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Final Project Paper Report

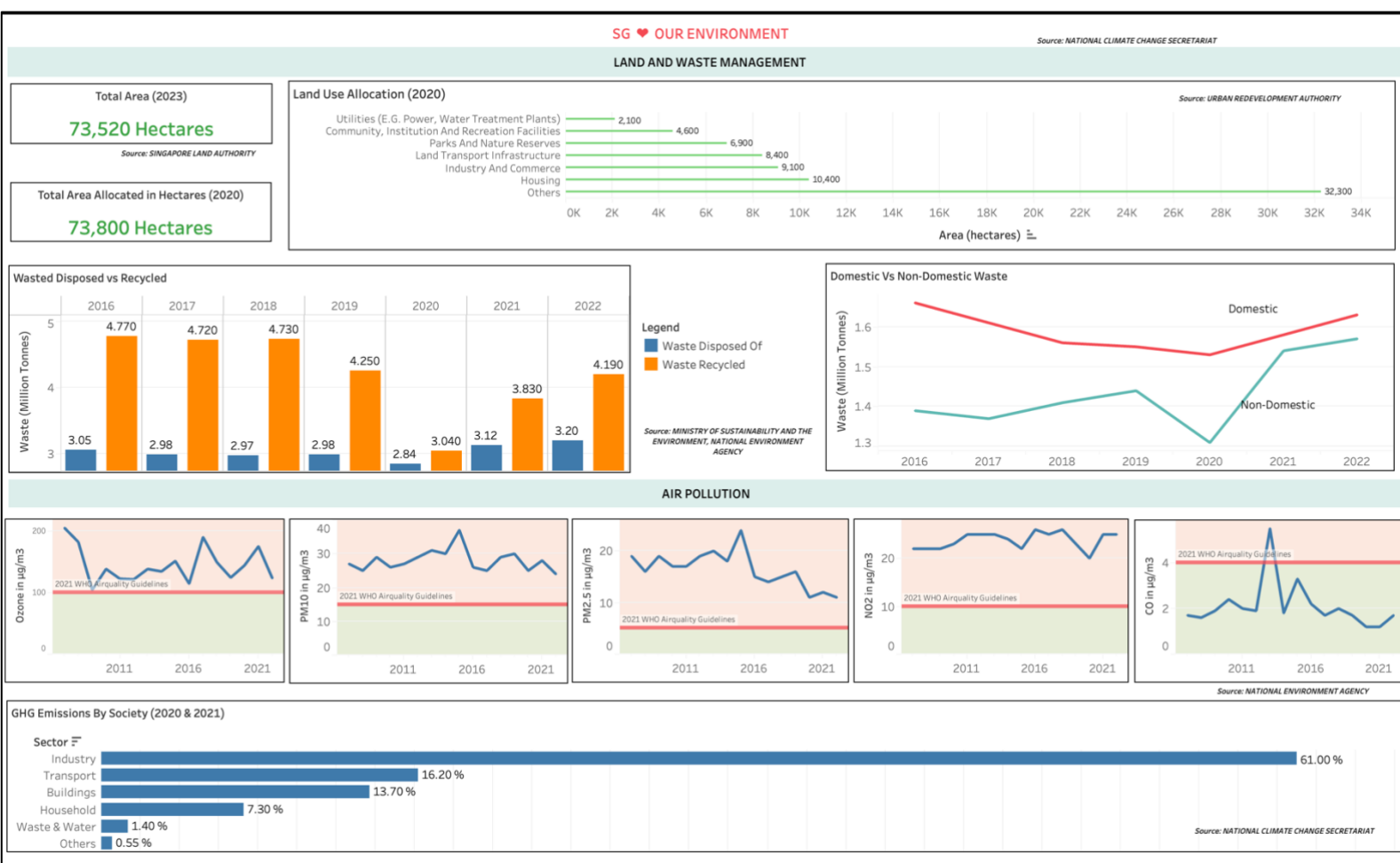
Introduction

In this report, we shall try to develop a dashboard that can help us measure the environment status in Singapore to identify their progress and shortcomings towards a greener future.

