



# INNOVATION UNDER UNCERTAINTY

*How to achieve Sustainable Growth in Singapore?*

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## Team Members :-

- Challagulla Sai Siddardha (20EC10023)
- G.V.K. Sai Sarath (20MF3IM08)
- Chukka Akhila (20CH10015)
- Shivin Gumber (20CE30028)
- Pate Satwik Dattatray (20AG30026)
- Rehana Tehazeen (20ME10066)

# **An outlook of Pre-Existent Environmental issues in Singapore**

Singapore's rapid economic growth in the 1970s and 1980s was accompanied both by increased air and water pollution and by increasingly effective government efforts to limit environmental damage. The government established an Anti-Pollution Unit under the Prime Minister's Office in 1970, set up the Ministry of the Environment in 1972, and merged the Anti-Pollution Unit with that ministry in 1983 to ensure a unified direction of environmental protection. The new unit, subsequently renamed the Pollution Control Department, had responsibility for air and water pollution, hazardous materials, and toxic wastes.

Singapore's primary target was to limit air pollution, closely monitoring oil refineries and petrochemical complexes and limiting the sulfur content of fuel oil for power plants, factories, and diesel motor vehicles. Because motor vehicles were the main source of air pollution, the government required emissions controls on engines and reduced (but not eliminated) the lead content of gasoline. The government also acted, partly for environmental reasons, to restrict private ownership of automobiles through very high (175 percent) import duties, high annual registration fees, and high charges for the entry of private automobiles to the central business district.

Singapore's environmental management program was intended primarily to ensure public health and to eliminate immediate hazards to citizens from toxins. Enforcement of the laws often reflected an appreciation of the economic benefits of polluting industries and provided time for industrial polluters to find ways to limit or eliminate their discharges.

## **Current Scenario**

### **Natural Resources of Singapore**

#### **Geography of Singapore**

Singapore is a very small, heavily urbanized, island city state in Southeast Asia, located at the end of the Malayan Peninsula between Malaysia and Indonesia. Singapore has a total land area of 724.2 square kilometers (279.6sq mi). As Singapore is a city-state with not much land area, it is not particularly rich in natural resources. Singapore is a leading global hub for Agri-commodities, metals and minerals.

#### **Natural Resource aspects of Sustainable Development in Singapore**

- ❖ Agriculture
- ❖ Atmosphere
- ❖ Biodiversity
- ❖ Desertification and drought
- ❖ Energy

- ❖ Forests
- ❖ Freshwater
- ❖ Land Management
- ❖ Mountains
- ❖ Oceans and Coastal Areas
- ❖ Toxic Chemicals
- ❖ Waste and Hazardous materials

## Climatic Changes

How can Climate Change affect Singapore?

- ❖ Sea level rise
- ❖ Water Resources
- ❖ Biodiversity and Greenery
- ❖ Effect on Public health
- ❖ Urban Heat Island effect
- ❖ Food security
- ❖ And many more indirect impacts.

These tell us that Climatic Changes have serious negative impacts on Singapore as a whole.

## Economy of Singapore

Singapore's economy is very developed, free-market (decisions are guided by demand and supply). It has the 3rd least corrupt and most pro-business Economic Sector. Singapore's largest industry by far is the manufacturing sector, which contributes 20%-25% of the country's annual GDP. Key industry clusters in Singapore's manufacturing include electronics, chemicals, biomedical sciences, logistics and transport engineering. Close behind Singapore's manufacturing industry, is its financial services industry, which has enjoyed stable growth due to Singapore's pro-business environment and political stability. Home to over 200 banks and a regional hub of choice for many global financial services firms, Singapore's financial services marketplace facilitates the transfer of knowledge, processes, technology and skills between global, regional and domestic markets.

Despite the strength of Singapore's economy, it faces several problems, with one of the most important ones being unemployment among the residents. The government of Singapore has put in place several measures to increase the number of jobs in the country and reduce the unemployment rate. Today, the Singapore economy is one of the most stable in the world, with no foreign debt, high government revenue and a consistently positive surplus.

