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SUSTAINING PARADISE: SINGAPORE`S JOURNEY TOWARDS ECOLOGICAL EXCELLENCE

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ABSTRACT

As the world faces environmental challenges, nations are realizing the urgent need to adopt eco-friendly practices, it is one of the priority goal of Singapore to attain environment sustainability and become a great guide for how countries can be kind to the planet. The nation showing that with smart ideas-and-everyone's help can make the world a better place for all of us. This study presents a thorough examination of Singapore's sustainable journey, shedding light on pivotal initiatives, policies, and innovations that have driven the nation toward ecological excellence. The study includes various-dimension for instance Singapore's urban planning-strategies, emphasizing the integration of green spaces with smart sustainable architecture to establish a resilient and eco-friendly urban-environment, waste management system with circular economy model, advanced recycling technologies including sustainable land use is the prominent one practices and most importantly examines the pivotal role of community engagement in Singapore's sustainable journey, emphasizing public participation, education, and awareness, which is drawing on government reports, academic research, and firsthand observations, this study will provide a comprehensive understanding of Singapore's sustainable development path. Singapore's journey stands as a compelling case study and inspiration for other nations aspiring to build a sustainable future for generations to come.

Keywords - Singapore, policies and innovations, urban planning, waste management, circular economy, sustainable development

Introduction

"The greatest threat to our planet is the belief that someone else will save it." **- Robert Swan**[1]

In the dynamic landscape of Singapore, ecological excellence is not merely a goal but a way of life. Singapore's success in balancing economic growth with environmental responsibility emerged lion city as a global model of sustainability. Look at places like Gardens by the Bay – those towering Super trees show the commitment to green living. They're not just pretty; they're a symbol of how Singapore builds while keeping nature in mind.

As the city grows, it's not forgetting about its water bodies, there's a unique program, Active, Beautiful, and Clean Waters, keeping in mind the flourishing of the water ecosystem. And the green spaces in the city aren't just parks; they're carefully planned homes for various plants and animals. Singapore's success story of ecological excellence teaches the world that you can have progress without harming nature, benefiting everyone now and in the future.

Urban Planning

Over the years, Singapore has undergone a remarkable transformation, evolving from the time Stamford Raffles first set foot on its shores. What was once a wilderness has now become a dynamic and modern city. The current planners have set ambitious goals for Singapore, envisioning it as a leading hub for businesses in Asia and a highly desirable place to call home. This vision extends beyond economic success. Planners aim to shape Singapore into a city with a unique Asian identity, offering state-of-the-art facilities and amenities. [2]

To achieve this, there's a focus on enhancing existing infrastructure, ensuring that it not only meets the needs of current residents but also attracts potential investors, fostering a conducive environment for business growth. The desire for improved housing, better healthcare, quality education, and expanded recreational and cultural opportunities resonates strongly. Striking a balance between economic development and the quality of life for its residents is a central theme in Singapore's ongoing urban planning narrative, which is reflecting on the Urban Redevelopment Authority's message from 1991, the significance of comprehensive and creative planning is underscored. It remains the linchpin for steering Singapore towards a future where economic vibrancy harmonizes seamlessly with an increasing exceptional standard of living, aligning with the enduring spirit of the Lion City's aspirations. Singapore, often characterized as a small city-state lacking natural resources, relies on its strategic geographical positioning and natural harbour for significance. With a current population slightly exceeding four million, situated at the southern tip of Peninsular Malaysia, Singapore has latitudes 1°09'N to 1°29'N and longitudes 103°38'E to 104°25'E. The primary island, shaped like a diamond and measuring 42 km in length and 23 km in breadth at its widest, is complemented by around 60 smaller islands. Through reclamation efforts, Singapore has progressively expanded its land area to 660 km2, with ongoing plans expected to further increase it to 730 km2, marking a 25% growth since 1967 [3]

To manage excellently in terms of sustainable architecture, the city-state prioritizes green building designs, energy efficiency, and environmentally friendly materials. Many buildings

[1] Swan, R. (2006). *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It* (p. 248). Emmaus, PA: Rodale Books.

