Welcome!

Hi, I am Chitra

- Goals to help my community and our planet
- Environmentalist, Minimalist and Vegan
- Utilize data science to discover solutions

ENTITY/SCI/WozU Data Science Graduate
B.A. in Economics (Minor in Global Sustainability)

Hi, Im Julie

- ENTITY/SCI/WozU Data Science Graduate
- Environmentally Conscious
- World Traveler
- Photographer
- Co-Owner of MapDonut

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Taking Care of Rubbish

Chitra Patel & Julie Boucher

Taking Care of Rubbish

Brainstorming ideas for our final project was exciting and came very naturally, as we are both passionate about the environment.

Unfortunately, waste being generated has turned into an “out of sight, out of mind”, type of mentality. This is an issue that is overdue and needs a new sustainable and proactive outlook.

Although we don’t have all the datasets that are generated on waste globally, we figured data from the UK and England would be sufficient enough to get a general idea. We have chosen this topic on waste produced, imports, exports, and treatments to get a better understanding on how much trash is being produced. Our goal is educate ourselves and others.


To leave the world better than you found it, sometimes you have to pick up other people's trash.
— Bill Nye —


Bloomberg

It's no secret

- Waste threatens our planet and our ecosystem
- Micro plastic pollution is everywhere, even in our bodies
- In 2018, **2 billion tons** of waste was produced 7.6 billion people, averaging of **4.9 pounds** of trash per person every day
- It is predicted by 2050 that waste production will rise 70%
- The United States is the largest generator per capita globally
- The average person in the US produces approximately one metric ton of trash per year

Started our search

Global Questions

1. What does the trash generated look like on a global ranking?

2. Is there any correlation between certain demographic points and waste produced? If so, what is the amount of produced waste for what population, and what is the average income for that population?

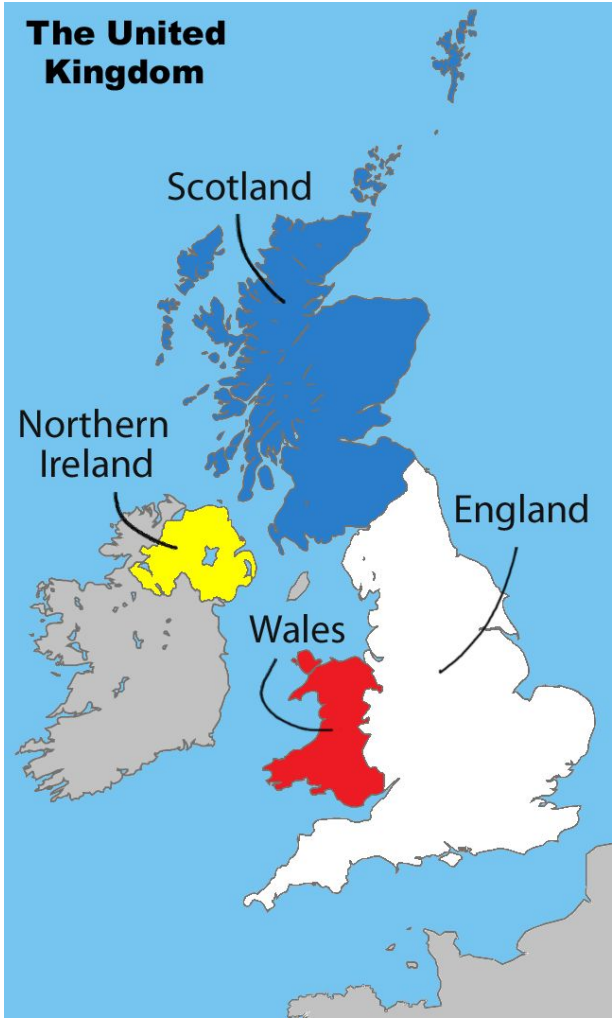
The United Kingdom and England Questions

3. Did time show any significance? If so, what's the overall amount of waste generated over time in England?

4. What are the relationships between the different **waste types**, **classifications***, and **treatment methods** for both the UK and England?

5. How do treatment methods differ by waste types?

* Classifications: European Waste Classification (EWC- Stat); Waste generation needs to be broken down according to the source (businesses or households) that generated them. Waste generated by businesses is broken down by economic activity in 18 categories based on the statistical classification of economic activities.


The United Kingdom
Scotland
Northern Ireland
England
Wales

Here's the tools that made all this possible

Excel

Google Drive

Studio®

python

GitKraken

Let’s check out our analysis for each question

Methods and Tools used for Q1, Q2, Q3:

- Correlation matrix
- Different datasets
- Tableau to build the graphs
- No data wrangling needed for these questions

Q1

TABLEAU & VISUALS

Q1

What does the average generated waste look like on a global scale?

Key Findings

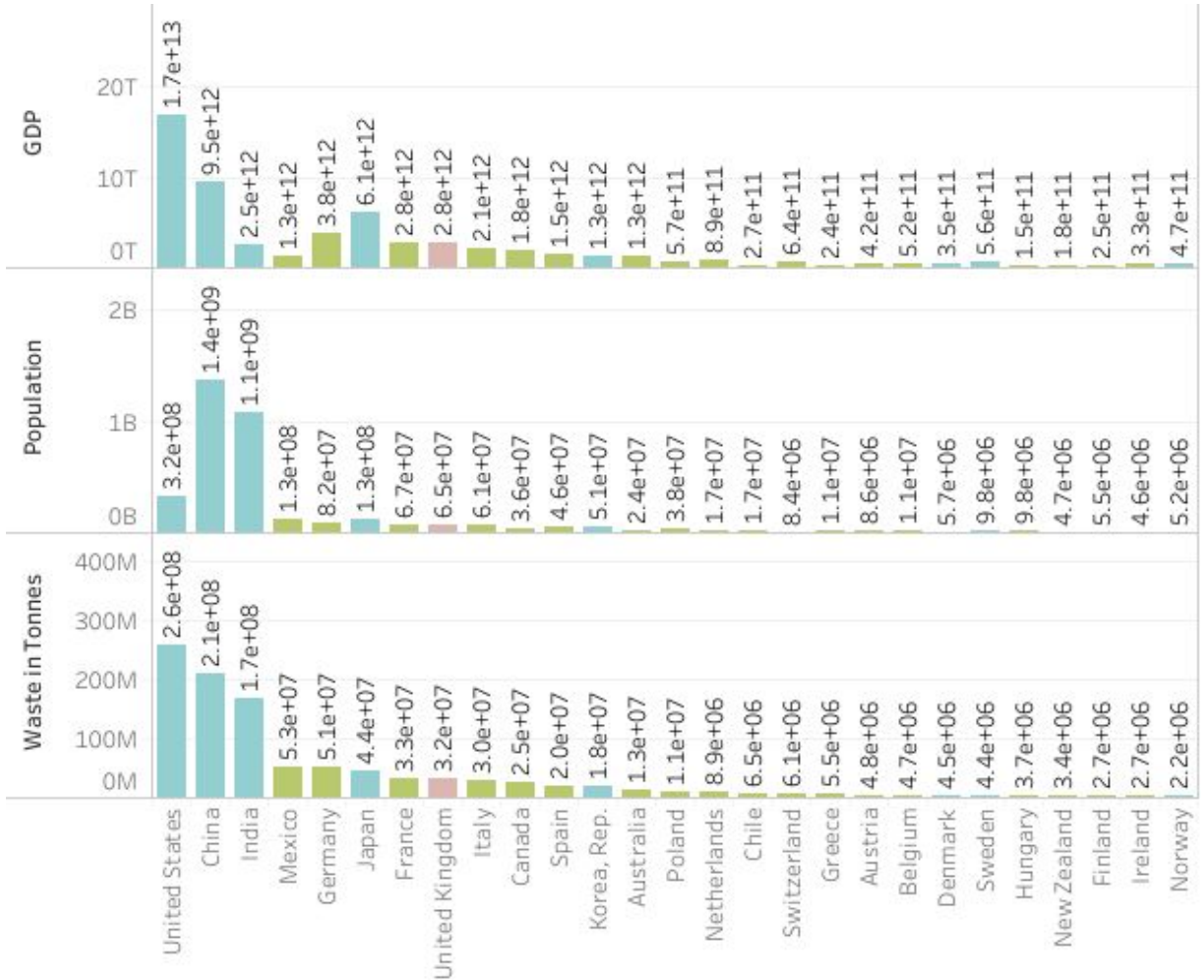
- The index aims to identify the most environment-friendly countries for waste management
- Each of the factors/techniques were allocated a number of positive or negative points relative to the amount of CO2 emissions and environmental contamination it causes on average
- Best:
  - **South Korea** being the most environment-friendly country and waste conscious 100/100
  - Followed by **Sweden** 93/100 and **Japan** 92/100
- Worst:
  - Latvia, New Zealand, Mexico (32/100), Chile (32/100) , and Italy (32/100) being the worst countries at managing their waste
- USA & UK: In Between
  - Following not too far behind is the **United States** with 65/ 100
  - **The United Kingdom** doing a little better with a score of 72/100

Q2

TABLEAU & VISUALS

Q2

What is the amount of waste produced for certain demographic populations, and what is the average income for that certain population in 2019?



