TACKLING PLASTIC BOTTLE POLLUTION: A COMPREHENSIVE PLAN

Abstract

Plastic is a ground-breaking material. It is one of the most common human-made products on the planet due to its unique characteristics of being highly mouldable, durable, lightweight, and inexpensive to produce. It saves money on transportation, keeps food fresh, and serves important medical purposes. Since the 2010s, plastic consumption has grown dramatically, and plastic production is expected to double in the next two decades. Plastic waste generation has quadrupled in India over the past ten years. Also, the pandemic created a surge in plastic production. To help tackle plastic waste generation in India, we have created a framework to study Plastic Generation, Plastic Wastage, and the Recycling Rate of Plastic.

Literature Review

We have implemented an existing idea that is currently an ongoing process in Australia of REVERSE VENDING Machines. Introduction of Australian base plastic bottle recycling model in the Indian system to study the trend of plastic recycling and the effect of this system on per year plastic pollution. Intensive Prediction of the Reverse Vending Machines Requirement. We have investigated the rate of plastic generation against the rate of plastic recycling rate. We have also predicted the effects of using vending machines in India and how will they help in reducing plastic pollution. Machine learning techniques show significant prediction results in tackling plastic pollution. Machine learning algorithms can be used to predict when machines used in plastic manufacturing processes are likely to fail. By detecting issues early, it can prevent unplanned downtime and reduce the number of plastics that are scrapped due to production defects. Machine learning can also be used to improve the efficiency of plastic recycling processes. For example, machine learning algorithms can be used to

detect impurities in plastic waste, which can make the recycling process less efficient. By removing impurities, it would be possible to recycle more plastic waste.

Objective

Our aim for this project is to sustainably reduce plastic pollution and also implement the sustainable methods that are used in other countries. Here we focus to provide a prediction of the time and machine requirements at which the rate of production of plastic will decrease as a result of the increasing rate of recycling of plastic. Using our prediction model we want to create awareness that India can also defend against the upcoming excess plastic waste in the upcoming decade.

Introduction

Machine learning and reverse vending machines can play a significant role in reducing plastic waste by encouraging recycling and promoting a circular economy. Reverse vending machines are automated machines that accept used beverage containers such as plastic bottles, cans, and glass bottles and provide a financial or non-financial incentive in return. The reward encourages people to recycle and reduces littering, as people are more likely to dispose of their empty containers properly if they can receive a reward for doing so.

These machines have been used for many years in countries such as Germany, Australia, and Sweden, where they have proven to be an effective way of promoting recycling.

Machine learning can be used to improve the performance of reverse vending machines by identifying and sorting different types of containers accurately. The technology can also help to detect fraud and prevent misuse of the machines. For instance, machine learning algorithms can be trained to recognize the unique features of different types of plastic bottles, such as their shape, size, and brand. This will enable the reverse vending machine to sort and separate the bottles

automatically, making the recycling process more efficient and effective.

Machine learning can help to optimize the design of reverse vending machines to make them more user-friendly and appealing to customers. For example, the technology can be used to analyze customer behavior and preferences, such as the time of day they are most likely to use the machines, the type of reward they prefer, and the location of the machine. Machine learning can improve the performance of reverse vending machines and promote recycling, which is an essential step toward reducing plastic waste and achieving a more sustainable future.

In this paper, we explore the challenges and best practices for predicting the levels of plastic waste that can be reduced with the help of these vending machines.

We have gathered all our data from the CPCB – Central Pollution Control Board, Government of India.

Here is the website link: https://cpcb.nic.in/index.php

We have considered data from 2011 to 2020. And on basis of this data, we have predicted no of machines required per state and their per-year recycling capacity.

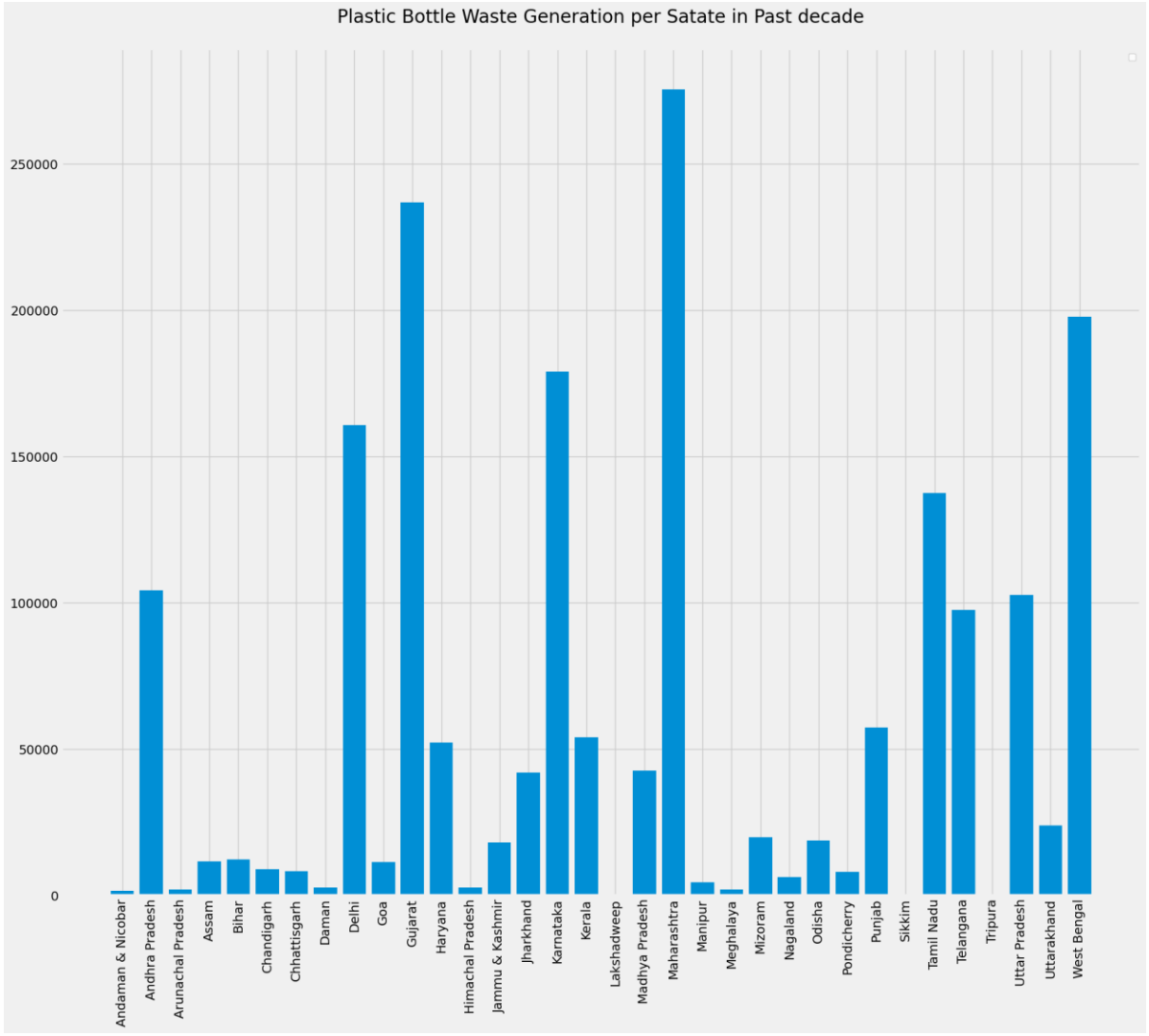
We also have assumed plastic bottle production from the year 2021 to 2030 and on basis of these assumptions we have determined the rate at which the machines will fulfill the total plastic waste recycling capacity for India.