## Population effects and Lifestyle changes

Singapore's population has shown a general increasing trend. This is projected even in the future. Given below are some major effects of increasing population

- ❖ **Increased energy demands for power, industry and transportation**

Larger energy demands usually lead to increasing fossil fuel extraction and burning- leading to higher emissions. A large population will lead to increased demand for goods - factories will have to produce more to meet our increased consumption

❖ **Greater rate of Deforestation in response to changes in land use**

Large scale deforestation has occurred in Singapore since 1959. More than 99% of the original forest was cleared, and more than half of Singapore was urbanized by 1999. Deforestation releases large amounts of Carbon Dioxide. This is as there will be less absorption by trees.

Thus, we can observe that there is a positive correlation between population growth and emissions, supported by a study conducted by Shi (2001).

## Extent of Research and Technical Growth

Singapore's science and Technology transformation over 50 years mirrors its remarkable leap from survival to excellence. Singapore's water technology, port management capability and petrochemical ecosystem are noteworthy. Key areas of development are autonomous vehicles and robotics in healthcare systems.

With the repurposed statutory boards imbued with a clear purpose, direction and mandate, the following decades saw six bold masterplans to power Singapore's ambitions in science and technology. They are :

1. National technology Plan 1995
2. National Science and technology Plan 2000
3. Science and Technology Plan 2005
4. Science and Technology Plan 2010
5. Research, Innovation and Enterprise 2015 (RIE2015) Plan
6. Research, Innovation and Enterprise 2020 (RIE2020) Plan

## Staying ahead in a Competitive World

On the policy front, Singapore's latest innovation leverages on a whole-of-government approach as evident by recent initiatives:

- ❖ Centralizing regulatory agencies
- ❖ Launch of SGInnovate dedicated to support Singapore's start-up ecosystem
- ❖ Bringing strategy and implementation under one agency

In conclusion, it is remarkable that a small country in 50 years could transform rapidly -- economically and technologically. Looking ahead, Singapore would do well to forge closer integration along and across value chains.

# Major problems & proposed solutions

## Increasing Density of Population

Population is an important asset for the nation but becomes a liability if it is uncontrolled. Most of the problems besetting Singapore can be pegged to one factor: overpopulation. (see Figure.1)

It is precisely overpopulation that leads to:

- Inflation / high cost of living
- Spiralling property prices
- Transport woes, traffic jams
- An infrastructure that is unable to cope with the surge
- Inadequate varsity places for locals (with foreigners taking up the bulk of admissions to new institutions being set up through collaboration with prestigious global universities) and overall
- A worsening quality of life for residents

### Main factors driving population growth

- Fertility rates
- Mortality rates (life expectancy)
- The initial age profile of the population (whether it is relatively old or relatively young to begin with)
- Migration

(see Figure.2)

### Various effects of overpopulation

#### ❖ **Degradation on the Environment**

##### 1. **Carbon Dioxide ,Greenhouse Effect and Global Warming.**

Undoubtedly human population growth is a major contributor to global warming, given that humans use fossil fuels to power their increasingly mechanized lifestyles. More people mean more demand for oil, gas, coal and other fuels mined or drilled from below the Earth's surface that, when burned, spew enough carbon dioxide (CO<sub>2</sub>) into the atmosphere which leads to melting of polar ice caps, changing climatic patterns, rise in sea levels are a few of the consequences that we might have to face due to environmental pollution. to trap warm air inside like a greenhouse. Besides, the exponential rise in the number of vehicles and industries has badly affected the quality of air.

##### 2. **Scarcity of food**

Increasing numbers of people often drive up demand for food, which typically results in additional use of arable land and water. This is especially true in the absence of adequate food production technology and integrated programs that simultaneously

address community needs for food and reproductive health. Population explosion is one of the major causes of food problems. There is less food production as compared to increasing demand. Due to overpopulation, a large portion of agricultural land is shifting into construction of industries, houses, buildings, cities, roads and other infrastructure. This leads to the shortage of food in the country.