[2] Urban Redevelopment Authority. (1991). (p. 8). Retrieved from [https://www.ura.gov.sg/Corporate]

[3] Singapore Department of Statistics. (Urban Redevelopment Authority. (1991) Retrieved from www.singstat.gov.sg.

incorporate features like green roofs, vertical gardens, and energy-efficient systems to minimize environmental impact. The concept of a *"Garden City"* is ingrained in Singapore's urban planning, promoting the integration of nature into the built environment. This not only enhances aesthetics but also contributes to biodiversity and the overall well-being of residents. This is very evident like: Green Building Certification that promotes green building standards through certifications like the Building and Construction Authority's Green Mark Scheme, encouraging developers to adopt sustainable practices. A great initiative of Energy-Efficient Design priorities energy efficiency through the use of *smart lighting systems, advanced insulation, and high-performance glass to reduce energy consumption and Natural Ventilation Architectural designs* often prioritize natural ventilation to reduce reliance on air conditioning, enhancing occupant comfort while minimizing energy use and by Use of Recycled and Eco-friendly Materials in Construction projects emphasize to reduce environmental impact and promote a circular economy and Adaptive Reuse in which people transform existing structures for new purposes, when feasible, is another aspect of sustainable architecture. The Punggol Digital District in Singapore is a prime example of sustainable architecture, combining energy-efficient design with smart technologies.[4]

The Green Towns Program initiated by the Housing and Development Board (HDB). The HDB is Singapore's major residential developer, providing housing for around 80% of the population (Ng, 2017). The Green Towns Program is guided by a Biophilic Town Framework that aims to increase the interconnectedness between developments and nature, and set targets for the quantity and quality of urban greenery that should be incorporated into development. One of the prominent examples is the Singapore's forthcoming Tengah town, which is the latest town to be designed under HDB's Green Town Program. The Tengah development has been marketed as "Tengah, the Forest Town," highlighting its ecological design vision Located in the western region of Singapore and spanning 700 ha in size, dominated by secondary rainforest that would be the first 'Forest Town' that will house around 42,000 new homes. As per the report of 2019 construction climate challenge Singapore leading in urban greening.[5]

Solid Waste Management

The sustainability of any country, especially a small island-state like Singapore, begins with ensuring that physical land resources and air are not overwhelmed by pollution from wastes. So, basically **Solid waste management** in Singapore is administered by the National Environmental Agency (NEA). Modern urban integrated waste management practices are fundamentally relied on two core technologies:

- Landfilling
- Incineration

Landfilling - The policy of NEA priorities the incineration process that is why Singapore has a total of 4 plant and 1 and only sanitary landfill named *Pulau Semakau Commissioned* in the year 1999, the life span of the landfill is expected to last until the year 2040. Semakau Landfill was originally a coral island and has been transformed into a landfill to accommodate Singapore's waste disposal needs its surrounded by impermeable rock, have no pores bunds to prevent

[4] Iqiia, M. (2028, October 24). How Sustainable Cities Like Singapore Succeed in Green Urban Development. Retrieved from. *Earth.com*

[5] Chia, E. H. P., & Goh, K. L. (Eds.). (2018). *Urban Green Spaces in Asia: A Sustainable and Resilient Paradigm*. Springer

leachate from contaminating surrounding waters. Semakau Landfill is designed to be an environmentally friendly and sustainable waste disposal solution. The landfill serves as a testament to Singapore's innovative approaches to handling waste in a densely populated urban environment. with bare minimum allowance like only 10% of total solid waste to be landfilled.[6]

Incineration - The second major waste management practice includes the incineration like in the 1970s and 1980s, Singapore faced challenges of limited land space and a growing population, prompting the need for innovative waste management solutions. The first waste-to-energy incineration plant, **Tuas Incineration Plant**, commenced operations in 1979, marking a significant step in Singapore's waste disposal evolution.