Key Findings

- USA:
  - Lower population than China and India
  - Twice as much import/export as China
  - Highest waste producer

- China:
  - Highest population in the world
  - Import and exports half the amount of the USA
  - Waste is followed by the USA

- India:
  - 2nd largest population
  - India extremely low GDP compared to population
  - Waste generated 3rd largest followed by the USA and China

- Japan:
  - Population is about half the USA
  - GDP is half
  - Produce ⅕ of waste generated compared to USA

- UK:
  - Extremely small population
  - Higher GDP than India
  - Waste produced is about ⅕ of USA

Correlation Table for GDP, Population and Total Waste Generated

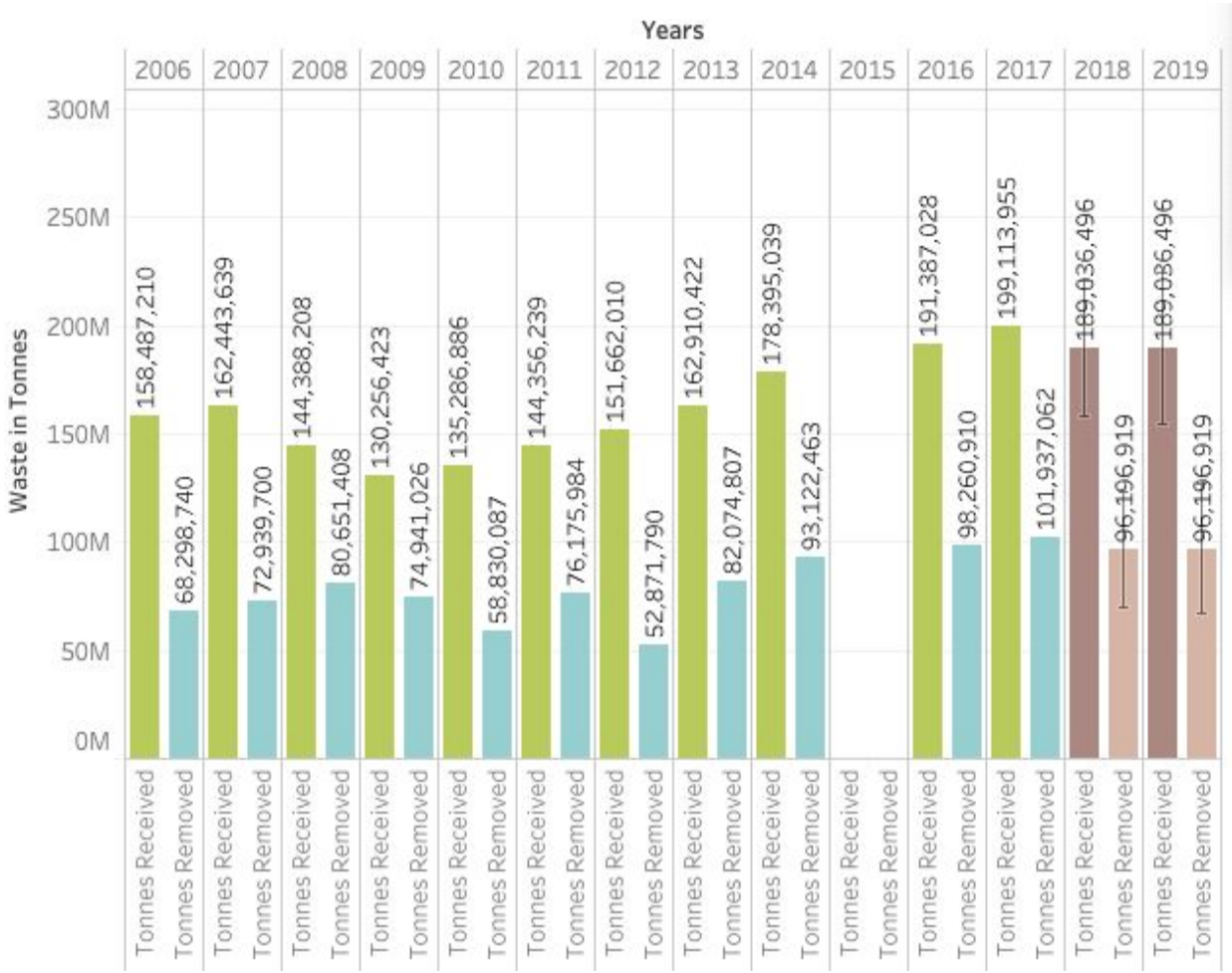
- Correlation between GDP and total generated waste per year in tons is 0.89
- Correlation between population and total generated waste per year in tons is 0.83
- Correlation between population and GDP is 0.57

Q3

TABLEAU & VISUALS

Q3

What is the overall amount of waste generated in England over time?



Key Findings

This is the overview into England. Getting a general idea on waste generated over the years.

- Waste received and removed fluctuates over time
- It shows that England receives twice the amount of waste removed
- Waste Removed: treatment, transfer, unknown, landfill, incineration
- Waste Received: The amount of waste collected before it was sent to: treatment, transfer, unknown, landfill, incineration
- Waste received started to decrease back in 2008 for couple of years, and since 2009 it has gradually increased over time
    - Might be because of market crash in the US in 2008-2009
        - Low GDP
- Forcast - same for future years after 2017

Q4

ANOVAS, MANOVAS, RANDOM FOREST, REGRESSIONS

What are the relationships between the different waste types, classifications and treatment methods for both the UK and England?

Before we dive in, this is our most evaluated question. Let's take a look at the base of our data.

33 Waste Types

01.1 → Spent Solvents
01.2 → Acid, alkaline or saline wastes
01.3 → Used oils
01.4, 02, 03.1 → Chemical wastes
03.2 → Industrial effluent sludges
03.3 → sludges & liquid wastes from waste treatment
05 → Healthcare & biological wastes
06.1 → Metallic wastes, ferrous
06.2 → Metallic wastes, non-ferrous
06.3 → Metallic wastes, mixed
07.1 → Glass wastes
07.2 → Paper & cardboard wastes
07.3 → Rubber wastes
07.4 → Plastic wastes
07.5 → Wood wastes
07.6 → Textile wastes
07.7 → Waste containing PCB
08* → Discarded equipment
08.1 → Discarded vehicles
08.41 → Batteries & accumulators wastes
09.1 → Animal & mixed food waste
09.2 → Vegetal wastes
09.3 → Animal faeces, urine & manure
10.1 → Household & similar wastes
10.2 → Mixed & undifferentiated materials
10.3 → Sorting residues
11 → Common sludges
12.1 → Mineral waste from construction & demolition
12.2, 12.3, 12.5 → Other mineral wastes
12.4 → Combustion wastes
12.6 → Soils
12.7 → Dredging spoils
12.8, 13 → Mineral waste from waste treatment & stabilised waste