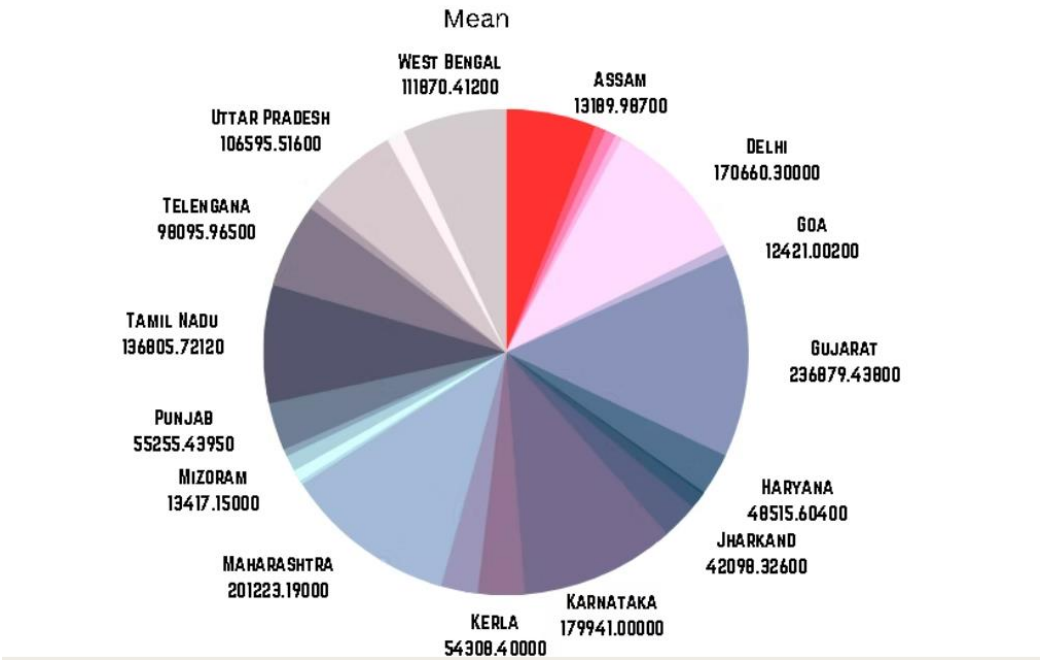
Reading of the Dataset that consists of 34 states of India plastic pollution data.

	Sr.no	state	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	1	Andaman & Nicobar	2675.00	2555.00	2123.000	2737.00	1583.00	567.0000	983.000	1850.000	387.00
1	2	Andhra Pradesh	28888.00	243820.00	243820.000	128480.00	128480.00	82863.0000	74588.000	66314.000	46222.00
2	3	Arunachal Pradesh	453.00	673.00	863.000	1273.00	1454.00	3836.0000	6000.000	3787.370	2715.00
3	4	Assam	1226.00	1116.00	781.000	1363.00	24010.00	24030.0000	28153.000	32277.870	4971.00
4	5	Bihar	1527.00	1673.00	1723.000	1893.00	2314.00	2280.0000	2280.000	68903.328	41365.00
5	6	Chandigarh	5548.00	4964.00	4818.000	8992.00	13167.00	21516.7500	12775.000	11715.400	6746.00
6	7	Chhattisgarh	4678.00	5840.00	6123.000	6345.00	6897.00	7300.0000	6650.000	6000.000	32850.00
7	8	Daman	1274.00	1347.00	14736.000	1573.00	1637.00	1733.0000	1836.000	1947.700	1948.00
8	9	Delhi	261234.00	251850.00	23456.000	24567.00	128649.00	232732.0000	228771.000	224810.000	230525.00
9	10	Goa	415.00	1642.50	117.730	104.00	106.00	28273.0000	26242.000	32580.520	26068.00
10	11	Gujarat	23666.00	251796.65	251796.650	265568.20	269294.88	271092.0000	269808.000	356873.000	408201.00
11	12	Haryana	52883.00	55480.00	50332.690	44536.00	32452.00	23369.0900	46353.000	68735.260	147734.00

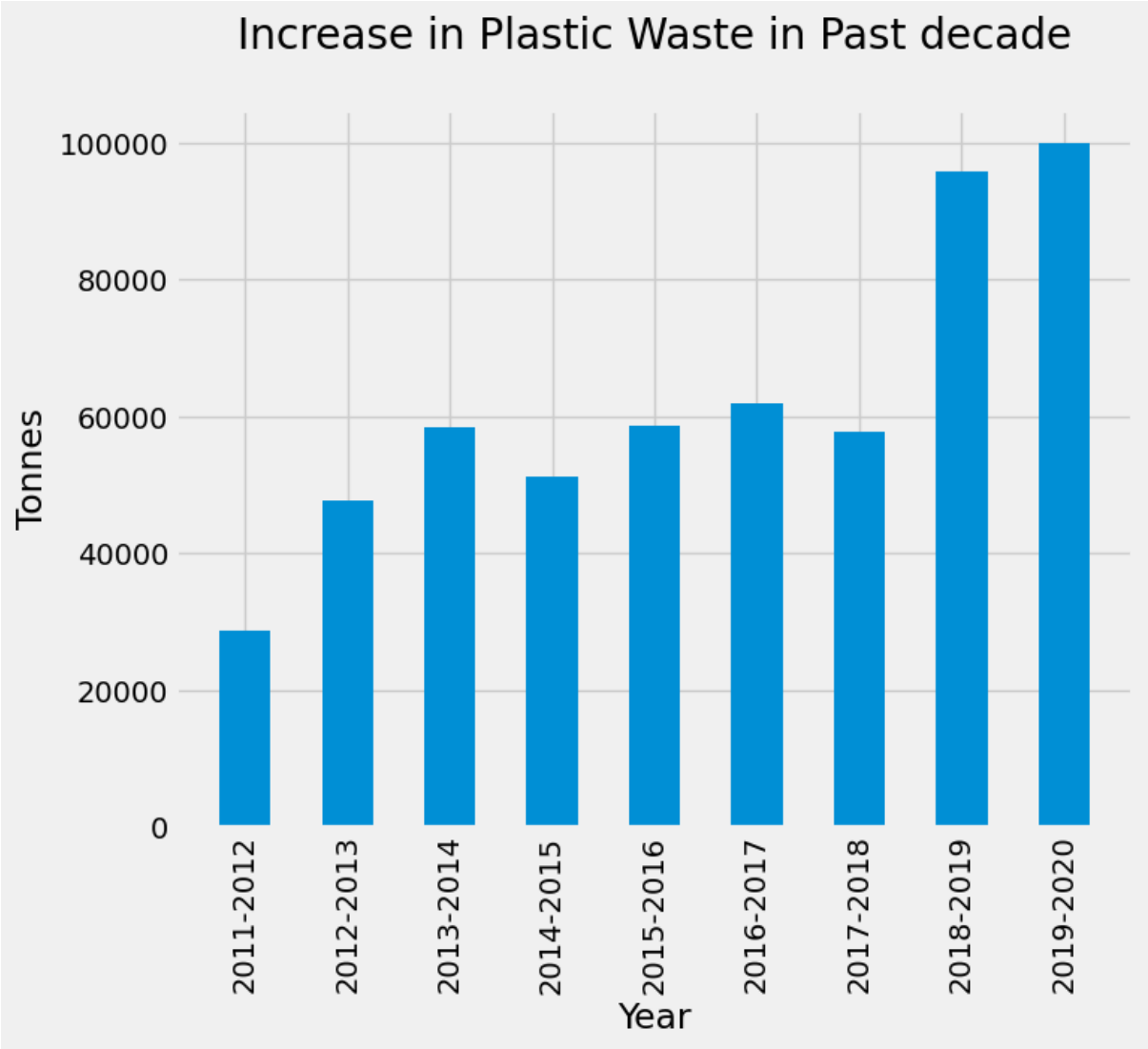
Finding out the average plastic pollution for all 34 states that will be required for the prediction of the number of reverse vending machines:

