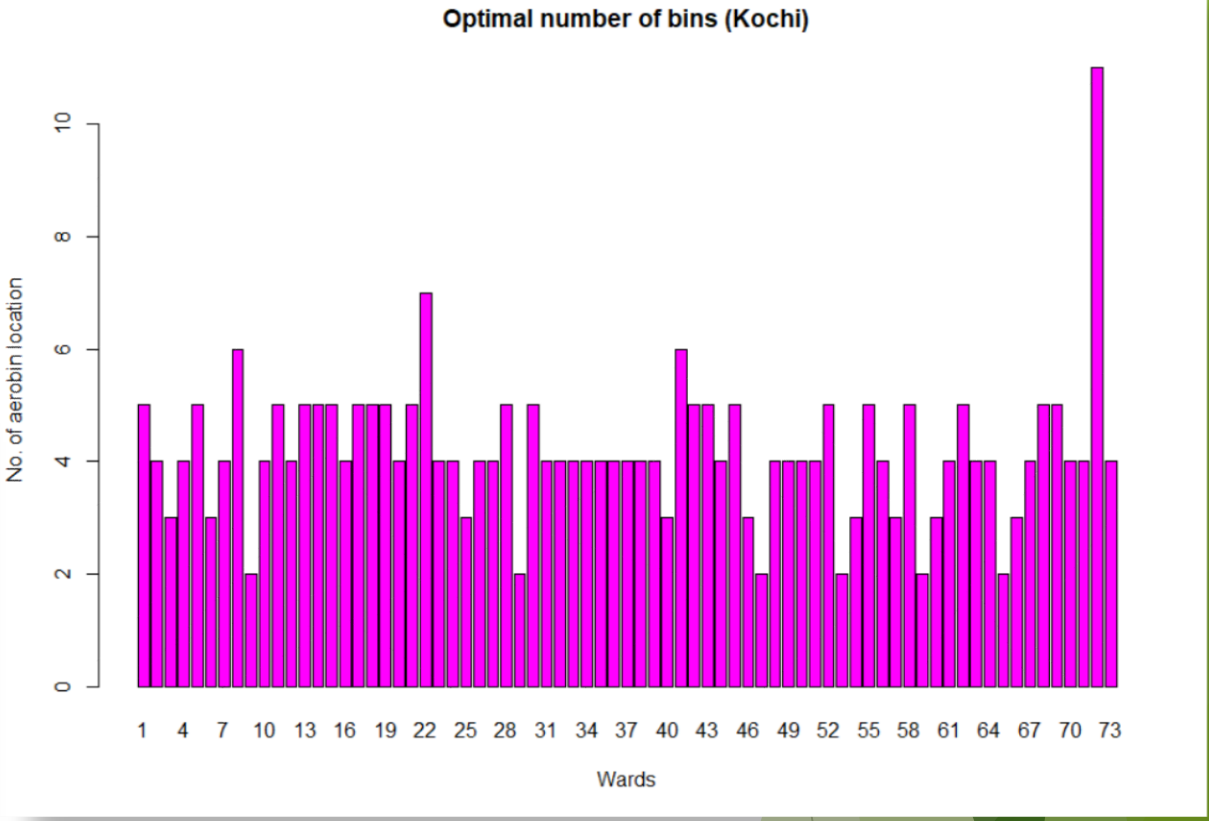


- Represents the range within which the Aerobin should be placed.
- Represents division of ward area.



MATHEMATICAL MODEL APPLIED ON OTHER DISTRICTS





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INFERENCE

- From the study we conducted on TMC's waste management system, we were able to analyse the inflow and outflow of waste, generate a mathematical model and apply it on other districts.
- Although we wanted to analyse the existing system, by comparing it with the old system of centralised waste management, we couldn't do so due to authoritative issues in obtaining the old data.