### **3. Shortage of water**

Water is one of the most integral and important aspects of daily life for every human being, for example, food, clothing, and almost everything else humans interact with involves water. Therefore, water and water security is going to be a crucial focus for governments in the next few decades, especially since the population is increasing rapidly. On the other hand, if current water resources are not properly regulated, an eventual increase in world population will become problematic for many regions and countries. Overpopulation will strain current water resources to their limits, cause an increase in water pollution, and lead to an increase in civil and international conflicts over existing water supplies. (see Figure.3)

## **❖ Economic impacts of overpopulation**

### **1. Rise in Unemployment**

When a country becomes overpopulated, it gives rise to unemployment as there are fewer jobs to support a large number of people. The rise in unemployment gives rise to crime, such as theft, as people want to feed their families and provide them basic amenities of life.

### **2. High cost of living and Quality of Life**

As the difference between demand and supply continues to expand due to overpopulation, it raises the prices of various essential commodities, including food, shelter, and healthcare. This means that people have to pay more to survive and feed their families. Rapid growth of population accounts for low standard of living. Even the bare necessities of life are not available adequately. As the population increases pressure on healthcare centres, education departments, transporting services, and other public services increases.

### **3. More pressure on land**

Rising rate of population growth exerts more pressure on land. On the one hand, per capita availability of land goes on diminishing and on the other, the problem of sub-division and fragmentation of holdings goes on increasing. More and more agricultural land comes under the construction of industries, roads, cities and other infrastructure. Population explosion leads to environmental degradation. Higher birth rate brings more pollution, more toxic wastes and damage to the biosphere. It adversely affects the economic development of the country. Briefly speaking, population explosion hinders economic development. It should be controlled effectively.

## ❖ Social problems

### 1. Urbanization

Overpopulation gives rise to various social problems. It leads to movement of people from rural areas to the urban areas and causes the growth of slum areas. People live in most unhygienic and insanitary conditions. Unemployment and poverty lead to frustration and anger among the educated youth. This leads to robbery, beggary, prostitution and murder etc.

(see Figure.4)

## Solutions to counter Overpopulation

- **Women Empowerment: Change in Social Outlook**

In most developing countries, the women folks are not considered equivalent to men in terms of force and might. People keep giving birth to kids in order to have more sons than daughters. Empowering woman with a say in matters concerning them like child birth and educating them to fight against discrimination will ensure a healthy and aware society.

- **Education**

Education is the solution to all the problems. Education is the backbone of an individual and the economy of a country. Educated people can easily understand the adverse effects which a high population growth rate possesses. Education, especially women's education, can work wonders in controlling the population. An educated man and woman can easily understand the merits of a small family. Without proper education most measures like awareness campaigns and women empowerment will prove to be inefficient and useless.

- **Eradicating Poverty**

Poverty is one of the main causes of social problems. Poverty. Poverty is one of the reasons for overpopulation. Poor people are mostly illiterate and ignorant. They have a high fertility rate and give birth to many children. They don't follow family planning and other methods of population control. Therefore the Government should take steps to eradicate poverty so that they get awareness and benefits of family planning.

- **Actions at Community Level**

Join local environmental groups, encouraging them to connect the dots between population and the environment and voice the population issues. Write opinion pieces to local newspapers, contract local media sources requesting more reporting on population issues - create demand !

- **Family planning**

This method implies family by choice and not by chance. By using preventive measures, people can regulate the birth rate. Family planning mainly depends on the availability of cheap contraceptive devices for birth control and proper medical facilities. The government should give various types of incentives to the people to

adopt birth control measures. Teenagers should be educated about sex contraceptives early on, without taboos.

## Economic Measures

- **Creating employment opportunities**

Government should create more and more employment so that the income of people can be raised. This will increase the living standard of people and people will adopt small families instead of big one.

- **Standard of Living**

Improvement in the standard of living acts as a deterrent to large family norms. In order to maintain their higher standard of living people prefer to have a small family. Government should take important steps to increase the living standard of the people.