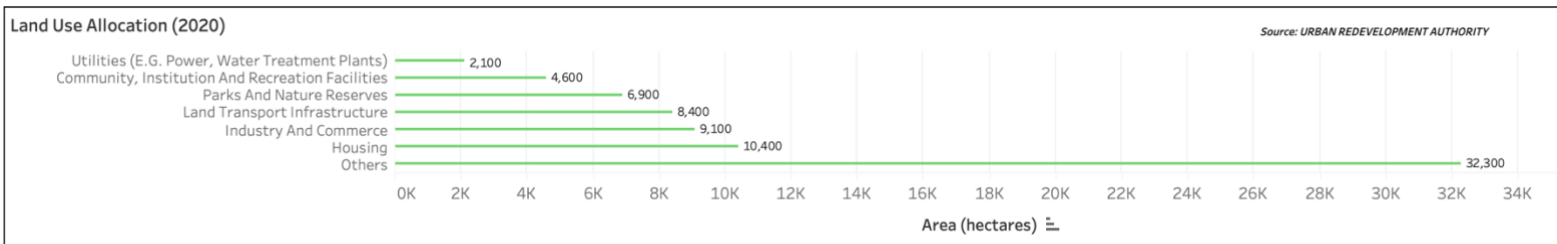
Singapore is a tropical island in Southeast Asia. It's made up of the mainland and other islands. Singapore is a very small country in terms of size, in comparison the United States is almost 13,600 times the size of Singapore. It has a population of 6 million, which is a lot for a country of this size. As of 2023, the population density of Singapore is 8592 per Km² and stands 114th in the world!

Singapore is a highly urbanized city-state with a unique set of challenges and constraints, particularly its limited land area combined with a high population density. Let's look at how Singapore manages to contribute to saving nature and environment despite all these challenges.

Overview of Dashboard



Land Management



Let's look at how the Singaporean government has planned to allocate their available land for the various requirements of the city while keeping the environment safe as possible.

Land Management Plans that Save The Environment:

1. Protecting Nature:

- Allocating 9.35% of its land to parks and nature reserves, in addition to the 6.23% for community and recreational facilities despite the small size shows Singapore's commitment to preserving nature.
- Community and recreational facilities in Singapore generally are in the form of parks which adds to the greenery of the country!

2. Urban Greenery:

- Not just parks and reserves, Singapore incorporates greenery and nature into its urban areas through tree planting, rooftop gardens, vertical green spaces, and many more methods.

3. Sustainable Urban Mobility:

- The 11.38% land allocation for transport facilities highlights Singapore's focus on prioritizing land transport facilities.
- They have also built dedicated bike and walk paths throughout the city. Singapore promotes public transportation, walking, and cycling, to reduce vehicle emissions and pollution.

4. Efficient Utilities and Sources:

- Singapore uses just 2.84% of land to provide a huge population. This is possible because about 95 per cent of Singapore's electricity is generated from natural gas.
- A natural gas power plant has an approx. 1000 times lesser physical footprint when compared to other popular sources like coal and nuclear power plants.

5. Renewable Energy Sources:

- Natural gas is a cleaner energy source compared to other options but not 100% clean.

- Hence, Singapore has always been invested in renewable energy sources from solar, wind and hydrogen. Due to lack of wind and water in Singapore, these are not viable options.
- Singapore believes that solar power is the most promising energy source as they are located closer to the equator.

6. **Economic Prioritization:**

- Singapore's economy is built on top of industry and commerce. It also depends on import and export and have built a total of 9 harbors and ports for trading commerce.
- Hence, a 12.32% of land dedicated efficiently supports its economic growth and global trade activities. This is unavoidable as it's a necessity, but Singapore has some plans to combat the environment damage caused by industries which we will look in the upcoming topics.

7. **Innovative Housing Solutions:**

- Singapore holds a population of 6 million and is a very famous touristic country. Singapore can allocate just 14.09% land for housing by adopting, high-density apartments and mixed-use developments, to accommodate its population while conserving land. The number of private houses in Singapore is very minimal.

Overall, we can see that Singapore follows a balanced urban planning strategy, and there is a significant emphasis on the necessities such as housing, industry, commerce, and needs such as parks, nature reserves, community, and recreation facilities. Singapore also keeps the effect on environment as a major concern for the decisions regarding land use. This balance is crucial for maintaining a high quality of life in a densely populated city-state.