- Over the years, more incineration plants were established, which enhanced the country's capacity to handle the waste volumes. The historical shift towards incineration was a strategic response to the constraints of land scarcity and the necessity for efficient and sustainable waste disposal methods.
- Incineration involves burning waste at high temperatures, reducing its volume and generating energy.

The incineration process in Singapore is sophisticated, with the energy produced contributing to the national power grid. It helps minimize the amount of waste sent to landfills, optimizing land use in the densely populated area. Although excessive use of incineration leads to the generation of many harmful gasses elements like - SOx,NOx.Su,Hg etc to take control in these Singapore equipped with the pollution control techniques that has the power to minimize the effect of NOx up to 90% and 99% of toxic elements.

The ash produced through incineration is deposited in landfills, with a segment consisting of bottom ash and fly ash assumed to lack organic carbon due to complete combustion. After undergoing testing, the remaining bottom ash, used for road pavements, serves both economic and environmental purposes by reducing the volume of materials destined for landfills. This approach mirrors practices seen in countries such as Japan and Norway.[7]

Recycling

In Singapore, recycling is actively promoted through a comprehensive waste management system dating back to the 1970s when the National Environment Agency (NEA) oversees recycling initiatives. After the country faced landfill scarcity issues, leading to an early emphasis on waste management strategies. In 2001, Singapore launched the National Recycling Program, aiming to increase public awareness and participation in recycling efforts and also introduced the Mandatory Packaging Reporting framework in 2007 to encourage businesses to reduce packaging waste.

Country's first waste-to-energy plant, Tuas Incineration Plant, started operation in 2000, contributing to the country's sustainable waste management practices.

The 3R (Reduce, Reuse, Recycle) campaign has been a consistent theme, emphasizing the importance of waste reduction and responsible consumption. Numerous recycling firms operate

[6] Lee, S. H., & Lim, C. H. (2010). *Transforming Coral Islands: The Story of Semakau Landfill*. World Scientific.

[7] Chen, L., & Tan, K. (2015). *The Evolution of Waste-to-Energy Plants in Singapore*. National University of Singapore Press.

within the industrial zone known as Sarimbun Recycling Park. Trucks transport various waste materials, including construction and demolition waste, horticultural remains, and tires, to undergo further processing. Recycling not only conserves energy but also plays a crucial role in reducing carbon dioxide (CO2) emissions.

Recently the country recycled more waste than disposed of ,volume amounted approximately 4.19 million tons , The overall recycling rate increased to 57 per cent, largely due to the increased amounts of Construction & Demolition waste. Singapore continues to explore innovative recycling technologies, aligning with its commitment to environmental stewardship.[8]