- **Incentives:**

The government should give various types of incentives to people to adopt birth control measures. Providing educational, health or even financial incentive can be a highly effective population measure. Incentive policies like paying a certain amount of money to the people with not more than two kids or free or discounted education for single child etc. can help to adopt small family norms.

## Increasing pace of carbonisation

### Problems arising due to increase in carbon footprint

- The increasing amounts of carbon emissions trapped in our atmosphere causes global warming, which causes climate change, symptoms of which include melting of the polar ice caps, the rising of sea levels, the disturbance of animals' natural habitats, extreme weather events, and so many more negative side effects that are dangerous.
- Singapore is not insulated from the impact of carbon emissions. From 1980 to 2020, the annual mean temperature has increased from 26.9°C to 28.0°C.
- The mean sea level in the Straits of Singapore has also increased at the rate of 1.2mm to 1.7mm per year in the period 1975 to 2009.
- Rainfall has become more intense in recent years. Annual rainfall total for Singapore has increased at an average rate of 67 mm per decade from 1980 to 2019.
- Singapore, mostly being urban, tends to be warmer due to the replacement of natural land cover with buildings and other infrastructure that retain or produce heat. Higher annual temperatures can also lead to heat stress as well as greater use of air-conditioning, increasing Singapore's energy demands. This in turn results in higher domestic carbon emissions.
- Singapore is situated in a region where vector-borne diseases are endemic. Most cases of vector-borne diseases like dengue are observed during warmer periods of



the year. Hence the warm weather which is being induced by the carbon emissions may result in increased frequency of these diseases.

- A mean temperature increase of 1.5°C to 2.5°C could affect the natural diversity of Singapore's plants and animals at risk, as this alters our ecosystem's natural processes such as soil formation, nutrient storage and pollution absorption. (see Figure.5) , (see Figure.6)

## Some strategies to increase the pace of decarbonisation

### 1. **Transformations in Electricity sector**

Electricity production will be a driving feature of decarbonization of the economy.

The long-term trend has been towards the electrification of the energy economy, and this trend is expected to continue (IPCC, 2000). To the extent that expanded electricity use is a substitute for the direct use of fossil fuels (e.g., in transport, or for cooking or heating applications in households), the result can be less CO<sub>2</sub> emissions if the electricity is from carbon-free primary energy sources (renewable or nuclear) or from distributed generators such as fuel cells powered by hydrogen produced with near- zero fuel-cycle-wide emissions or from large fossil-fuel power plants at which CO<sub>2</sub> is captured and stored

In Singapore implementation of renewable energy cannot be taken on a large scale as it is a small, resource-constrained country, Singapore imports almost all its energy needs, and has limited renewable energy options:

- Commercial wind turbines operate at wind speeds of around above 4.5m/s but the average wind speed in Singapore is only about 2m/s.
- Singapore's relatively narrow tidal range and calm seas limit opportunities for commercial tidal power generation. Much of the sea space is also used for ports, anchorage, and shipping lanes, which limit the application of ocean energy technologies.
- Hydroelectric power cannot be harnessed, as Singapore does not have a river system with fast-flowing water throughout the year.
- No geothermal energy sources.
- Small physical size (728 sq km), high population density and land scarcity limit the potential for sustainably grown domestic biomass. It also constrains the safe deployment of nuclear power in Singapore.

### ❖ **Electric Transport**

A fast track to electrification, car-sharing and free public transport. The transport sector is the only sector where carbon emissions continue to grow. Increased use of electricity offers a promising decarbonization option. It can reduce your dependence on fossil fuels . When an electric vehicle is running on electricity, it emits no tailpipe (also known as direct) emissions. When evaluated on that factor alone, EVs are a lot more eco-friendly than conventional gasoline-powered vehicles on the market today. (see Figure.7)