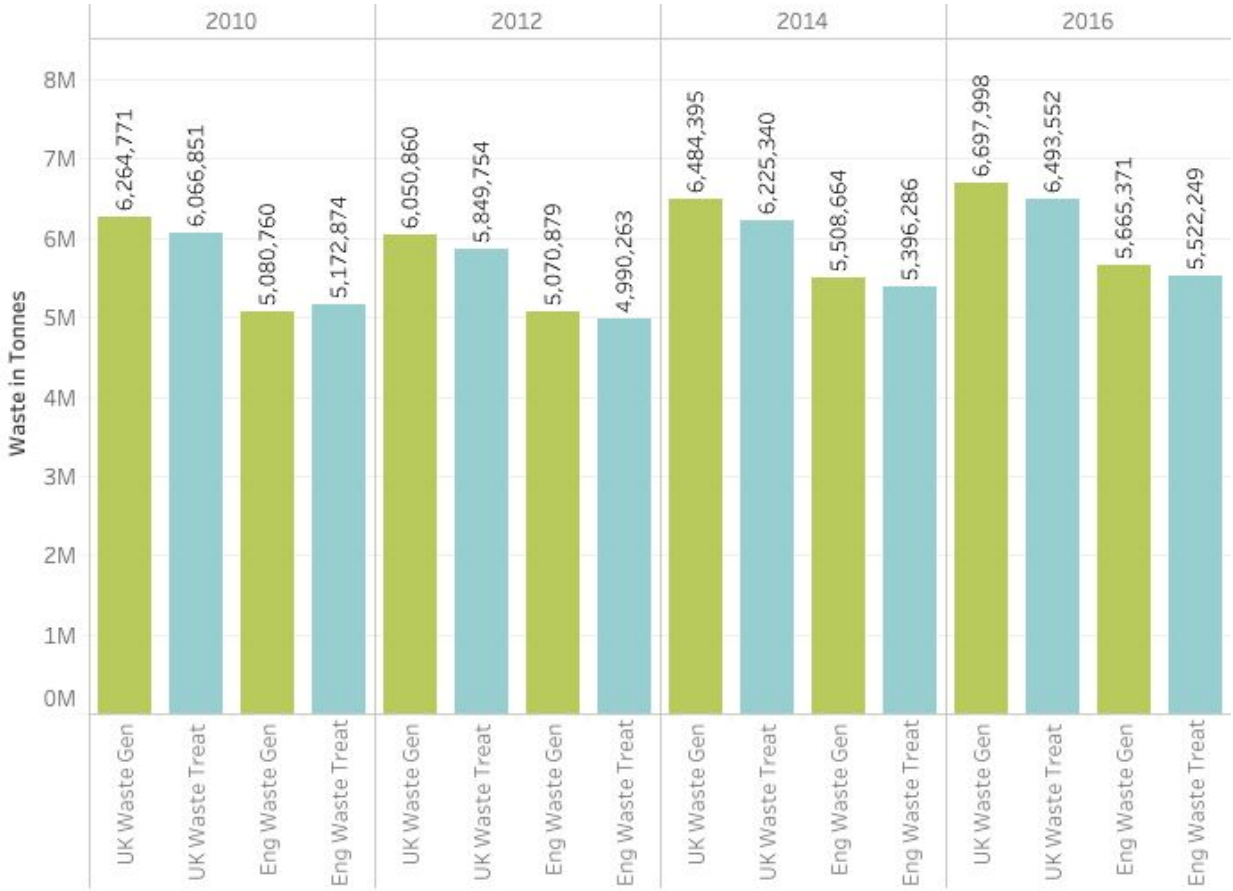
17 Classifications

A → Agriculture, Forestry and Fishing
B → Mining and quarrying
C10-C12 → Manufacture of food products, beverages and tobacco products
C13-C15 → Manufacture of textiles, wearing apparel, leather and related products
C16 → Manufacture of wood and of products of wood and cork, except furniture, manufacture of articles of straw and plaiting materials
C17_C18 → Manufacture of paper and paper products, printing and reproduction or recorded media
C19 → Manufacture of coke and refined petroleum products
C20-C22 → Manufacture of chemical, pharmaceutical, rubber and plastic products
C23 → Manufacture of other non-metallic mineral products
C24_C25 → Manufacture of basic metals and fabricated metal products, except machinery and equipment
C26-C30 → Manufacture of computer, electronic and optical products, electrical equipment, motor vehicles and other transport equipment
C31-C33 → Manufacture of furniture, jewellery, musical instruments, toys, repair and installation or machinery and equipment
D → Electricity, gas, steam and air conditioning supply
E36_E37_E39 → Water collection, treatment and supply, sewerage, remediation activities and other waste management services
F → Construction
G-U_X_G4677 → Services (except wholesale of waste and scrap)
EP_HH → Households

6 Treatment Methods

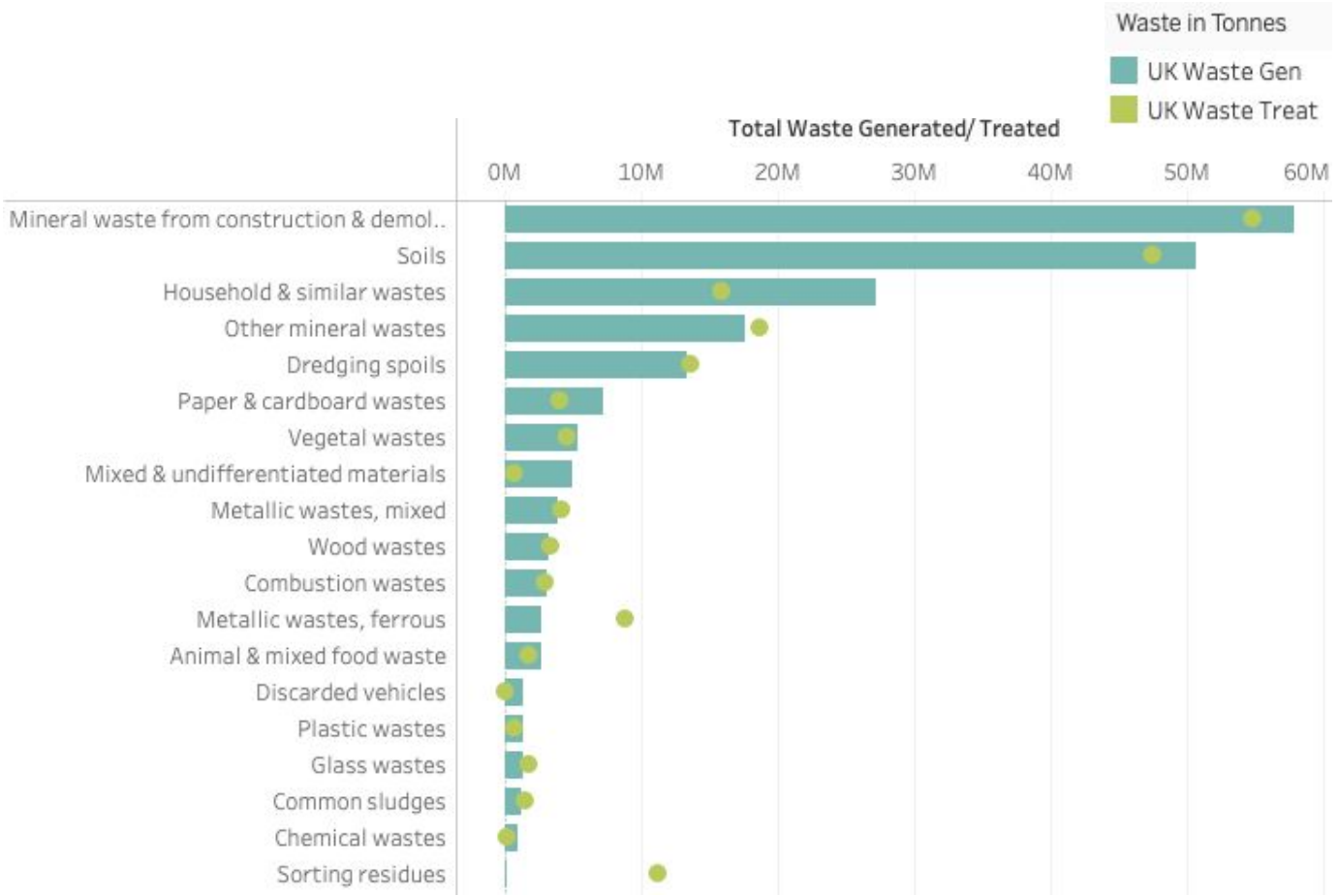
1. Energy recovery
2. Incineration
3. Recovery other than energy recovery - Except backfilling (Recycling)
4. Recovery other than energy recovery - Backfilling
5. Deposit it onto or into land
6. Land treatment and release into water bodies