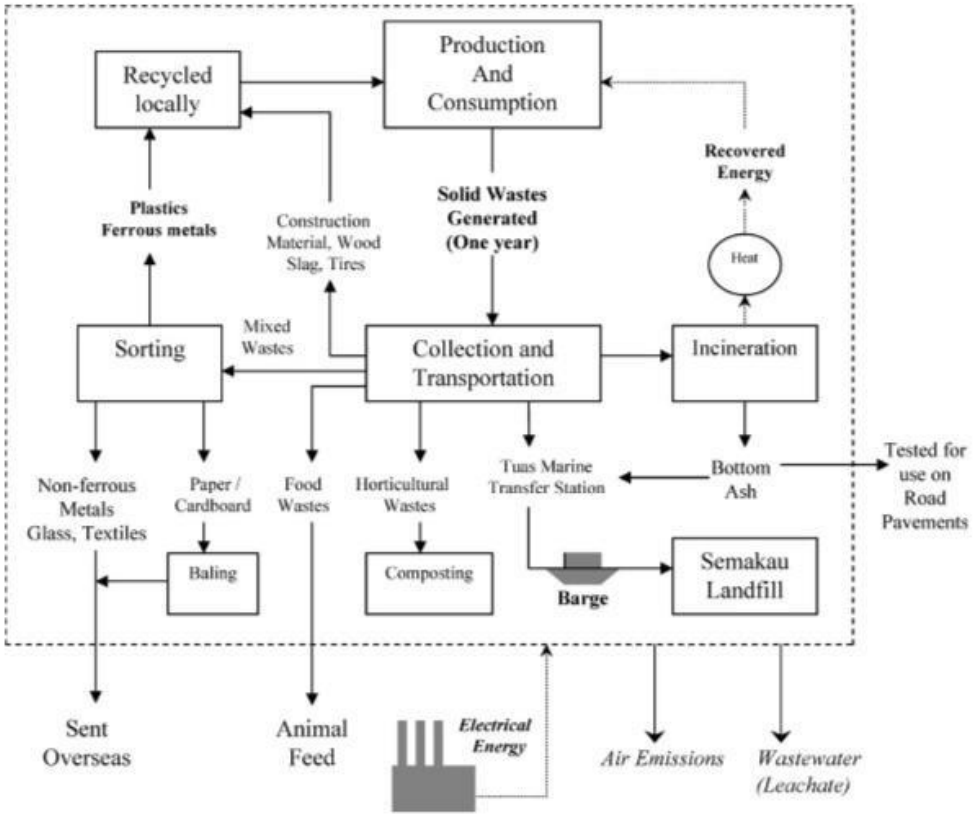


Figure 1. LCA system boundary for waste management in Singapore.

The process begins with the annual production of solid waste in Singapore, followed by the collection and transportation of the waste. Trucks transport some of the waste to incinerators and recycling centers, while others are taken to Semakau landfill by truck and barge. About 90% of disposed waste undergoes incineration, excluding construction materials, glass, and slag, which are sent to the landfill. The incinerator produces air pollution but simultaneously recovers energy. Gasses and leachate are generated from Semakau landfill, and composting horticultural waste also produces gasses. Energy is needed for the sorting and baling processes. After sorting, locally recycled materials include ferrous metals, slag, plastics, construction materials, and tires. Paper and cardboard are baled and sent overseas, while glass, nonferrous metals, and textiles are sent abroad for processing. Emission savings from overseas processing of recycled wastes are not considered within the system boundary.[9]

[8] National Environment Agency. (n.d.). *Recycling Initiatives in Singapore.* Retrieved from [https://www.nea.gov.sg/

[9] Huang, S. (2001). Planning for a Tropical City of Excellence: Urban Development Challenges for Singapore in the 21st Century. *Built Environment*, *27*(2), 112-128. Retrieved from https://www.jstor.org/stable/23287516

Sustainable Transportation

Sustainable transportation holds great importance in ecological excellence as it contributes to keeping our environment healthy by reducing pollution and lowering the amount of harmful gasses we put into the air. Secondly, it makes it easier for people to get around the city without getting stuck in traffic all the time. It's good for using resources wisely, like using land efficiently and saving energy. Also, it helps the economy by making businesses more productive and creating jobs in industries related to sustainable transportation. Plus, it keeps people healthier by encouraging activities like walking and cycling, and it makes Singapore look good globally by showing we care about the environment. So, sustainable transportation is not just about going from one place to another; it's about making our city a better and healthier place for everyone. With the commitment to significantly reduce the transport emission Singapore's 2050 net zero emission target , being a tiny island with many people and limited space, takes sustainable transportation more seriously than many other cities hence working on same rigorously to attain the goal by coming with the new initiatives.

Greening Public Transport - Encouraging the adoption of walking, cycling, and riding modes of transportation is a crucial step in significantly reducing emissions from the land transport sector.

To attain the goal government has 3 pillars

1. Discourage car dependency/Control car ownership

2. Alternative Modes of transport

3. Clean energy

1.Control car ownership the government has imposed various policies to increase the cost of driving. The first road pricing system in Singapore, ALS, was initiated in 1975. Under the ALS, motorists were required to purchase a paper license if they wished to enter the Restricted Zone (RZ) covering the CBD area during the restricted hour.