## **2. Direct air capture of CO<sub>2</sub>**

A vital technology for reducing carbon dioxide levels. Direct air capture is a technological method that uses chemical reactions to capture carbon dioxide (CO<sub>2</sub>) from the atmosphere. When air moves over these chemicals, they selectively react with and remove CO<sub>2</sub>, allowing the other components of air to pass through. The captured CO<sub>2</sub> can be injected underground for permanent storage in certain geologic formations or used in various products and applications. Permanent storage will result in the biggest climate benefit. (see Figure.10)

## **3. A National tree planting plan**

This will help in decreasing carbon dioxide in the atmosphere. When implemented correctly, trees are currently the most cost-effective and best technology for carbon removal and storage. When trees are planted and begin to grow, they start absorbing carbon dioxide emissions, which they then store and carry out photosynthesis with. Researchers at University College London, University of Oxford, and ETH Zurich found that if people work together worldwide to plant trees, two-thirds of the total carbon emissions (~three hundred tons) put into the atmosphere due to human activity can be removed. (see Figure.13)

Some things individuals should adopt to help increase the rate of decarbonisation

### **◆ Small Changes Make a Difference**

Smart decision making at home or at work could mean lower energy use, lower emissions and a better world for everyone. We can start by using energy, water and other resources more carefully so that we minimise wastage.

(see Figure.11) , (see Figure.12)

Here are some small tips that can make a huge long-term impact: (see Figure.8)

### **◆ Use Air Conditioning Sensibly**

Is it too cold? Raise the temperature setting on your air conditioner. Better yet, use a fan instead of an air-conditioner. You can save money and energy just by doing this!

### **◆ Switch Off Appliances and Equipment When Not in Use**

Just like you need to rest, your fan, television, computer and other electronic devices at home or work need a rest too. Give them a break by switching them off when you do not need them. Remember, they still consume energy while on standby mode, so switch them off at all the mains!

### **◆ Public Transportation is a Better Option**

Travelling long-distance? Why not take the bus or mass-rapid transit (MRT) instead of driving? Is your destination close by? Hop on your bicycle or take a leisurely stroll instead. Consider these travel options before you take any trip.

### **◆ Drive Greener Cars**

If you need a car to get around, choose one that emits less carbon. Look out for the mandatory Fuel Economy Labelling Scheme (FELS) labels, which will tell you the carbon emissions and fuel efficiency performance of the car model. With the introduction of the

Carbon Emissions Vehicle Scheme (CEVS) in January 2013, you get to enjoy a rebate as well as when you buy a vehicle that emits less carbon.

### ◆Buy Energy-efficient Appliances

Buying a new appliance for home or work? Choosing to spend a little more to buy a more energy-efficient model will not only lower your energy usage, but will lower your bills in the long term too! To lower your energy use, choose appliances that carry three or four green ticks on their energy labels as they are more energy efficient.

### ◆Reduce, Reuse and Recycle

By choosing to use less, less will be thrown away. Whatever we throw away, we can make sure our waste gets reused by channelling materials such as paper, metal, plastic and glass for recycling. Using recycled products also helps reduce carbon emissions because producing them uses much less energy.

Avoid using disposable utensils, cups and plastic bags whenever possible. Reduce waste by bringing your own utensils with you for meals and using your own reusable bag for grocery shopping. Also, think about whether you really need the packaging or wrapping when you buy things. (see Figure.9)

## Conclusion

Our natural environment makes human life possible, and our cultural environment helps define who we are. It is therefore essential that our population and economic growth are environmentally **sustainable**. We would like to express our gratitude to Professor Shamik Chowdary, who gave us the brilliant chance to do this wonderful project on the topic , which indeed helped us in completing a ton of research work and we came to think about numerous new things.