England produces more waste than Wales, Scotland, and Northern Ireland

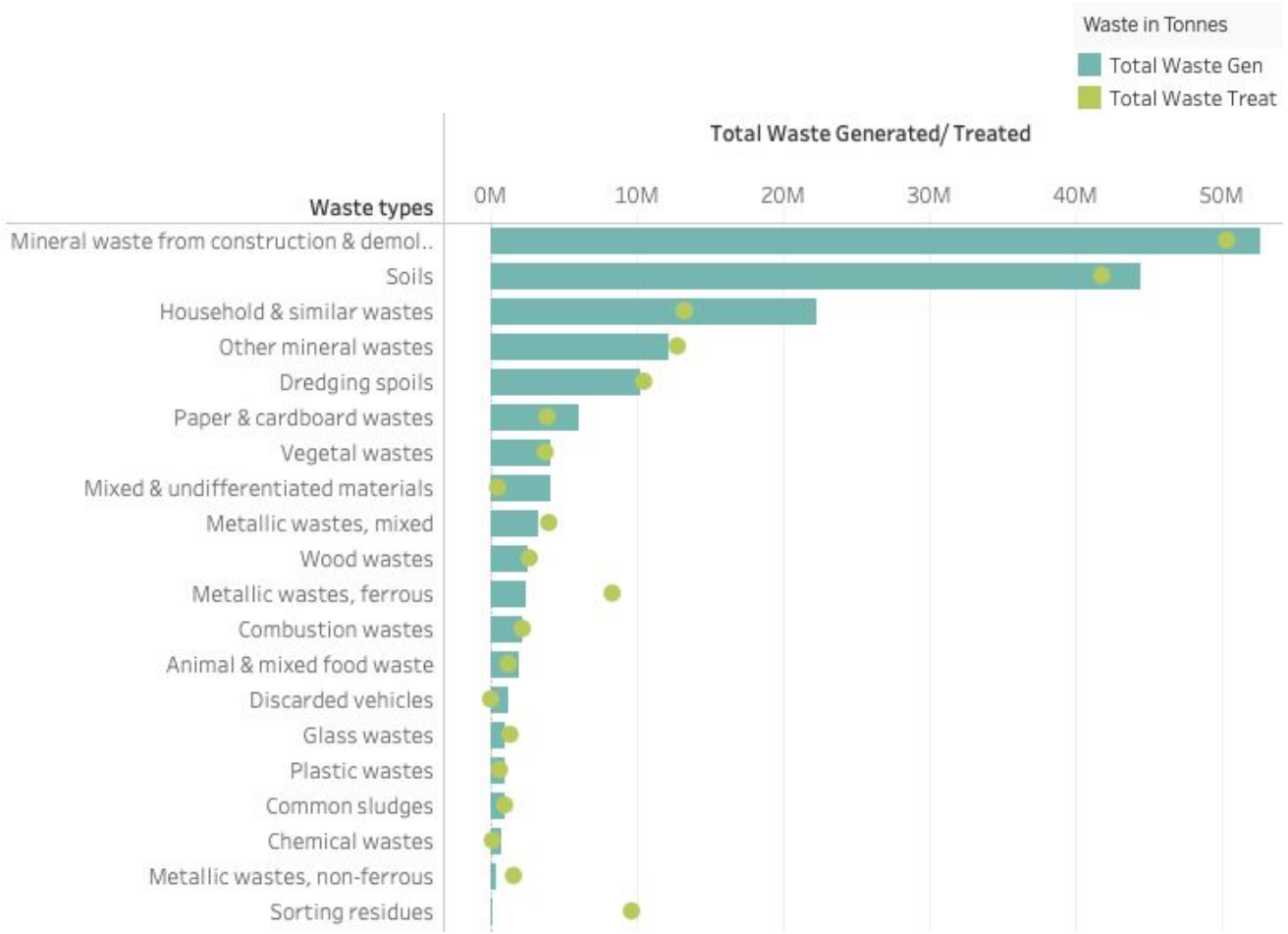


P-value < 0.01

The UK Avg of Waste Generated & Treatment



England Avg of Waste Generated & Treatment



Methods and Tools used for Q4:

- Data Wrangling in R and Python
  - Transform
  - Manipulation
  - Create New Variables
  - Renaming
  - Reshaping
  - Recoding
- ANOVAs
  - One-Way
  - Two-Ways
    - With ‘Year’
  - Repeated Measures (assumptions not met)
- MANOVAs
  - One-Way (assumptions not met)
- Machine Learning
  - Random Forest
  - Regression Models
    - Logistic Regression
    - KNN - KNeighbors Classifier GaussianNB
    - Linear Regression
    - Random Forest Regression

MANOVAS:
The UK & England Total Waste & Total Treatment

- DV: total waste generation & total sent treatment
- IV: waste type

- There is a significant difference in both the amount of waste generated and treatment by waste types
- We ran the analysis and violated the assumptions of multivariate normality
  - Highly correlated 0.97
  - Meaning presence of Multicollinearity
    - Which means we can’t say the components are influenced by one another

Let’s touch base on ANOVAs

What are ANOVAS?

- ANOVAS - “Analysis of Variance” (1DV, multiple IV’s)
  - Is analysis tool used in statistics. It helps determine the relationship between certain variables
  - This comparison is useful information to help eventually generate future analysis (such as: regression models etc)

* DV - Dependent Variable
  IV - Independendent Variable

Why run ANOVAS?

- Why not compare multiple groups with multiple tests?
- It gives you a better understanding how each individual component are correlated/influenced by each other

One-Way ANOVA: England & The UK Total Generated Waste & Treatment:

Generated Waste:

- There is an influence on the waste type and waste generated
- Average in the next slide

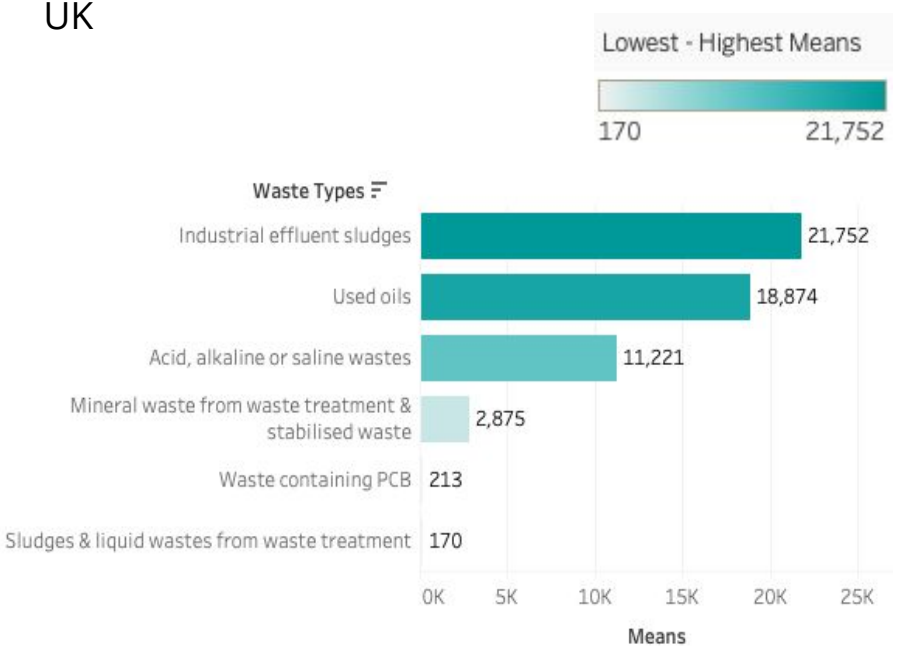
Treatment:

- There is no influence on the waste type and waste treated

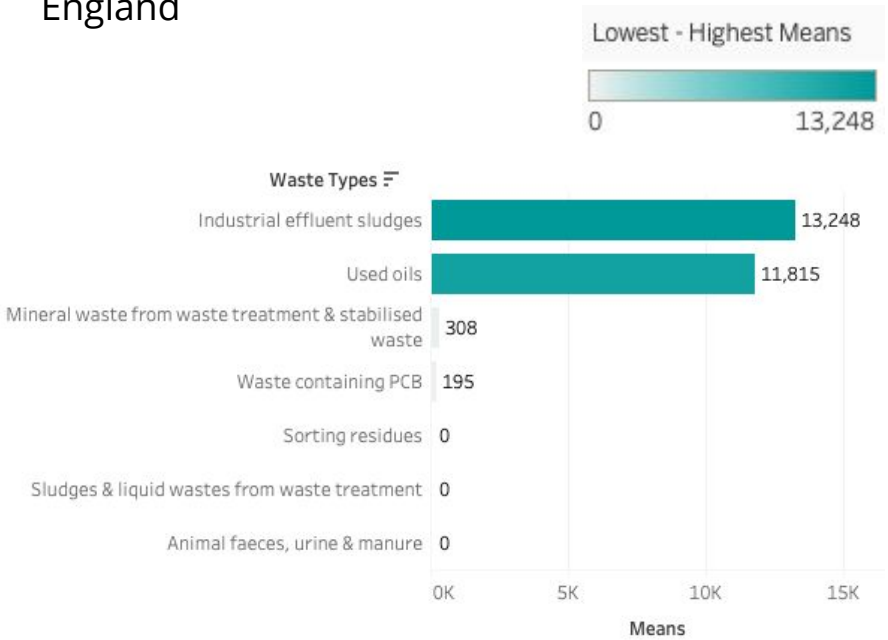
P-value: 0.01

One-Way ANOVA Significant Means for Generated Waste

UK



England



Let’s touch base on Random Forest

When running Random Forest

- Firstly, it is a type of machine learning
- And is most commonly used for forecasting and predictions
- When we talk about accuracy scores, it’s the outcome rate of the analysis we ran
- It tells us Yes, you can make predictions
- Or No, you shouldn't make predictions and if you do, do with caution

Why Random Forest?

- We ran various Machine Learning analysis and tests
- Random Forest presented the highest accuracy score in comparison to other Machine Learning models

Model 1
The United Kingdom Predictions for Classifications and Treatment Methods

Model 1: The United Kingdom

Classification

Prediction Accuracy Score

97%

Is a high accuracy score

Treatment

Prediction Accuracy Score

64%

64% Prediction is low. Should find other analysis with higher accuracy or do data wrangling.