Singapore employs a controlled and regulated approach to manage car ownership, primarily through the Certificate of Entitlement (COE) system. It is a crucial component of Singapore's vehicle quota system. The COE is essentially a permit that individuals or businesses must obtain before they can register and own a vehicle in Singapore valid for period of 10 years and to obtaining a COE, vehicle owners in Singapore are required to pay additional taxes and levies, such as the Additional Registration Fee (ARF) and Goods and Services Tax (GST). It is available in a limited number and through a bidding process - whoever so bids the higher prices gets the one.[10]

2. **Alternative Modes** -

Government provides the alternative transport system in efforts to diminish reliance on cars, the Singaporean government is proactively enlarging the MRT/LRT network, Comprising the Mass Rapid Transit (MRT) system, Light Rail Transit (LRT) system, buses, and taxis, the MRT, functioning as a robust heavy rail passenger system, has been operational since 1987 and serves as the fundamental framework for public transportation, offering a dependable and competitive

[10] Diao, M. (2018). Towards sustainable urban transport in Singapore: Policy instruments and mobility trends. *Transport Policy*. Advance online publication. https://doi.org/10.1016/j.tranpol.2018.05.005

alternative for travellers. The quality of bus services has seen enhancements through the expansion of bus fleets, the installation of real-time bus information systems at crucial stops, and the establishment of dedicated bus lanes. Country is hoping to raise the mass public transport model by 75% till 2030. Some exemplified of public transport are :-

•The MRT system includes lines like the North-South Line, East-West Line, and Downtown Line. For instance, the Circle Line expansion improved connectivity to various neighbourhoods, enhancing accessibility.

•The Sengkang and Punggol LRT (light rail transit) systems serve residential areas, seamlessly connecting residents to MRT stations. This provides convenient intra-town transport, exemplified by the integration of these systems with broader transit networks.

•Singapore's extensive bus network, operated by companies like SBS Transit and SMRT Buses, ensures comprehensive coverage. Bus services such as the Bus Service Enhancement Programme (BSEP) have enhanced frequency and connectivity, benefitting commuters.

•Taxis, operated by companies like ComfortDelGro and Grab, offer an efficient alternative. With digital platforms facilitating easy bookings and payments, taxis contribute to the overall accessibility of public transport. With the smart technology - govt introduced Simply Go system which allows commuters to use contactless payment cards and mobile phones for fare payments across various modes of transport, showcasing the integration of smart technologies.[11]

3. **Clean energy** –

The government is focusing on increasing the use of green energy by gradually replacing the existing diesel vehicles with cleaner energy buses. To encourage electric vehicles: - Govt offers incentives, including tax breaks and The Early Adoption Incentive rewards early EV adopters with additional registration fee rebates. Government has been investing in charging infrastructure. The nationwide rollout of charging stations, including fast chargers, at key locations underscores the commitment to facilitating electric vehicle usage.

- Green vehicles also enjoy perks such as free parking in public car parks. This policy encourages eco-friendly vehicle adoption and contributes to a more sustainable transportation landscape. Due to these efforts the growing popularity of electric vehicles (EVs) is evident with the increasing presence of models like the Tesla Model 3 and Nissan Leaf on Singapore's roads. And Hybrid vehicles, such as the Toyota Prius, have gained traction in Singapore. [12]

The Circle Line and Downtown Line rail systems have received the BCA Green Mark Gold Plus certification for their eco-friendly features from the Building and Construction Authority (BCA) and Land Transport Authority (LTA). Additionally, Canberra station was the inaugural recipient of the Green Mark for Transit Station Platinum Award in 2019. Under the plan of 2030

[11] Land Transport Authority. (2022). Enhancing Public Transportation: MRT/LRT Expansion Projects. *Transportation Research Journal, 18*(4), 112-128. Retrieved from https://www.lta.gov.sg/content/ltagov/en.html

[12] Land Transport Authority. (2021). Encouraging Electric Vehicle Adoption: Incentives and Initiatives. *Energy Policy Review, 10*(2), 87-102. Retrieved from https://www.lta.gov.sg/content/ltagov/en.html

Singapore is continuing to promote walk cycle ride mode of transport, most interesting as of personal experience too cycling is the major focus of intelligent transportation in the country.