References

- https://www.researchgate.net/publication/260230170_MUNICIPAL_SOLID_WASTE_MANAGEMENT_IN_INDIA_A_REVIEW_AND_SOME_NEW_RESULTS
- https://www.cag.org.in/blogs/solid-waste-management-dummies
- https://www.downtoearth.org.in/blog/waste/india-s-challenges-in-waste-management-56753
- https://www.cag.org.in/database/centralised-and-decentralised-waste-management
- www.corporationoftrivandrum.in/sites/default/files/Rating%20report-TVM.pdf
- http://thanal.co.in/uploads/resource/document/standard-operating-procedure-of-community-aerobic-composting-bins-thumburmoozhi-model-44732514.pdf

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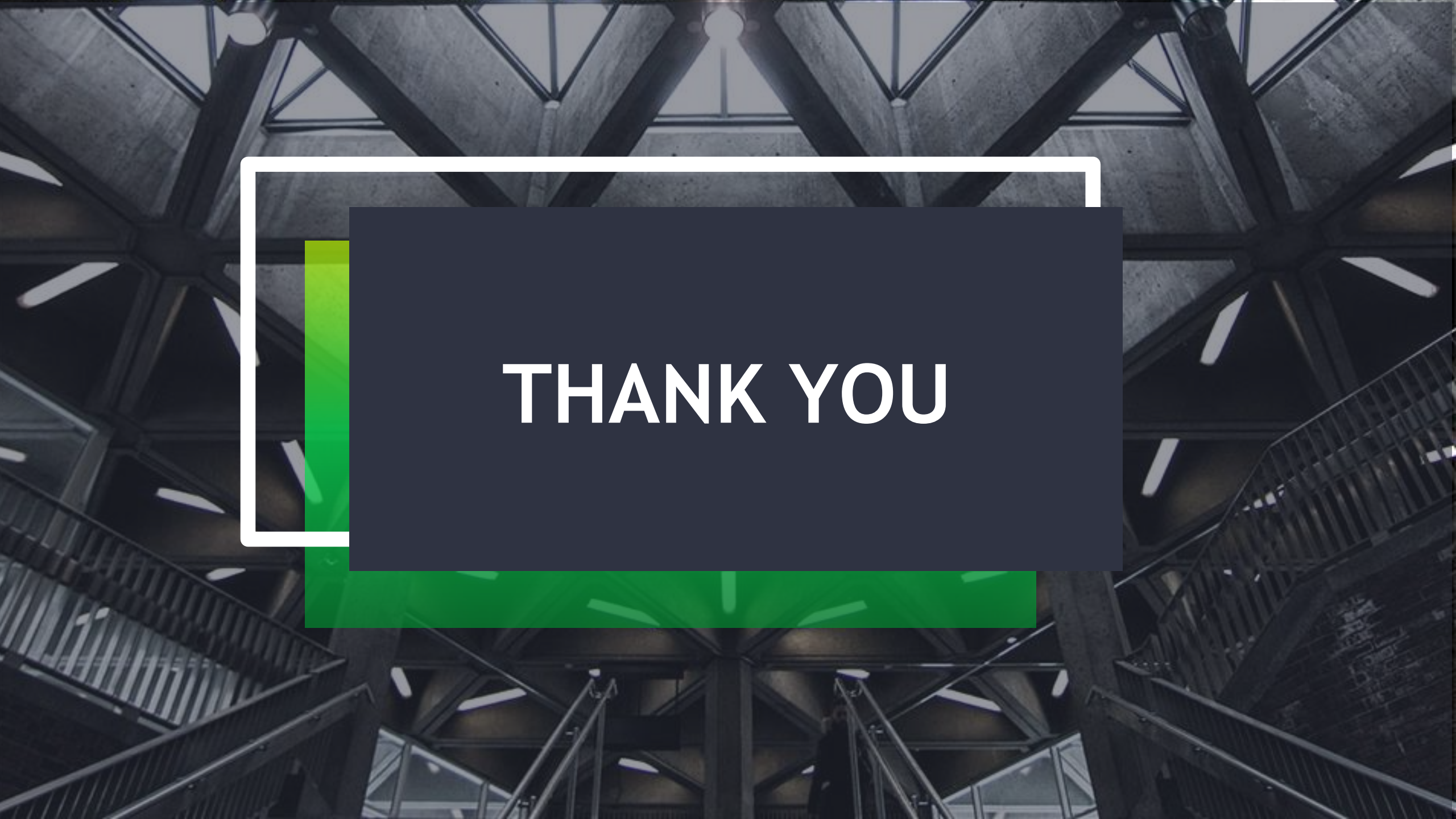
THANK YOU