My Suggestions for Singapore:

1. **Urban Farming Initiatives:**

- Only 1 percent of land in Singapore is being used for agriculture, this increases the demand for food importation.
- Government must promote agriculture and use vacant spaces to increase local food production and reduce the carbon footprint associated with food importation.

2. **Smart Transportation Systems:**

- Invest in smart transportation solutions, such as traffic flow optimization and demand-responsive public transit.
- If we can access the demand of public transport and automatically reroute the buses and trains, we will be able to maximize the efficiency of existing infrastructure and minimize the need for new construction.
- This also helps reduce the need for people choosing their own vehicles and reduces the emissions in the air.

3. Strict Environmental Impact Assessments (EIA):

- All new developments must be made to follow a stricter EIA requirement.
- The new EIA requirements must measure the environmental impact, incorporating considerations for biodiversity, water resources, and carbon footprint.

4. Incentivize Environment Friendly Plans:

- When new development projects for commercial or housing purposes are being developed, government can offer financial incentives for the inclusion of environment friendly plans such as using greener technologies of solar panels, energy-efficient lighting, water-saving fixtures.
- This can help accelerate the greening of Singapore's city environment.

Waste Management

Waste management is crucial for maintaining public health and preserving the environment. Effective waste management practices reduce pollution, mitigate the impact on climate change, and conserve natural resources by recycling and reusing materials.

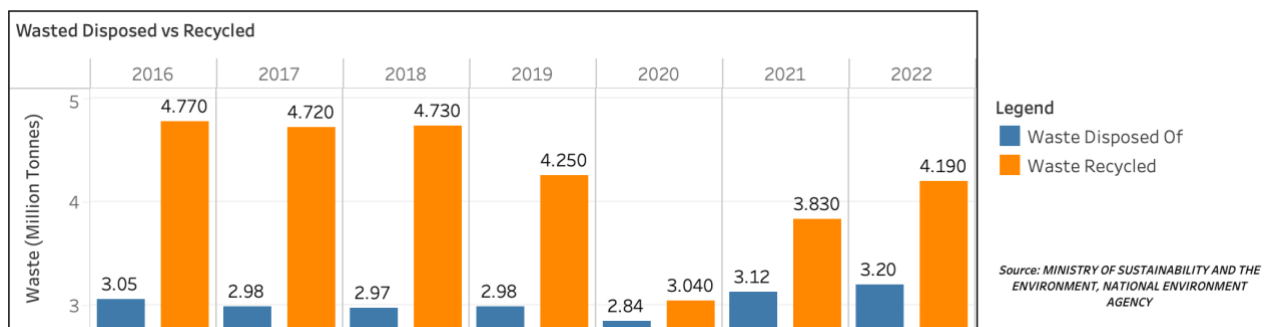
Semakau landfill, the one and only landfill in Singapore is filling up in a rapidly vast speed and expected to fill by 2035. In recent years, Singapore has developed various waste disposal plans with environment conservation in mind. Singapore is trying to increase their recycling capacity to try reducing the amount of waste being sent to Semakau. Singapore has built some of the world's most advanced waste management systems and there are five Waste-to-Energy (WTE) plants in Singapore currently.

Singapore is targeting to increase their recycling rates to 70% by 2030 and reduce waste sent to the landfill by 30%. For a country like Singapore, where land is limited. If proper waste management methods are not followed could lead to overfilling of landfills in the future.

Let's look at the waste disposal and recycling rates in Singapore from 2016 to 2022 to understand how far they are from their goal. We also look at the breakdown between domestic and non-domestic sources.