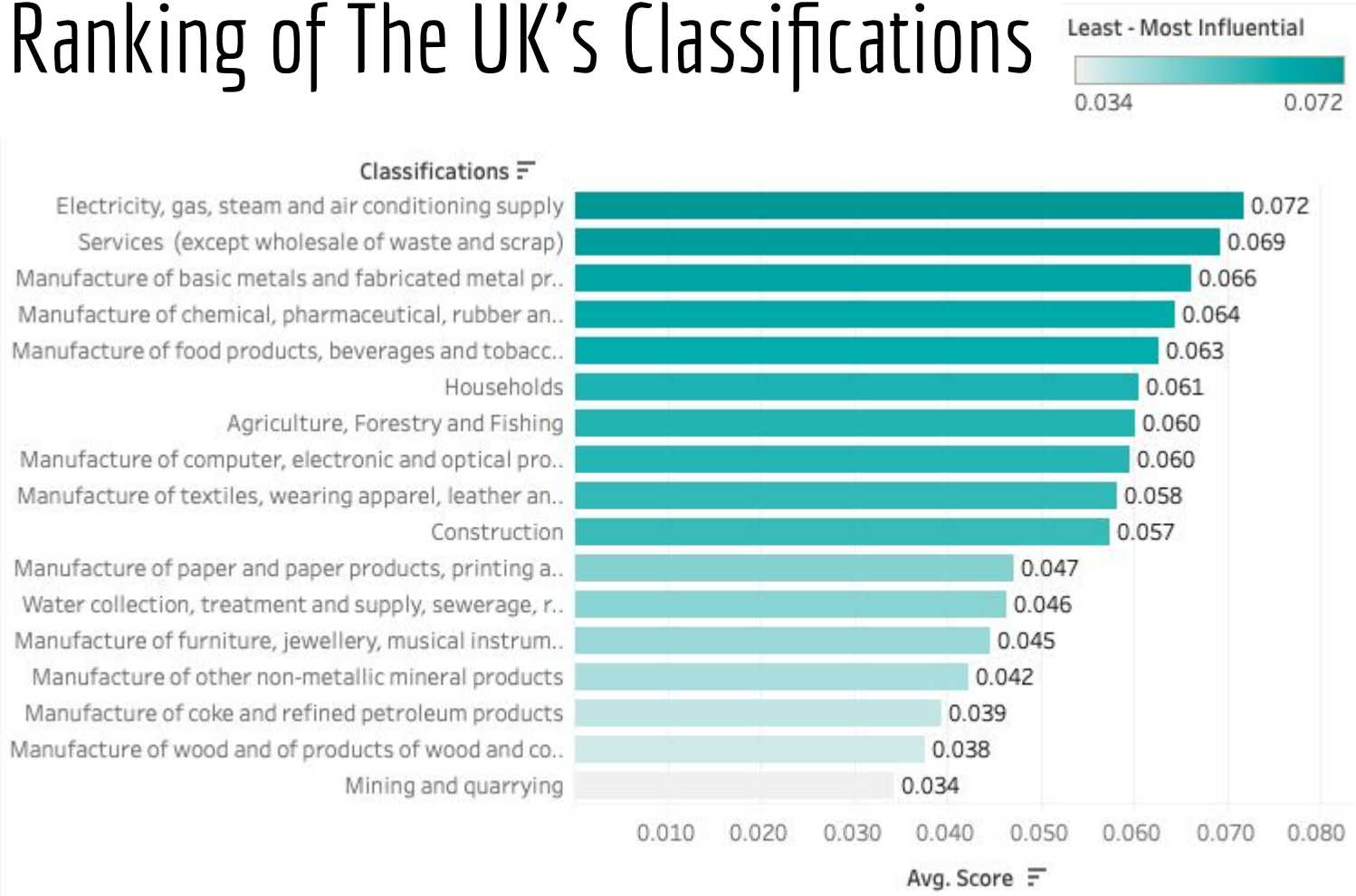
Classification & Treatment

Prediction Accuracy Score

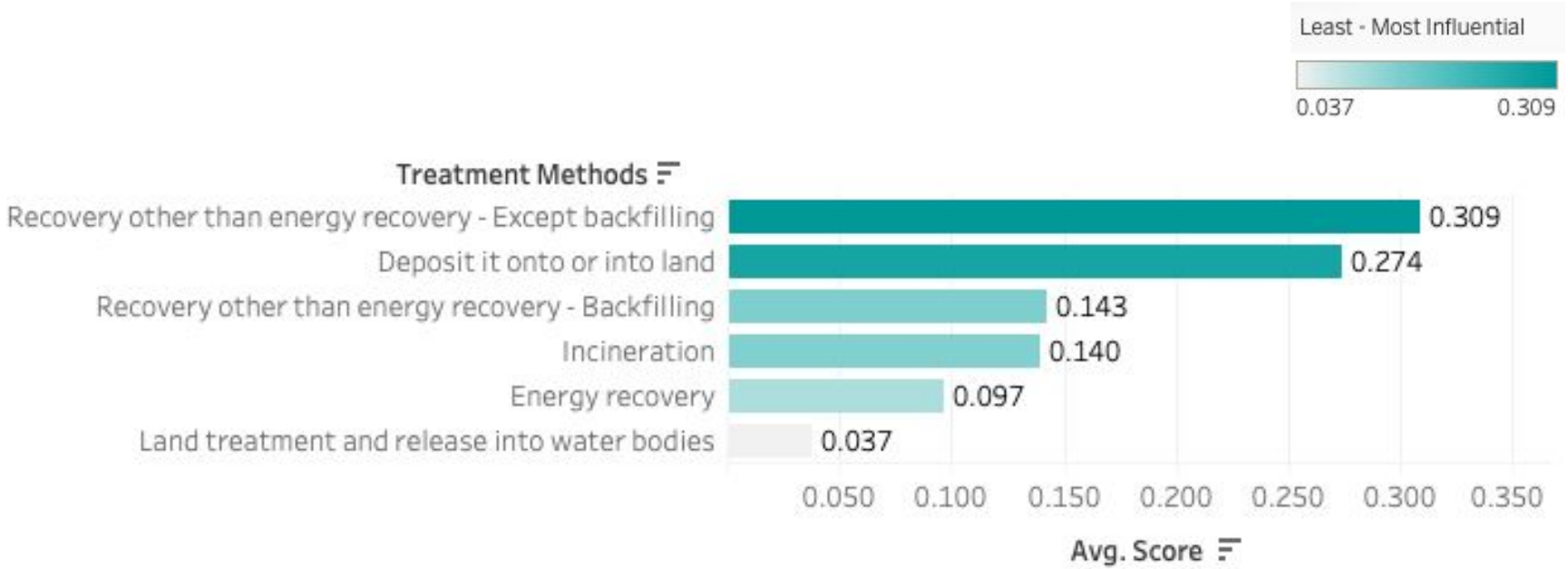
97%

Prediction 97%, is a high accuracy score.

The Ranking of The UK's Classifications



The Ranking of The UK's Treatment Methods



Model 2
England Predictions for Classifications and Treatment Methods

Model 2: England

Classification

Prediction Accuracy Score

83%

Above average accuracy score. Proceed with caution.

Treatment

Prediction Accuracy Score

63%

63% Prediction is low. Should find other analysis with higher accuracy or do data wrangling.

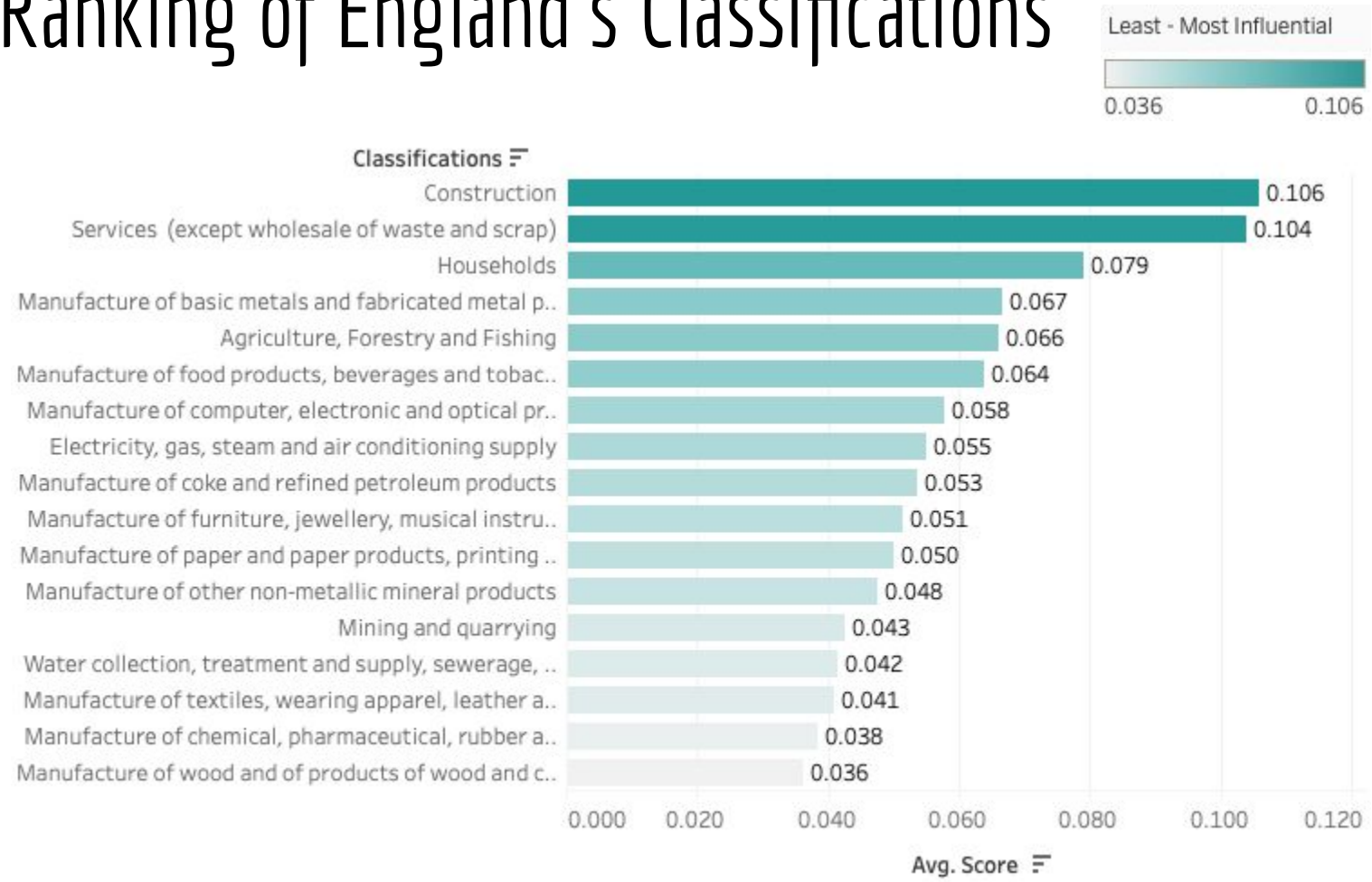
Classification & Treatment

Prediction Accuracy Score

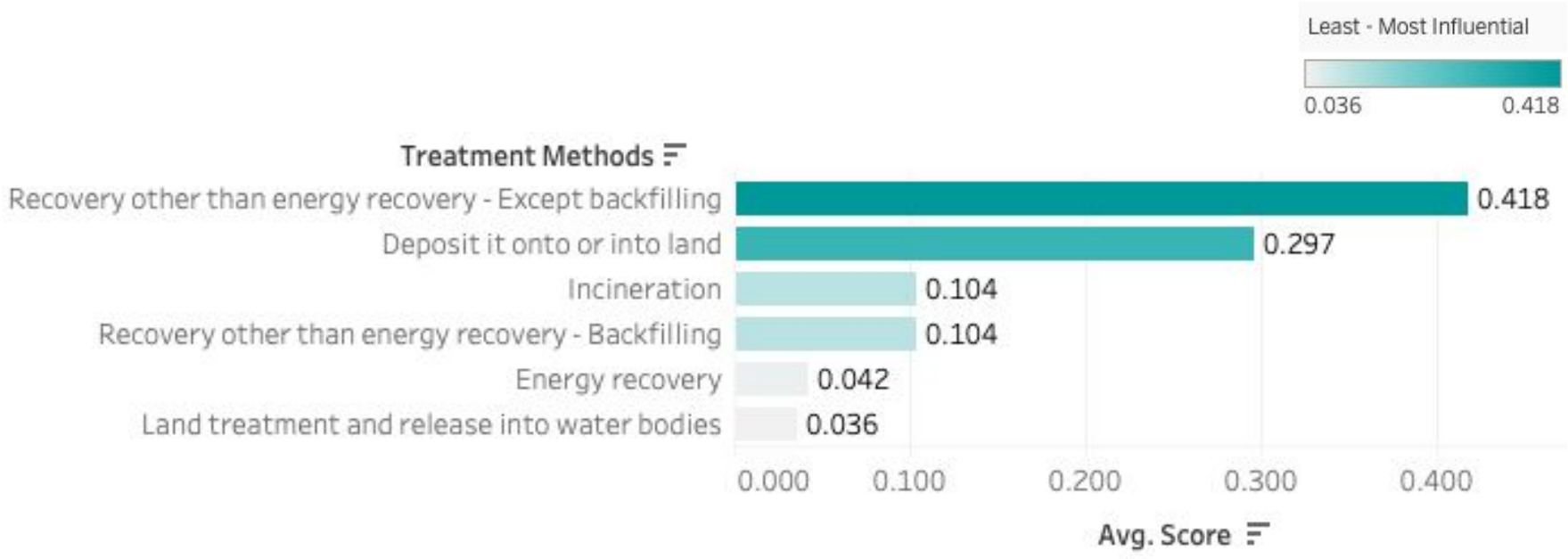
100%

Over accurate score.