	Sr.no	state	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean
0	1	Andaman & Nicobar	2675.00	2555.00	2123.000	2737.00	1583.00	567.0000	983.000	1850.000	387.00	1546.10000
1	2	Andhra Pradesh	28888.00	243820.00	243820.000	128480.00	128480.00	82863.0000	74588.000	66314.000	46222.00	104347.70000
2	3	Arunachal Pradesh	453.00	673.00	863.000	1273.00	1454.00	3836.0000	6000.000	3787.370	2715.00	2105.73700
3	4	Assam	1226.00	1116.00	781.000	1363.00	24010.00	24030.0000	28153.000	32277.870	4971.00	11793.18700
4	5	Bihar	1527.00	1673.00	1723.000	1893.00	2314.00	2280.0000	2280.000	68903.328	41365.00	12396.33280
5	6	Chandigarh	5548.00	4964.00	4818.000	8992.00	13167.00	21516.7500	12775.000	11715.400	6746.00	9024.81500
6	7	Chhattisgarh	4678.00	5840.00	6123.000	6345.00	6897.00	7300.0000	6650.000	6000.000	32850.00	8269.00000
7	8	Daman	1274.00	1347.00	14736.000	1573.00	1637.00	1733.0000	1836.000	1947.700	1948.00	2803.97000
8	9	Delhi	261234.00	251850.00	23456.000	24567.00	128649.00	232732.0000	228771.000	224810.000	230525.00	160660.30000
9	10	Goa	415.00	1642.50	117.730	104.00	106.00	28273.0000	26242.000	32580.520	26068.00	11555.87500


Plastic Bottle Waste Generation per Satate in Past decade
250000
200000
150000
100000
50000
0
Andaman & Nicobar
Andhra Pradesh
Arunachal Pradesh
Assam
Bihar
Chandigarh
Chhattisgarh
Daman
Delhi
Goa
Gujarat
Haryana
Himachal Pradesh
Jammu & Kashmir
Jharkhand
Karnataka
Kerala
Lakshadweep
Madhya Pradesh
Maharashtra
Manipur
Meghalaya
Mizoram
Nagaland
Odisha
Pondicherry
Punjab
Sikkim
Tamil Nadu
Telangana
Tripura
Uttar Pradesh
Uttarakhand
West Bengal


Mean
WEST BENGAL
111870.41200
ASSAM
13189.98700
UTTAR PRADESH
106595.51600
DELHI
170660.30000
TELENGANA
98095.96500
GOA
12421.00200
TAMIL NADU
136805.72120
GUJARAT
236879.43800
PUNJAB
55255.43950
MIZORAM
13417.15000
HARYANA
48515.60400
JHARKAND
42098.32600
MAHARASHTRA
201223.19000
KARNATAKA
179941.00000
KERLA
54308.40000

Evaluation of the increase in plastic waste in the past decade



This was evaluated in order to find the Rate of increase in plastic waste that would be used to predict the number of machines required.

Prediction of the Number of Reverse Vending Machines

The average weight of a plastic bottle =10grams

The capacity of a reverse vending machine= 550 bottles

So according to this data if per day 550 bottles are collected in a machine then the total weight will be 5500 grams per day. So for a month, it's about 165000 grams =165kgs approx. of bottle weight. According to this

the yearly capacity of a single reverse vending machine will be 1.91625 tonnes of plastic bottles.