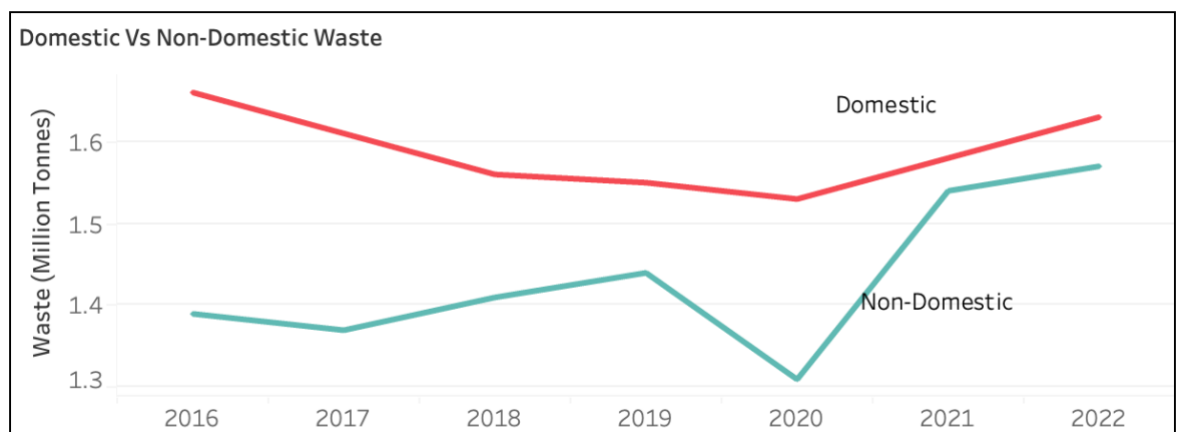
Waste Management Trends and Plans:

1. Waste Disposal and Waste Recycling:



- Over the years, Singapore has consistently recycled more waste than it disposed of, highlighting the effectiveness of its waste management strategies.
- Between 2016 and 2019, Singapore constantly recycled almost 50% more waste than being created.
- The pandemic of COVID-19 resulted in a slower rate of disposal and recycling of waste which is due to the lack of activities.
- Post-pandemic, the amount of waste being disposed has seen a slight increase while the recycling is slowly rising back to the pre-pandemic standards.
- Overall, Singapore has always been able to recycle more waste than being disposed which shows a good sign.

2. Domestic vs. Non-Domestic Waste:



- Singapore distinguishes their waste into 2 type -domestic waste (households waste) and non-domestic waste (industrial, commercial waste) Surprisingly, both these wastes are almost the equal levels throughout the years.
- Pre-pandemic, the domestic waste was decreasingly slowly while the non-domestic waste was slowly increasing.
- During the pandemic the domestic waste was almost the same but non-domestic waste production reduced by a lot as many industries were shut down during this time.
- Post-pandemic, the waste from both domestic and non-domestic sources can be seen increasingly rapidly. I believe this sudden growth in waste disposal is a concern that must be looked upon.

From this data, we can see Singapore's commitment towards environmental sustainability efforts through waste management. The effort to maintain high recycling rates despite fluctuations in waste generation reflects a strong national emphasis on reducing landfill use and conserving their resources.

My Suggestions for Singapore:

1. Invest in R&D:

- Research and adopt advanced technologies that can handle a wider variety of recyclables, including plastics that are currently not recyclable.
- Invest more into the chemical recycling technology that Singapore is currently interested in. It might be the way to safely recycle and reuse plastics.

2. Zero-Waste Businesses:

- Zero-waste business is the concept of a business that creates no waste as part of their product, for example – package free products. Customers are interested only in the product but not the packaging and that ultimately goes to the waste.
- Hence, we can incentivize businesses that follow a zero-waste policy.
- Government must limit or penalize the use of packaging for online ordering and delivery services.

3. Bring Your Own Bag Shopping:

- Right now, Singapore restricts the purchase of plastic bags to only Thursdays to Sundays but must follow this permanently. Jute bags or paper bags must be promoted instead.
- Government must make it compulsory for people to bring their own bags for shopping and supermarkets or groceries stores must not be allowed to give or sell bags to the customers.

4. Electronic Waste Management

- I would argue that majority of the public lack's proper knowledge regarding the dangers behind improper disposal of e-waste. The harmful toxic chemicals that are in them, end up affecting the soil, water, and air. Government can run campaigns to educate the public.
- The government must establish e-waste collection points.
- Government can try and encourage electronic manufacturers to take back old devices and reuse them to help reduce the e-waste.