The Ranking of England's Classifications



The Ranking of England's Treatment Methods



Next is Regression Models

Why Linear Regressions?

After running some analysis the highest accuracy score came from Linear Regression.

- First off, regressions is a statistical approach to modeling a relationship between a dependent variable and a given set of independent variables
- Unlike Random Forest, we had to run Linear Regressions because the variables matched up with this specific analysis
- Although, Random Forest and Linear Regression are two different machine learning techniques, they both still run predictions and forecasting

Models 3-6:
The UK Predictions with/out Waste Types & Year

The UK

- Running the Linear regression analysis we found
- 94 - 99.8% are the averages of the accuracy scores
- Means the predictions are accurate

England

- Running the Linear regression analysis we found
- 96 - 99.5 % are the averages of the accuracy scores
- Means the predictions are accurate

Model 5 & 6:
England Predictions with/out Waste Type & Year

UK DV is continuous as Total Waste Treatment

w/ Waste Types, Years, & Classifications: 94%
w/o Waste Types: 96%
w/o Waste Type & Year: 96%

England DV is continuous as Total Waste Treatment

w/ Waste Types, Years, & Classifications: 99.5%
w/o Waste Types: 96%
w/o Waste Type & Year: 96%

UK DV is continuous as Total Waste Generated

w/ Waste Types, Years, & Classifications: 99.8%
w/o Waste Types: 95%
w/o Waste Type & Year: 95%

England DV is continuous as Total Waste Generated

w/ Waste Types, Years, & Classifications: 99.5%
w/o Waste Types: 97%
w/o Waste Type & Year: 97%

Q5

TABLEAU & VISUALS

How do <u>treatment</u> methods differ by waste types?
Does the particular waste type matter for which treatment method process it goes through? Do specific waste types need specific treatment methods? If so, what are the specifications for both waste types correlated with treatment methods?

The UK & England: Correlation between Waste Types and Treatment Methods

Deposit Land	0.40
Treated Water bodies	0.36
Backfilling	0.28
No Backfiling	0.21
Incineration	0.14
Energy Recovery	0.08

The UK: Correlation between Treatment Methods

	Energy Recovery	Incineration	No Backfiling (Recycling)	Backfiling	Land Deposit	Waterbodies
Energy Recovery	1.0	0.23	-0.041	-0.033	0.11	-0.045
Incineration		1.0	-0.058	-0.045	0.33	-0.059
No Backfiling			1.0	0.23	0.18	-0.074
Backfiling				1.0	0.81	-0.037
Land Deposit					1.0	-0.056
Wasterbodies						1.0

England: Correlation between Treatment Methods

	Energy Recovery	Incineration	No Backfiling (Recycling)	Backfiling	Land Deposit	Waterbodies
Energy Recovery	1.0	0.22	-0.039	-0.027	0.088	-0.038
Incineration		1.0	-0.059	-0.042	0.27	-0.058
No Backfiling			1.0	0.21	0.18	-0.08
Backfiling				1.0	0.83	-0.04
Land Deposit					1.0	-0.054
Wasterbodies						1.0

Now that we have overloaded you with tons of info, here’s a quick recap

Summary

After running the analysis, the three components of Waste Types, Classifications, and Treatment Methods are highly correlated and influence one another.

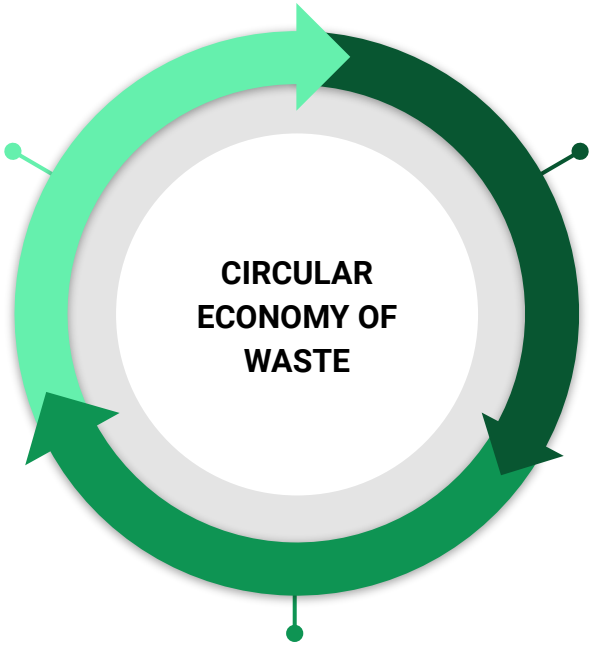
- Treatment Methods are not significantly related to Waste Types
- Most common Waste Types and Classifications:
    - Waste types: Industrial effluent sludges, Used oils, Mineral waste from construction & demolition, Waste containing PCB, Soils, and Households & similar wastes
- Best predictors of Waste Types to Classifications:
    - Electricity, gas, steam and air conditioning supply, Manufacture of basic metals, and fabricated metal products, expect machinery and equipment, Households, Services, Construction, Manufacture of chemical, pharmaceutical, rubber and plastic products, Manufacture of food products, beverages and tobacco products, Agriculture, forestry and fishing
- Best predictors of Waste Types to Treatment Methods:
    - Recovery other than energy recovery- except backfilling (Recycling), Deposit it onto or into land, Recovery other than energy recovery- Backfilling, Incineration

How can we unite and prevent?
Here are some recommendations, resources, and benefits


MAKE A BIG IMPACT
BY MAKING
LITTLE IMPACT

Business Outlooks and Benefits

- Inventing a new unique economic principle to eliminate trash altogether can be lucrative
- Seeing garbage as a commodity, it is a business
  - Sweden imports trash from other European countries to fuel its power needs
  - Make and save money
    - Neighboring countries export waste to Sweden to avoid paying taxes towards landfill disposal
- Building an ecosystem to develop innovative products that cater to sustainability and to the needs of today's rapidly-shifting market



COLLECTION AND PROCESSING

Improve collection methods
Encourage recycling
Invest in infrastructure

PRODUCTION AND PURCHASING

Design products that are sustainable and reusable
Develop market for recycled materials
Reduce manufacturing waste