The capacity of a Single Reversing Vending Machine

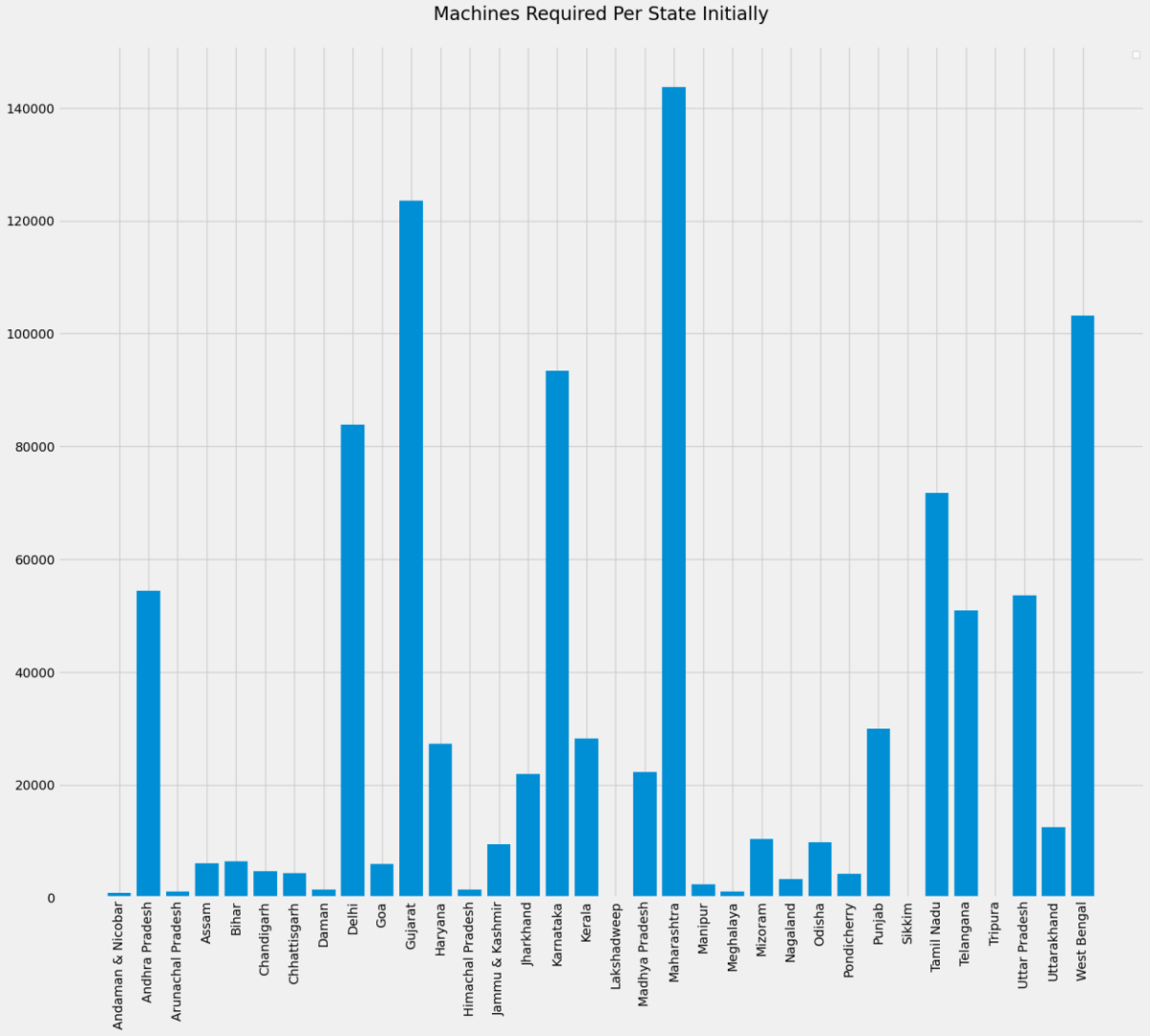
Per Year = 1.91625 tonnes

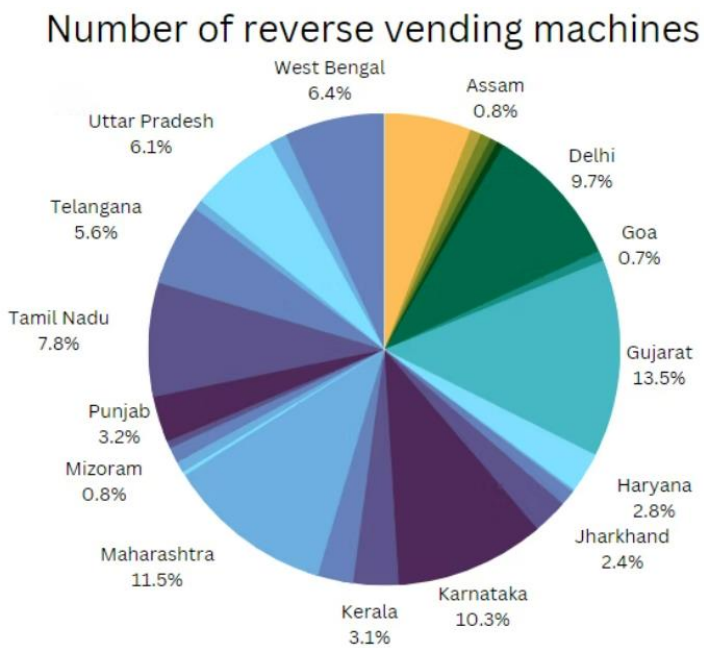
Per Month = 165 Kilograms

Year day= 5.5 kilograms

Hence relating to this calculation the Number of reverse vending machines required initially is calculated.

	Sr.no	state	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean	Number of reverse vending machines
0	1	Andaman & Nicobar	2675.00	2555.00	2123.000	2737.00	1583.00	567.0000	983.000	1850.000	387.00	1546.10000	806.0
1	2	Andhra Pradesh	28888.00	243820.00	243820.000	128480.00	128480.00	82863.0000	74588.000	66314.000	46222.00	104347.70000	54454.0
2	3	Arunachal Pradesh	453.00	673.00	863.000	1273.00	1454.00	3836.0000	6000.000	3787.370	2715.00	2105.73700	1098.0
3	4	Assam	1226.00	1116.00	781.000	1363.00	24010.00	24030.0000	28153.000	32277.870	4971.00	11793.18700	6154.0
4	5	Bihar	1527.00	1673.00	1723.000	1893.00	2314.00	2280.0000	2280.000	68903.328	41365.00	12396.33280	6469.0
5	6	Chandigarh	5548.00	4964.00	4818.000	8992.00	13167.00	21516.7500	12775.000	11715.400	6746.00	9024.81500	4709.0
6	7	Chhattisgarh	4678.00	5840.00	6123.000	6345.00	6897.00	7300.0000	6650.000	6000.000	32850.00	8269.00000	4315.0
7	8	Daman	1274.00	1247.00	14736.000	1573.00	1637.00	1733.0000	1836.000	1947.700	1948.00	2803.07000	1463.0





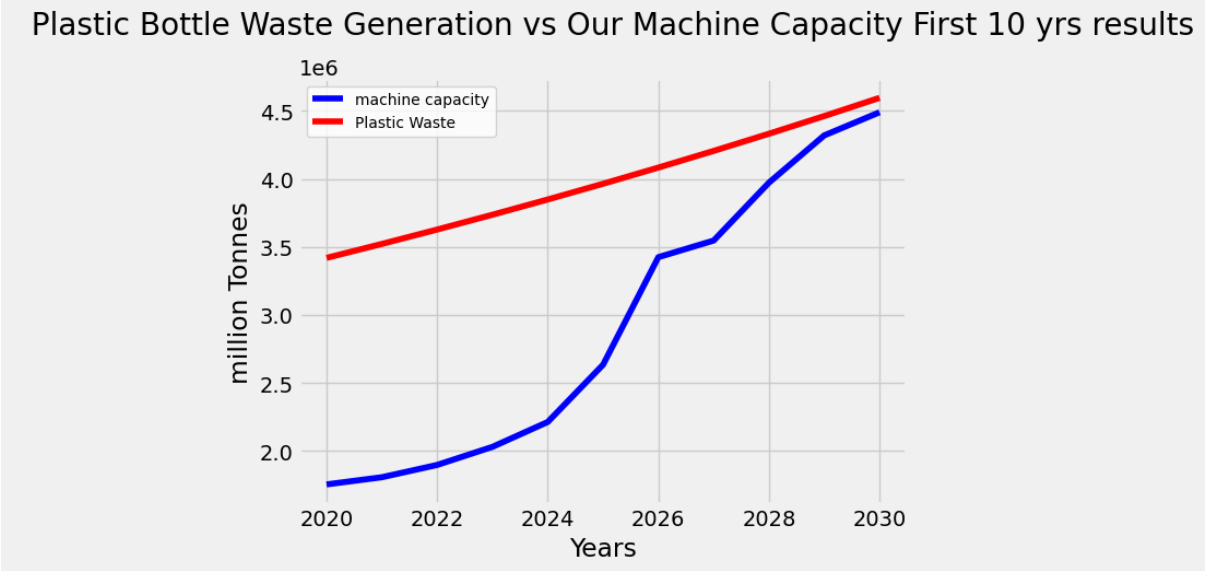
Approx. Total of 1000000 (10 Lakhs) Machines needed