Air Pollution

Air pollution is a risk to health of people and environmental quality and its management is a critical concern. A densely populated country like Singapore with high levels of traffic and huge industrial sector, managing air pollution can be a real challenge.

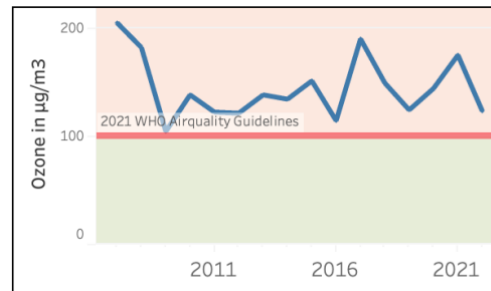
Singapore takes air pollution seriously and has implemented strong regulations to limit emissions from industrial and transportation sources. Singapore also has an air quality monitoring system, the Pollutant Standards Index (PSI) to provide real-time information on air quality.

Singapore also takes proactive measures such as promoting public transportation, implementation of green building standards, investing in renewable energy sources to better their environment and health.

The following data provided outlines the annual average concentrations of various air pollutants in Singapore from 2007 to 2022, measured in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). We compare these values to the 2021 World Health Organization air quality guidelines (WHO AQG) to better understand the level of air pollution in Singapore.

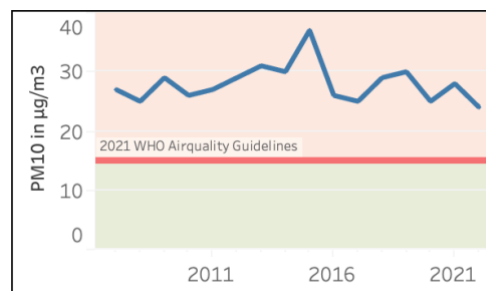
Air Pollution Level According to WHO:

1. Ozone (O₃):



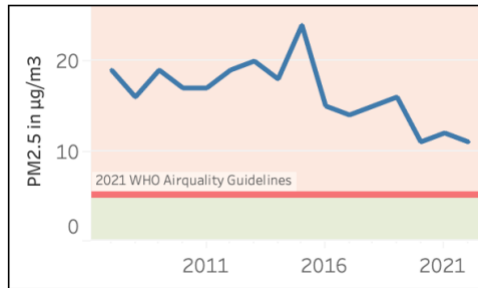
- Ozone concentrations have always been above the WHO air quality guidelines limit of 100. In 2007, it has been in the highest in the last 2 decades.
- Following this, ozone concentrations have been reduced significantly till 2016. In 2017, the Ozone concentrations have witnessed a sudden spike.
- Pandemic helped reduce the level but in 2021 it rises again. The occasional spikes in these years are potentially harmful to respiratory health.

2. Particulate Matter (PM₁₀):



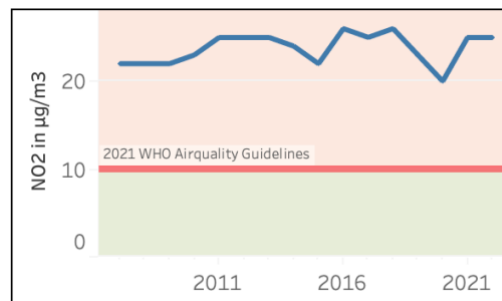
- PM10 levels have also been above the WHO guideline of 15 $\mu\text{g}/\text{m}^3$ throughout the years.
- Although there's a slight decreasing trend from the peak in 2015, the values still significantly exceed the recommended levels, suggesting ongoing challenges with dust and other particulate pollutants.

3. Particulate Matter (PM_{2.5}):



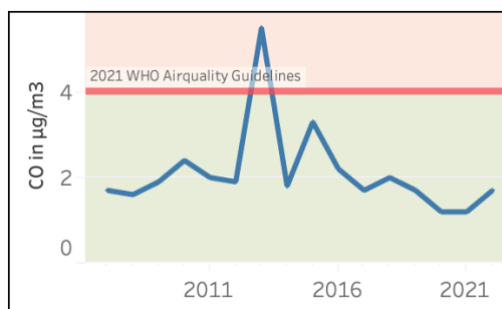
- PM2.5 levels have almost been double of the WHO recommended level of 5 $\mu\text{g}/\text{m}^3$ for this period.
- While there is a noticeable decrease in PM2.5 levels from the peak in 2015, but the figures from 2022 still indicate more than double the WHO's recommended limit.