CONSUMPTION AND USE

Optimize lifecycle through alternative consumption
Promote Recycle and Reuse

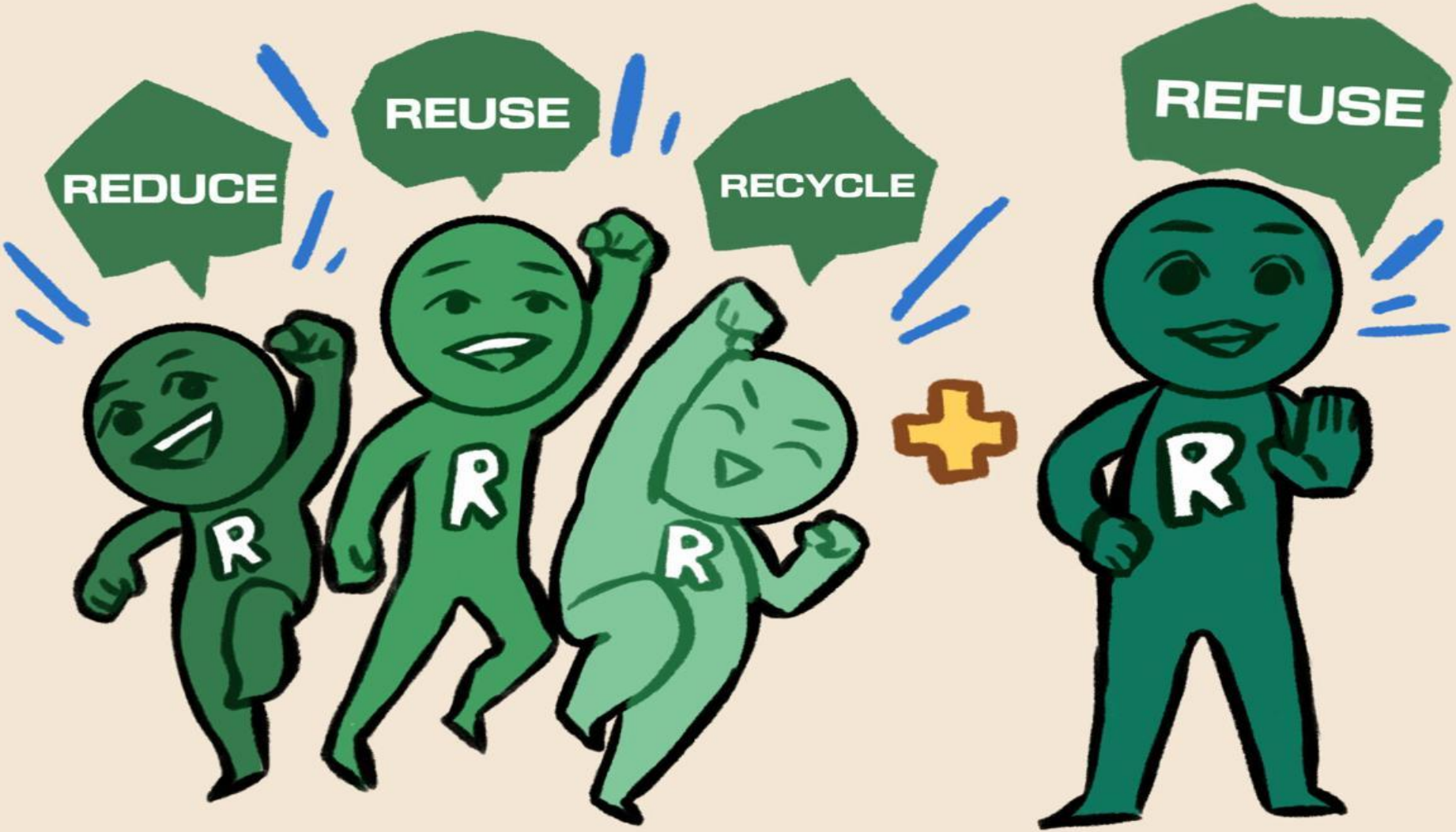
Circular Economy Resources

- UK BIOBUS: https://www.goodnet.org/articles/you-guess-what-fuels-uks-new-sustainable-bus
- Company: https://www.loopindustries.com/en/ (plastic revolution)
- Projects: https://theoceancleanup.com (largest ocean cleanup)
- NonProfit/Company: https://www.4ocean.com (clean up and make accessories)
- Circular Economy - Brief Video

How this benefits the UK government?

- Waste management has lucrative potential in the UK
- Proactive measures towards Circular Economy, can help achieve zero waste policies
  - UK government funding £22.5 million to turn industry waste into environmental wins
- UK Circular Economy Regulation:
  - The Waste (Circular Economy) (Amendment) Regulations 2020
- Sustainable solutions for treatment
  - Veolia offers industrial effluent treatment solutions
    - Takes specific natural procedures for each pollutant
  - Zero Avoidable Waste is specifically for mineral waste from construction
    - Waste prevention program for specific pollutants

Overall...


REDUCE
REUSE
RECYCLE
REFUSE
R
R
R
R

Conclusion

- England in particular, compared to the UK, produces a large amount of industrial waste sludge
  - Based on our statistics, industrial waste is a huge problem, and as a business owner and consumer, it is important to be aware of our own waste generated
  - Independent awareness and research of the companies you support and what they use to produce waste can make an impact
  - Converting to sustainable companies is beneficial to the people and the environment
- Although this specific project is based on information from the UK and England, it can be compared to the general population

Reduce, Reuse, Recycle 🔄

Thank you!

Acknowledgements

- Shout out to Woz-U for mentoring us
- A big thanks to Meredith and Devin for guiding us and answering all of our questions and showing us the ropes
    - Especially Devin’s code
- Thank you Sherlin for mentoring us through the course and always ready to help

Go Green!!!

THE END.

Questions?

Further Questions?

- If you had more time, what else would you do on this project?
  - Done further investigation in the ANOVA; post hocs each variable and see relation
    - ANOVA's for Treatment and Year needed further DW. (One way ANOVA's: Treatment has no means. All p-values in Post Hocs are more than 0.05)
- What's next for you?
  - Updated data with recent year - to predict the future
  - Random Forest -> Treatment 64% -> further DW to produce higher accuracy score, and re-run the ML
  - Year-> not influence, nan ML, further investigation
- What was the most difficult part of this project?
  - Reshaping the datasets for further analysis, and running ML
  - How to interpret the results and explain in layman's terms

What can I do???

Our Personal Insight to Solve a problem of Waste:

- “The Fate of Waste is in our Hands!”
- The Government may implement strict rules and regulations to manage waste, and monitor waste in developing countries like India (from our experiences)
    - I remember every year after schools were finished, waste collector of things you can recycle and reuse such as books, and boxes, etc
        - Those collectors are mom-and-pop independent businesses
            - Circular Economy on small scale, but we can have effective and efficient impact if everyone adopt and understand the simple method of reuse, reduce and recycle
- Personally seeing trash affecting day to day lives of people and animals in countries like India, and feeling useless to be able to take proactive actions to solve the crisis of waste
- Just a little bit of effort can make big impact in waste

Conti...

- AWARENESS is key
  - Educating/ informing, hosting workshops on how to manage the waste and how to recycle at schools and colleges, communities, etc as many of us are do not know how to recycle and which materials are recyclable
- Hand out paper straw to use instead of just telling people
- Have 10 years target to reduce waste by %, and promote that and encourage businesses and government to invest in innovative waste management ideas and technology
  - Keeping in mind of Circular Economy
    - Socioeconomics strategies
- Our approach to sustainability
- We decomposed organic material in our backyard, and use as a fertilizer to grow plants for following harvesting season
  - Conserve soil health and ending up with natural costfree no chemical fertilizer
  - This will reduce contamination and harmful bio chemicals

Recommendations

- Buy locally
- Sustainable/ Eco-friendly products
- Grocery stores like in olden days
- Use a reusable water bottle instead of plastic bottles
- Metal and paper straws
- Bring your own tupperware for leftovers
- Reusable trash bags
- Beeswax cloths, instead of plastic wrap
- Reusable silicone covers, instead of foils
- Wood, bamboo, plant-based, metal, glass products instead of plastic
- Thrift cloths, repurposed/ recyclable sustainable material cloths
- Shop consciously

Resources

- https://www.onyalife.com/eco-friendly-products/
- https://earthsider.com
- https://byhumankind.com
- https://www.tru.earth
- https://dyper.com/?gclid=CjwKCAiAjp6BBhAIEiwAkO9WuhtogtVicOK6Lx-gdnvcQ3VgawFxLj9_YPwp8KKgvjwqXQ0fNRuibBoC30gQAvD_BwE
- https://packagefreeshop.com
- https://lollicupstore.com/eco-friendly-sustainable-products?gclid=CjwKCAiAjp6BBhAIEiwAkO9WurQ7Z_nRziR_rBxGmNm2k1VW0_mUpMwqrwLIwHjVPP1oXK6a02ylcxoCUY0QAvD_BwE