Here we will focus on the prediction of further 2 decades with our machine prediction and effects on the recycling rate and production rate

Prediction for the Years 2020 to the Year 2030:

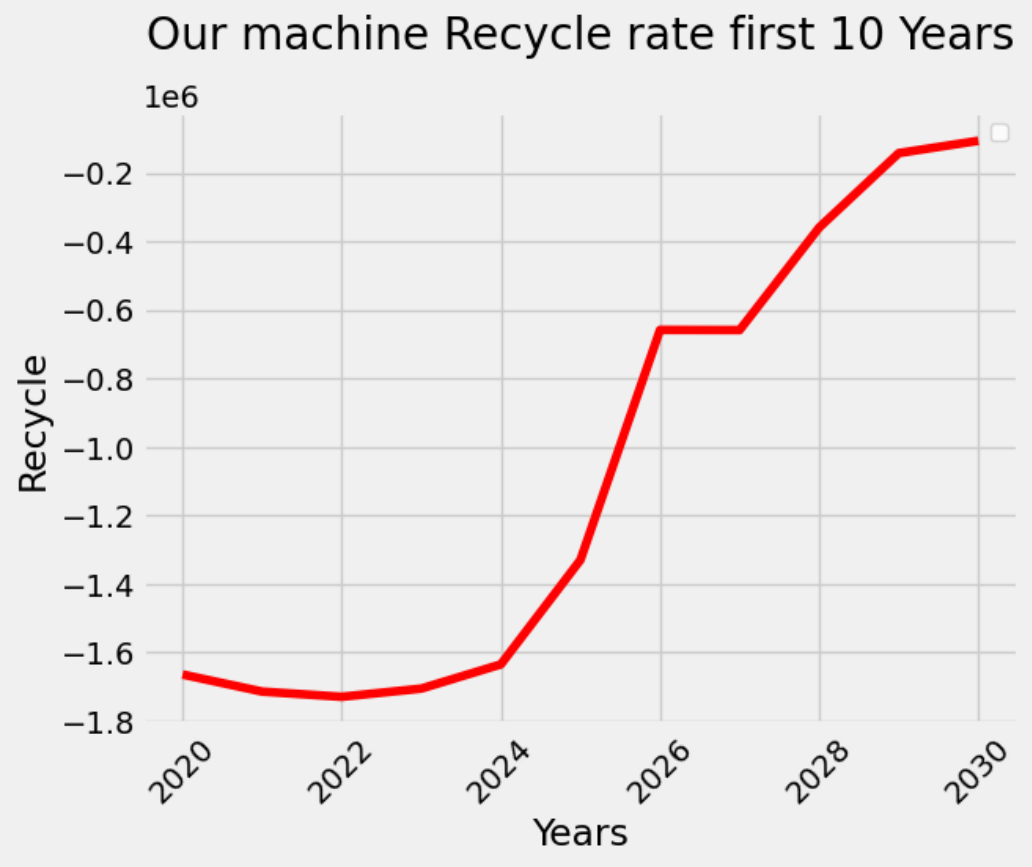
Plastic Waste Generation is Increasing by 2% to 7% For the first decade. Machine Numbers Increased by 1%-2% per Year and Machine Recycling Capacity Increased by 3%-4% per Year respectively.

	Year	PlasticProductionWaste	MachineCapacity	Recycle
0	2020	3419480	1755140	-1664340
1	2021	3522046	1807794	-1714252
2	2022	3627726	1898184	-1729542
3	2023	3736558	2031057	-1705501
4	2024	3848654	2213852	-1634802
5	2025	3964114	2634483	-1329631
6	2026	4083037	3424829	-658208
7	2027	4205529	3546902	-658627
8	2028	4331694	3972530	-359164
9	2029	4461645	4319644	-142001
10	2030	4595499	4489528	-105971

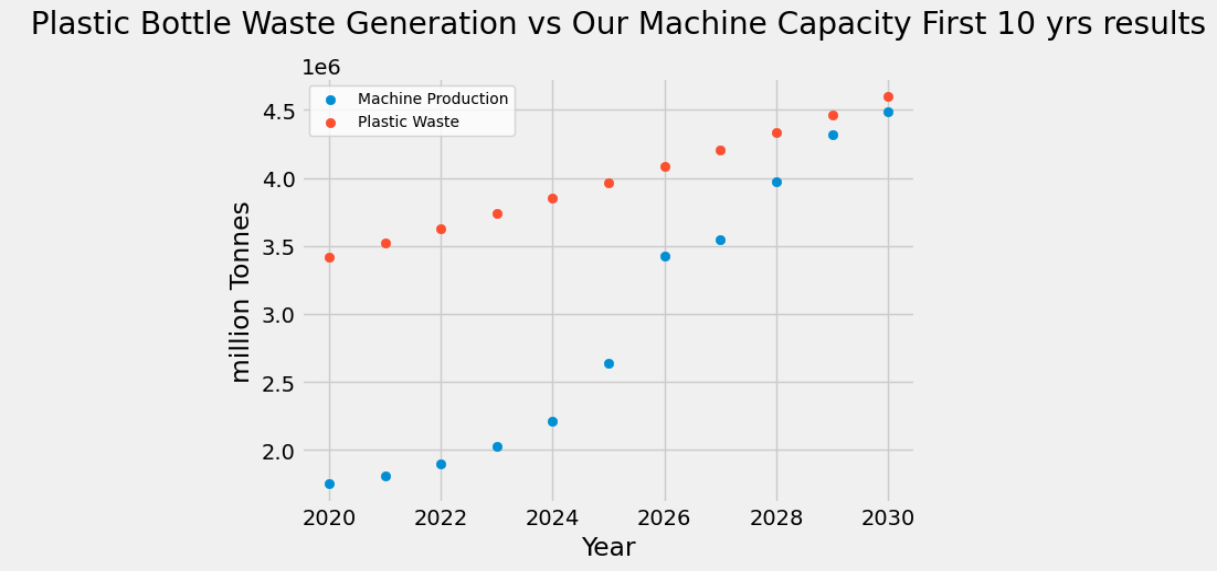


Using the prediction graph above we can find that if the rate of plastic waste increase against the increase in the number of reverse vending machines hence at some point we will able to meet the requirement for the plastic to get collected and recycled.