4. Nitrogen Dioxide (NO₂):



- NO₂ levels have always exceeded the WHO guideline of 10 $\mu\text{g}/\text{m}^3$ every year from 2007 to 2022.
- While there has been some fluctuation, the concentrations have remained relatively stable, indicating a challenge in reducing it to meet the recommended standards.

5. Carbon Monoxide (CO):

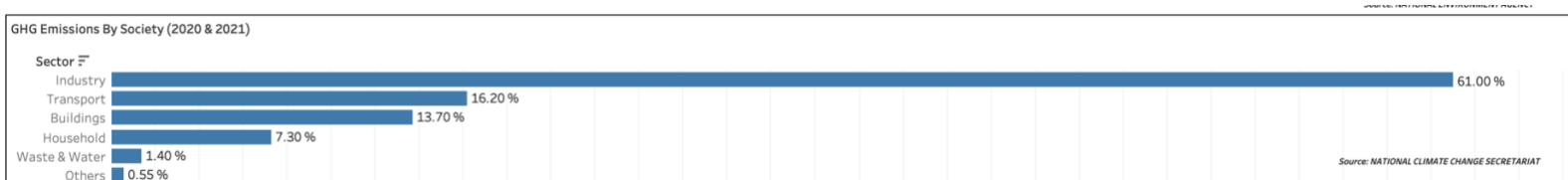


- CO levels are the only gas that has been within the WHO's guideline of 4 $\mu\text{g}/\text{m}^3$ for the entire dataset, with a decreasing trend observed over the years.
- This suggests effective management strategies targeting CO emissions, which are highly from vehicle and industrial sources.

Singapore's air quality data from 2007 to 2022 shows an effort to try and manage air pollution, with the notable success in reducing CO levels over the years. However, the other pollutants are above the WHO guidelines highlighting the needs for methods to try improving the control over air pollutants.

It is important to note that the WHO guidelines are the recommended levels to improve the overall air quality and that no country has been able to meet the recommended levels. Just because, Singapore hasn't kept the air pollutants limit within the guidelines doesn't mean it's bad since Singapore is the 77th best country in the world in terms of air quality.

Greenhouse gas emissions and policy changes:



Singapore has also analyzed the Greenhouse gas (GHG) emissions based on sectors in 2020 and 2021.

1. Dominance of the Industrial Sector:

- All over the world, the industrial sector is the largest contributor to GHG emissions. In Singapore, it accounts for 61% of the total GHG emissions.
- This highlights the importance for cleaner production technologies and energy efficient improvements.
- Singapore is one out of 46 countries worldwide, that has carbon taxes on industries and forces them to reduce their own emissions.

2. Transportation's Impact:

- Singapore's next biggest contributor is the transport sector, with 16.2% of emissions.
- This highlights the importance for transitioning to cleaner fuel sources or electric vehicles.
- Singapore has proactively promoted public transportation, cycling, and walking as alternatives. Recently in 2023, Land Transport Authority has procured electric buses as well.
- Singapore is one of the few countries in the world using a traffic congestion pricing to control their traffic congestions since 1975. Singapore's Electronic Road Pricing (ERP) system charges vehicles based on time and congestion levels. The price ranges from \$0.50–\$1.90 for passenger vehicles and \$3.80–\$6.00 for large vehicles like trucks and buses.

3. Buildings and Household's Role:

- Buildings and households together contribute 20% of the emissions.

- This highlights the importance of greener building designs, better insulation, energy-efficient appliances, and the integration of renewable energy sources in buildings to reduce their carbon footprint.

This data emphasizes that Singapore must primarily focus on reducing the greenhouse gas emissions in the industry and transport sector. It also shows us that small sustainable practices at household levels can impact almost 20% of the emissions.

My Suggestions for Singapore:

1. Incentives for Clean Technology:

- Industries that invest in clean technologies and continuous monitoring of their emissions can be offered tax incentives, grants, and subsidies to industries.
- People who choose to drive electric vehicles, can be offered some tax incentives. Businesses like taxis can be offered incentives for choosing electric vehicles as well.