Through the Smart app called any-wheel one can cover the entire island on bicycle, in minimal expenses and short periods of time.it is a great way to explore the city more than the tourist attractions only. There are initiatives by the government car free Sunday's, car free zones, the car lite movement etc. The urban planning of the road itself shows the efforts of encouraging the bike sharing mode of transport. The one thing which is very evident is that there is no rickshaw and auto system in the country. Either you ride a bicycle or walk or take the bus and MRT.

Water Conservation

Singapore has successfully tackled one of its most pressing issues - water scarcity with advanced technology, public engagement and forward-thinking policies which ensured the sustainable water supply became a remarkable example for the world. The journey starts from the first water conservation campaign in 1971 by PUB (public utilities board) aimed to encouraged people to cutting down the daily water uses, following the success the PUB launches various campaign with the heartfelt taglines like - "Don't wash your car like fighting a fire", "Water is more precious than gold, silver and wealth" and "Water is our life". The impact of these efforts could be seen as in 1976 daily per capita domestic water consumption downward about 263 litres and by 2010 dropped to 154 and 141 in 2019.The recent target of PUB is to reduce the country's per capita water to 130 by 2030.

So basically, Singapore has the FOUR National Taps- the diversified water supply through - local catchment water, imported water, NEWater and desalinated water and by relying on these, the supply remains sustainable in the country.

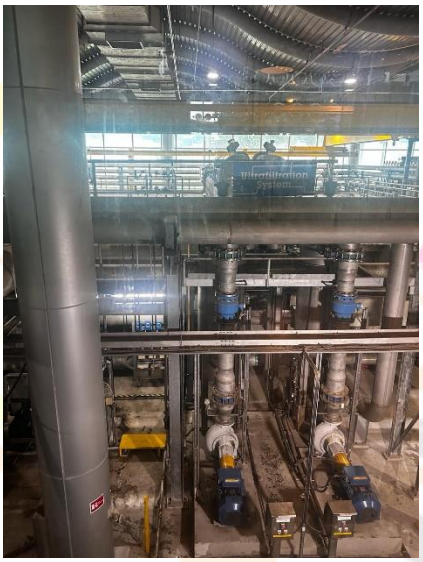
Local catchment- Through the efficient management of local catchment areas, country optimizes the best utilization of rainfall, reduces the enlightenment on the external source of water. For more than 20 years, Singapore national water agency pub has effectively implemented extensive nationwide initiatives for harvesting rainwater on ta large scale. Notable example - Marina Barrage, a reservoir with function as a dam to prevent seawater intrusion with area of 10,000 hectares. Country has 17 reservoirs which connected by 32 major rivers and more than 7500 km of drains and canals for water supply.

Import Water- Singapore has strategically handled the water scarcity in the country by upheld the long-standing bilateral agreement with Malaysia from the last 2 decades which actually provides a crucial supplement to the country. The Johor River water agreement outlines the terms of water supply from Malaysia to Singapore, the country has the right to import up to 250 million gallons of raw water per day[13]. The country has actively invested in alternative sources for diversification in water supply; one of the prominent sources is NEWater.

NEWater - This groundbreaking project launched in 2003, which involves the treatment and purification of waste water, the water undergoes with an advanced purification process first through microfiltration, reverse osmosis and ultraviolet disinfection- these all ensure the removal of the impurities and resulting in high quality water. Through the implementation of NEWater, Singapore reduces its dependence on conventional water sources and strengthens its

[13] Tan, Y. (2015). Singapore's water story: A model of water sustainability. *Environmental Science & Policy, 54*, 352-360. Doi: 10.1016/j.envsci.2015.06.017

ability to withstand the effects of climate change and variations in water availability. Beyond consumption, NEWater has a wide range of applications, including industrial processes, urban landscaping, and other non-potable purposes. The country has invested significantly in enhancing water security and drought resilience, with about $3 billion invested in the past five years to diversify Singapore's water supply with local catchment water, imported water, NEWater, and desalinated water. These weather-resilient sources are crucial during dry periods like El Nino, ensuring a stable water supply for the nation. In 2017, NEWater successfully met 40% of Singapore's daily water demand of 430 million gallons. With a projected doubling of demand by 2060, the PUB aims to boost NEWater capacity to cover 55% of demand. Desalinated water will contribute 30%, up by 5% from 2017, and the remaining 15% will be sourced from local catchments and imported water due to land limitations for runoff collection despite ample tropical rains.