Here is the recycle rate prediction:

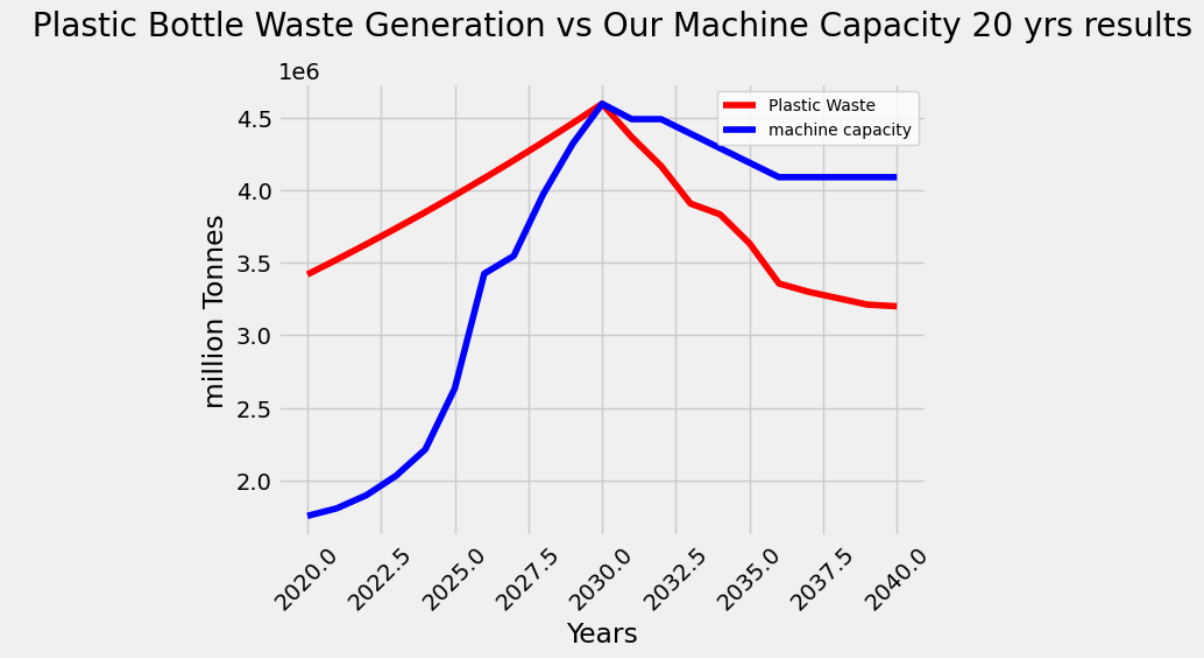


Recycling Rate is negative initially since machine capacity is less than total Plastic Bottle waste generation. The recycling Rate will increase down the decades.

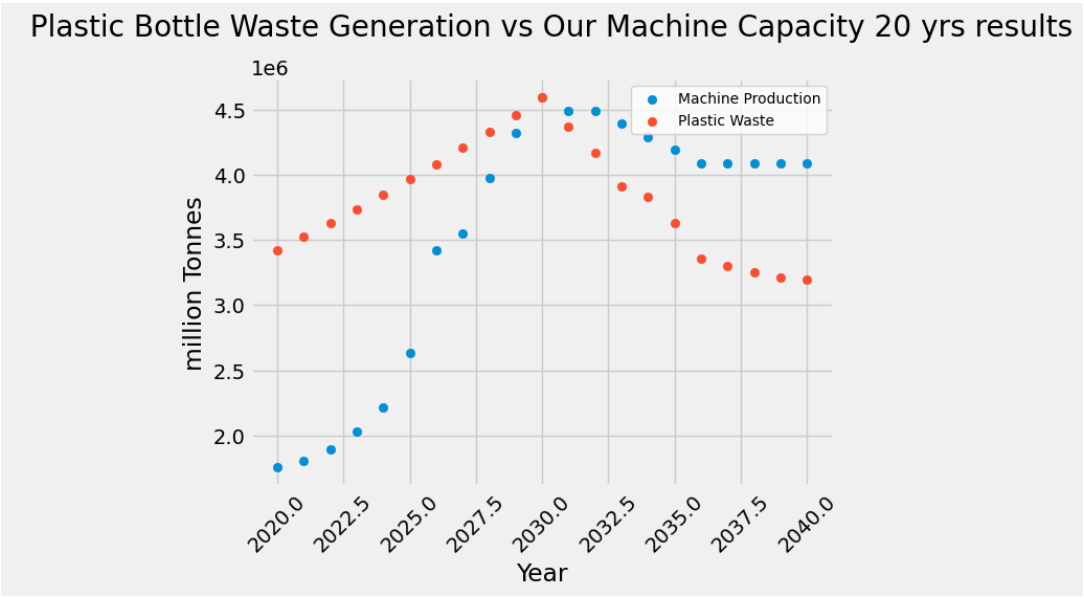


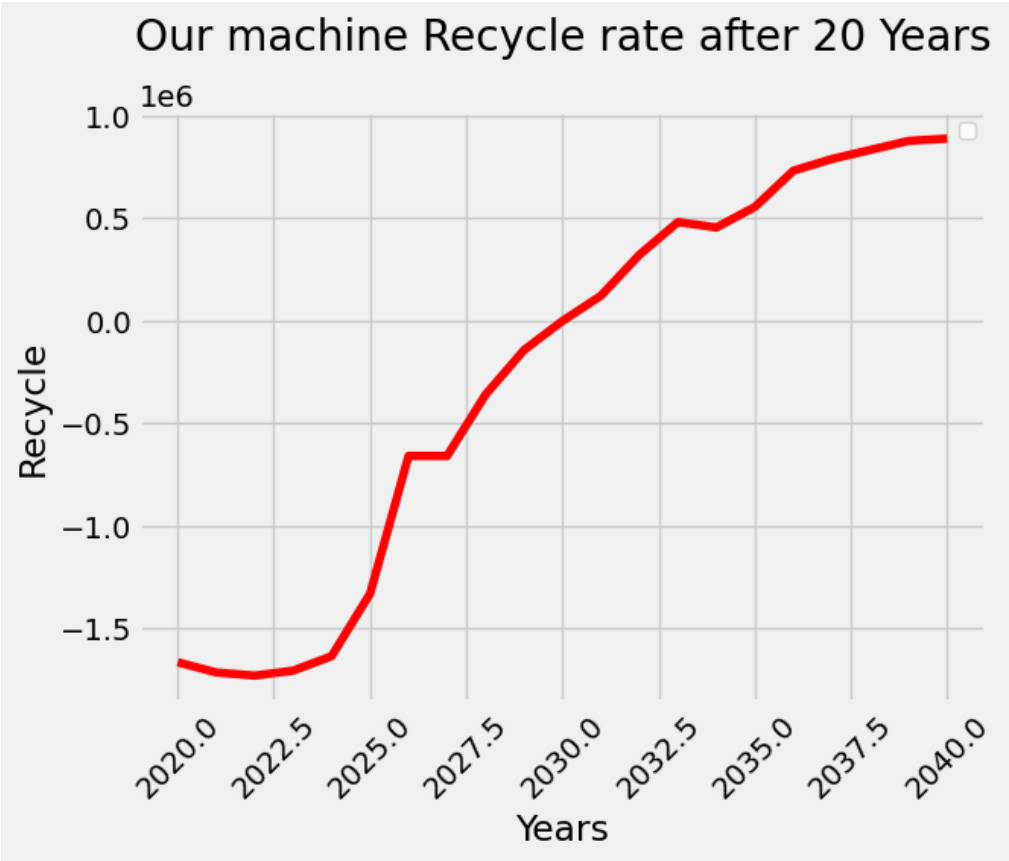
Prediction for the Year 2020 to the Year 2040:

	Year	PlasticProductionWaste	MachineCapacity	Recycle
0	2020	3419480	1755140	-1664340
1	2021	3522046	1807794	-1714252
2	2022	3627726	1898184	-1729542
3	2023	3736558	2031057	-1705501
4	2024	3848654	2213852	-1634802
5	2025	3964114	2634483	-1329631
6	2026	4083037	3424829	-658208
7	2027	4205529	3546902	-658627
8	2028	4331694	3972530	-359164
9	2029	4461645	4319644	-142001
10	2030	4595499	4595499	0
11	2031	4366365	4489529	123164
12	2032	4166635	4489530	322895



Here Machine Recycling Capacity has Surpassed Plastic Bottle Waste Generation. The point where both curve meet is the point from which the recycling rates increase and plastic waste reduces

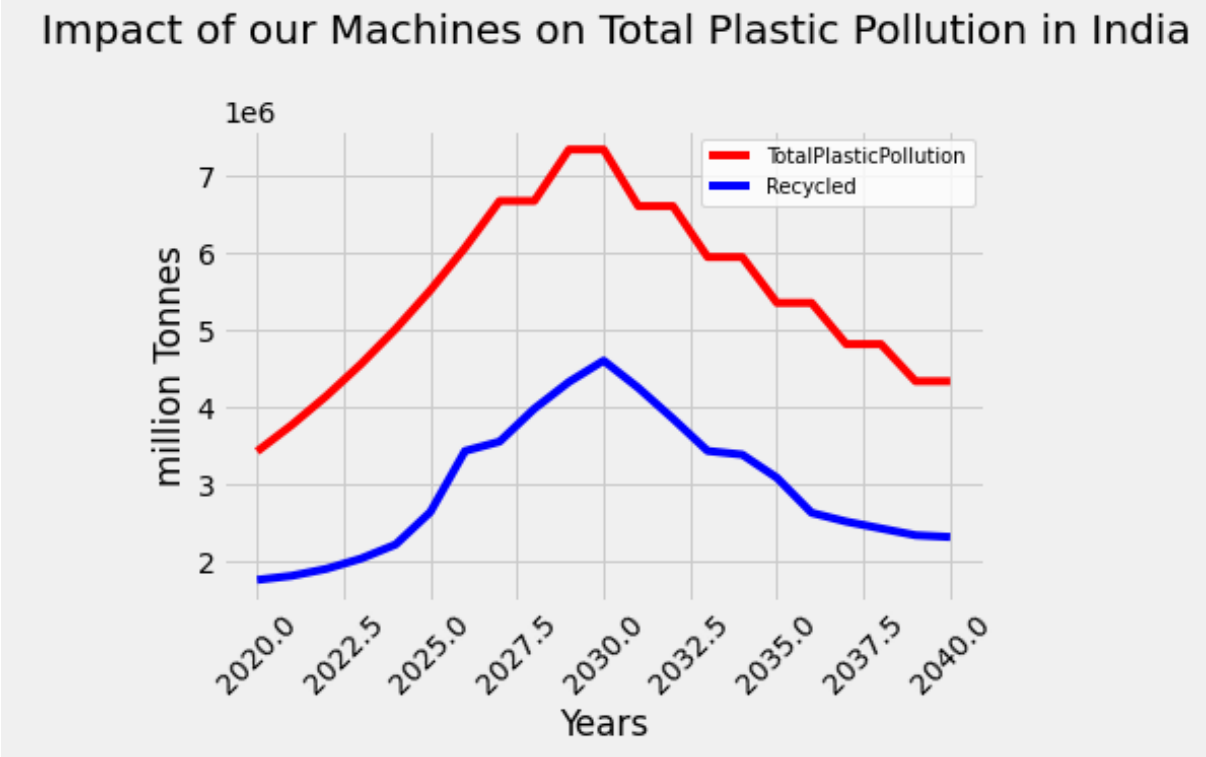




Here is the curve of the recycling rate. If we meet this recycling rate then we will be able to sustainably reduce plastic waste in India.

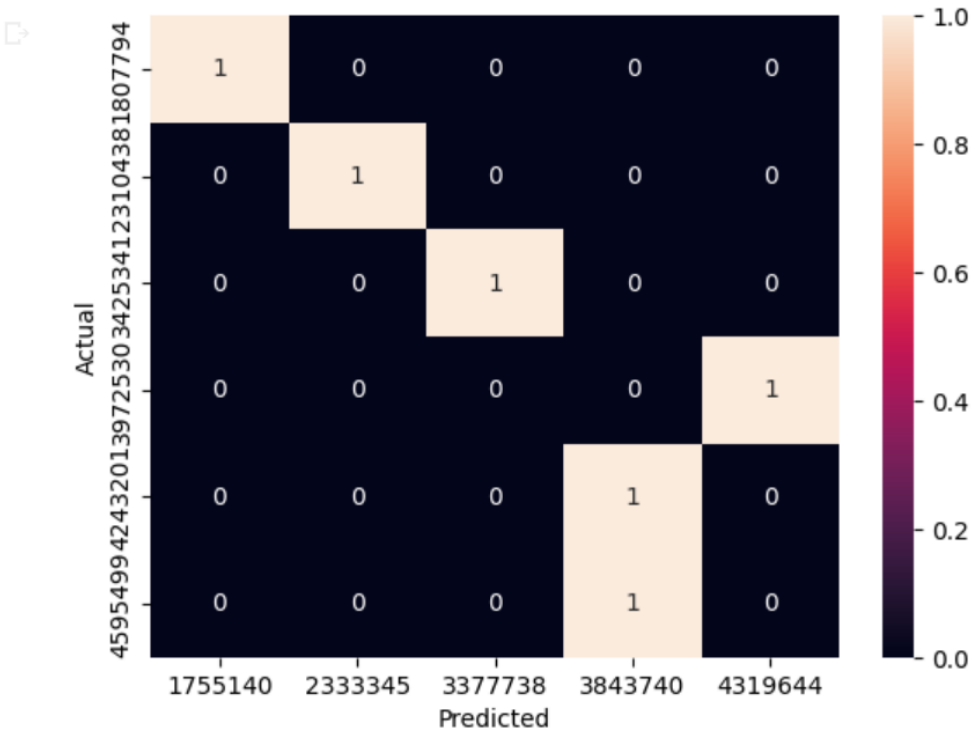
Here is the data set for the total plastic pollution and the impact of our machines' prediction of the plastic that is recycled. As the recycling rate increases the total plastic pollution also decreases gradually