2. Invest in Research:

- Allocate significant funding for research into new technologies and methods for reducing air pollution and GHG emissions, including renewable energy, battery storage technology, and sustainable urban planning.

3. Reducing Air pollution from Ports:

- Invest in smart technologies such as supply chain management, travel route planning to optimize sea trading.
- Switch to low-sulfur fuel alternatives or a newer technology called “On-Shore electricity”. Shore power cuts air pollution from ships at berth by 95 percent and can be implemented in Singapore.

Water Management

Unfortunately, we do not have sufficient data regarding the water pollution or management strategies that Singapore follows. I did not want to leave this out and choose to include the water management as Singapore has one of the most advanced water management systems in the world and acts as an example for the world.

Singapore is one of the most water-stressed country in the world, but it also acts as an example for how cities can thrive even under most scare conditions by employing proper techniques.

Singapore follows some simple and advanced water management techniques such as:

1. Rainwater Harvesting:

- One of the most basic ways to save water.
- Singapore is a tropical country which sees a lot of rain throughout the year, so they developed an extensive rainwater saving plan.
- The roads are developed in such a way that all the rainwater is collected in the rainwater harvesting drains.

- Also, approximately 86% of Singapore's population lives in high-rise buildings. By integrating rooftop water collection systems into the design, they have been able to maximize the collection of rainwater.
- Singapore has a total of 17 reservoirs, most of them are artificially created to hold rainwater. Singapore has built an extensive network of drains, canals which lead to the reservoirs.

2. Desalination:

- Desalination is the process of producing pure drinking water from seawater by removing the salt in the water. Singapore's desalination process uses reverse osmosis to make seawater drinkable.
- The quality of water is top-grade and is safe to drink straight from the tap without any filtration required.
- In 2005, Singapore built its first desalination plant. Right now, it has a total of 5 desalination plants.
- As of 2021, desalination water provides around 37% of the Singapore's daily water demands.

3. NEWater:

- NEWater is the treatment of used water for the purpose of recycling water.
- NEWater is a more energy and cost-efficient solution than desalination. The reason is because it treats used water instead of seawater.
- In 2000, Singapore built the first NEWater treatment plant. Currently, it has a total of 5 NEWater plants.
- NEWater is mainly used for non-potable industrial and commercial purposes.
- It supplies around 40% of the Singapore's daily water demands and is expected to fulfill 55% by 2060.

My Suggestions for Singapore:

1. Community-Based Water Recycling Systems:

- Instead of collecting water from various regions and recycling the water together. The government could implement small-scale water treatment plants at community-level.
- In these plants, graywater (from showers, sinks, and laundry) can be treated and reused for non-potable purposes such as flushing toilets, gardening, and cleaning, reducing the demand on the main water supply.

2. Solar-powered plants:

- The community level plants mentioned above, are used to recycle smaller scales of water and if possible, could be powered by solar power, reducing the carbon footprint associated with water production.

3. Underground Water Reservoirs:

- Investigate about the feasibility of constructing underground reservoirs which can store excess rainwater and treated water.

- This would help maximize space usage in land-scarce Singapore and ensuring a stable water supply during dry periods.

Conclusion:

This report encompasses the comprehensive overview of Singapore's environmental management strategies. We focused on their proactive and balanced approach towards urban planning and sustainability for land, waste, air, and water. Over the years, careful allocation of land, innovative waste management strategies, continuous air monitoring and improvement measures and water reusing strategies can be witnessed as proof of their commitment in preserving the environment without sacrificing the quality of life for their citizens.

They have constantly faced challenges throughout the years, particularly from industrial and transport sectors but have been putting efforts to overcome these challenges one step at a time. Their ongoing efforts of transition to cleaner energy sources, enhance public transportation, promote green urban living as efforts for a cleaner future.

A big part of praise must go to the Singapore's government and their environmental policies for their commendable mission for their country and the world. Singapore's policies are designed to support urban sustainability and balancing development needs with ecological preservation. These serve as a valuable example for cities all over the world, showcasing the potential to provide high quality of life while prioritizing environmental health and sustainability.

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