So yes, to sum up, NEWater is a prime example of Singapore's dedication to sustainable water management and shows how problems with water scarcity may be solved by adopting creative ideas. Singapore's NEWater initiative is a remarkable example for other places looking for resilient and sustainable water solutions as global water worries develop.[14]

Circular Economy

Singapore recognizes the significance of a circular economy model, and aims to shift from a linear 'take, make, waste' traditional economy to a circular one, creating economic opportunities while addressing waste issues, boosting resource productivity, and enhancing competitiveness. Country focuses on sustainable growth and climate change resilience through policies such as Segregated Waste Disposal and Collection, Adoption of EPR and DRS System, for sustainable production, research grants for sustainable design, and collaboration for innovative waste management solutions and developing comprehensive circular economy policies with a focus on plastics. Singapore sets measurable targets, prioritizes recycling over waste-to-energy solutions. Some of the prominent examples are Gardens by the Bay, a great tourist attraction, employing sustainable practices by recycling around 70% of its horticultural waste. This involves the conversion of tree branches and plant trimmings into energy, contributing to the cooling of the Gardens' conservatories. Similarly, Tuas Nexus represents a forward-thinking development, bringing together the Tuas Water Reclamation Plant and the Integrated Waste Management Facility. This integration is expected to result in an annual reduction of more than

[14] National Research Foundation. (2018). Singapore's National Water Agency Announces Plans to Ramp Up NEWater Production. Retrieved from [https://www.nrf.gov.sg]

200,000 tonnes of carbon emissions through the efficient recycling of waste, showcasing a commitment to environmentally responsible practices. Progress has also been made in areas like in construction waste recycling and water loop closure, with the goal of increasing national recycling rates and reducing waste-to-landfill by 2030.[15]

Conclusion

Singapore's dedication to environmental conservation and sustainability is highlighting its ecological superiority. Singapore has achieved great progress in encouraging green projects, successfully managing limited resources, and incorporating nature into urban development over the years. The nation's strategy for the 2030 Agenda for Sustainable Development is in line with its long-term sustainability objectives; it places special emphasis on a number of issues, including clean energy, sustainable cities, responsible production and consumption, addressing climate change, and biodiversity preservation. The Green Plan 2030 approach basically focused on five pillars - City in Nature, Sustainable Living, Energy Reset, Green Economy, and Resilient Future. This initiative aims to reinforce Singapore's commitments under the United Nations' 2030 Sustainable Development Agenda and the Paris Agreement, aligning with the nation's own sustainable development goals. Outlined strategies within the Green Plan involve a fivefold increase in solar energy deployment by 2030, the planting of an additional one million trees, a 30% reduction in waste sent to landfills, and the goal of making at least 20% of school campuses carbon neutral by 2030. The plan also places importance on establishing a green finance hub, promoting sustainable tourism, and developing an eco-friendly transportation system. This collaborative effort is led by five ministries—Ministry of Education, Ministry of National Development, Ministry of Sustainability and the Environment, Ministry of Trade and Industry, and Ministry of Transport. The Green Plan encompasses various initiatives and support measures spanning research and development, energy, green finance, sustainable tourism, and land transport sectors. Achieving these goals requires a united effort, collaborating with the community and industries to co- create solutions and make progress in these key areas. The country's unwavering dedication to environmental care and creative problem-solving establishes it as a guiding light for worldwide sustainability and an example of living in harmony with nature.

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