	Year	xx	yy	zz	Recycled	TotalPlasticPollution
0	2020	3419480	1755140	-1664340	1755140	3419480.000
1	2021	3522046	1807794	-1714252	1807794	3761428.000
2	2022	3627726	1898184	-1729542	1898184	4137570.800
3	2023	3736558	2031057	-1705501	2031057	4551327.880
4	2024	3848654	2213852	-1634802	2213852	5006460.668
5	2025	3964114	2634483	-1329631	2634483	5507106.735
6	2026	4083037	3424829	-658208	3424829	6057817.408
7	2027	4205529	3546902	-658627	3546902	6663599.149
8	2028	4331694	3972530	-359164	3972530	6663599.149
9	2029	4461645	4319644	-142001	4319644	7329959.064
10	2030	4595499	4595499	0	4595499	7329959.064
11	2031	4366365	4489529	123164	4243201	6596963.158
12	2032	4166635	4489530	322895	3843740	6596963.158
13	2033	3907436	4389531	482095	3425341	5937266.842
14	2034	3833635	4289532	455897	3377738	5937266.842
15	2035	3633666	4189533	555867	3077799	5343540.158
16	2036	3356766	4089534	732768	2623998	5343540.158
17	2037	3299898	4089535	789637	2510261	4809186.142
18	2038	3255554	4089536	833982	2421572	4809186.142
19	2039	3211441	4089537	878096	2333345	4328267.528
20	2040	3199988	4089538	889550	2310438	4328267.528



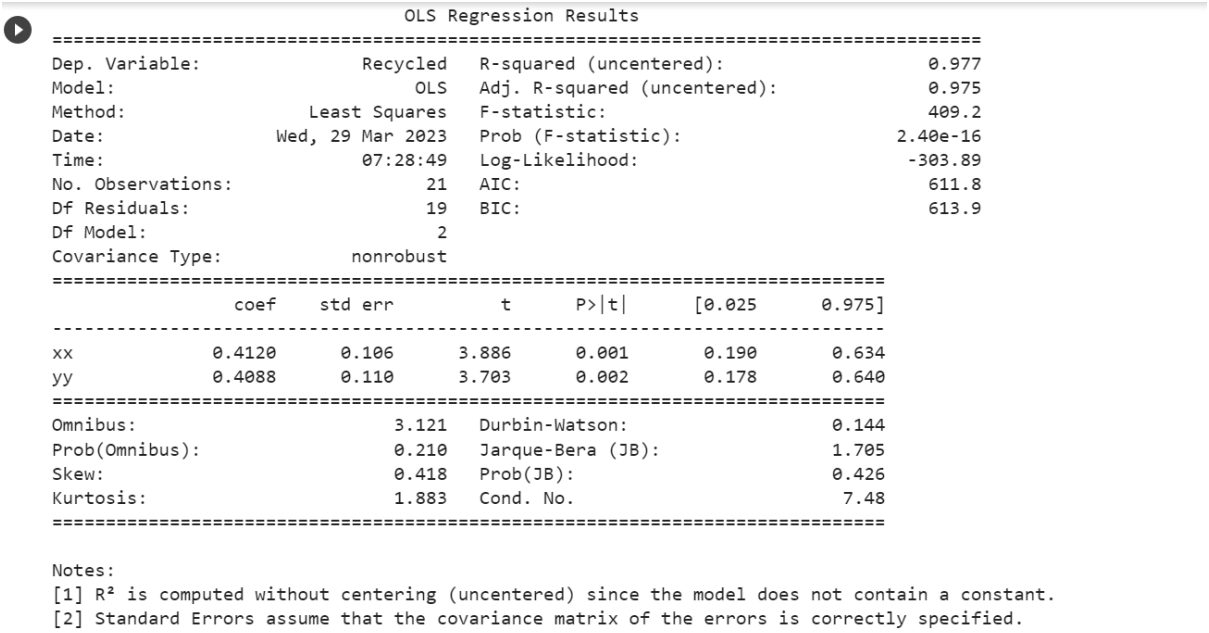
As the recycling rate increases the total plastic pollution also decreases gradually

Logistic Regression model:



Logistic Regression was the most accurate of this prediction.

Future Scope and Feasibility



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                            OLS Regression Results
==============================================================================
Dep. Variable:               Recycled   R-squared (uncentered):                   0.977
Model:                            OLS   Adj. R-squared (uncentered):              0.975
Method:                 Least Squares   F-statistic:                              409.2
Date:                Wed, 29 Mar 2023   Prob (F-statistic):                    2.40e-16
Time:                        07:28:49   Log-Likelihood:                         -303.89
No. Observations:                  21   AIC:                                      611.8
Df Residuals:                      19   BIC:                                      613.9
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
xx             0.4120      0.106      3.886      0.001       0.190       0.634
yy             0.4088      0.110      3.703      0.002       0.178       0.640
==============================================================================
Omnibus:                        3.121   Durbin-Watson:                   0.144
Prob(Omnibus):                  0.210   Jarque-Bera (JB):                1.705
Skew:                           0.418   Prob(JB):                        0.426
Kurtosis:                       1.883   Cond. No.                         7.48
==============================================================================

Notes:
[1] R² is computed without centering (uncentered) since the model does not contain a constant.
[2] Standard Errors assume that the covariance matrix of the errors is correctly specified.
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If plastic bottle pollution is significantly reduced, the future scope and feasibility of using reverse vending machines will continue to be relevant in promoting sustainable waste management practices. Here are some of the future scopes and feasibility of reverse vending machines if plastic bottle pollution is reduced significantly:

1. Diversification: If plastic bottle pollution is reduced, reverse vending machines could be used to recycle other types of waste, such as aluminum cans, glass bottles, and paper products. This would increase their usefulness and promote more sustainable waste management practices.
2. Increased Efficiency: With reduced plastic bottle pollution, reverse vending machines could become more efficient in handling other types of recyclable materials. This would improve recycling rates and reduce the amount of waste that ends up in landfills or the environment.

3. Innovation: As technology advances, reverse vending machines could be further improved to increase their efficiency and reduce costs. This would make them more attractive to businesses and individuals looking to promote sustainable waste management practices.
4. Accessibility: With reduced plastic bottle pollution, reverse vending machines could be more widely distributed and accessible in public areas such as parks, airports, and train stations. This would make it easier for individuals to recycle and reduce their environmental impact.
5. Partnership: Companies and organizations could partner with reverse vending machine manufacturers and operators to promote responsible recycling behaviour and support sustainable waste management practices. This would increase the visibility and popularity of reverse vending machines, leading to a more sustainable future.

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