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### CRediT Author Statement

*Siddhardha: Supervision and Investigation*

*Akhila: Data Curation and Analysis*

*Rehana: investigation and proof reading*

*Sathvik: Original Draft preparation and Draft editing*

*Shivin: Investigation and Data Curation*

*Sarath: Supervision, Draft finalisation.*

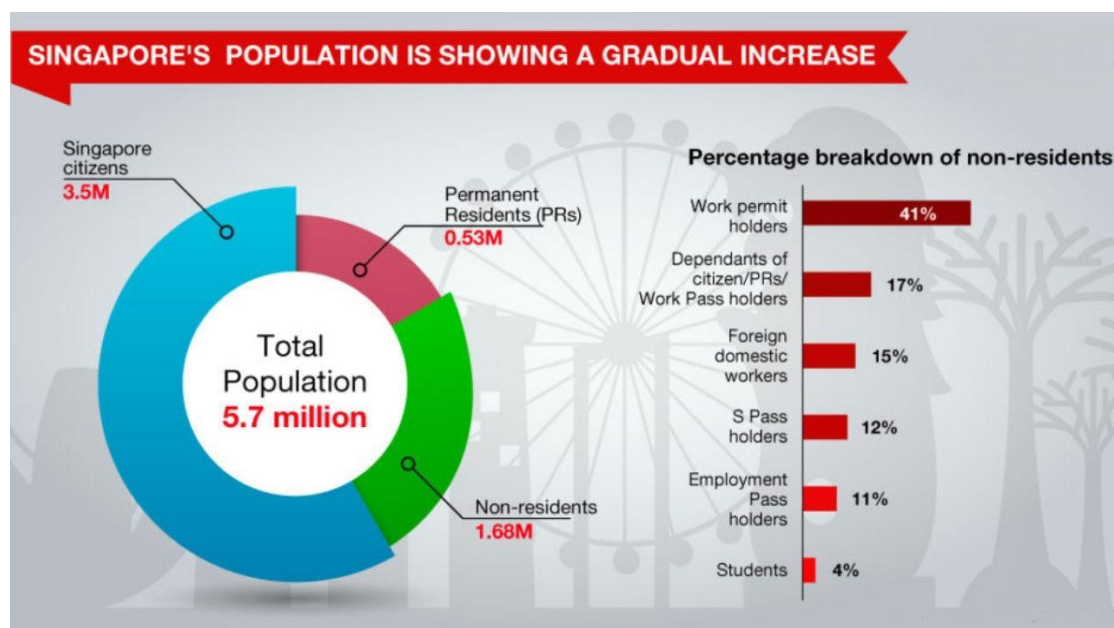


Figure.1

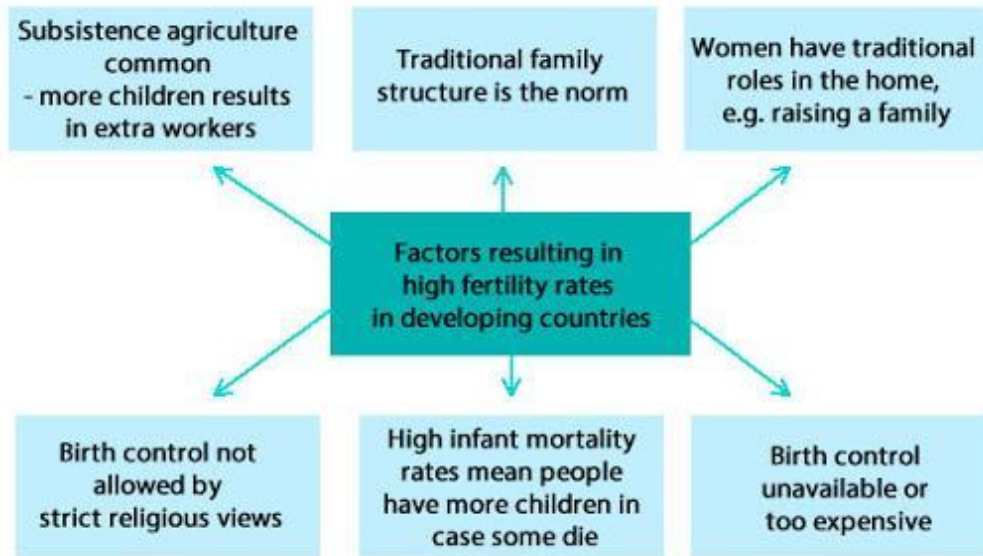


Figure.2



Figure.3

Figure.4



Figure.5



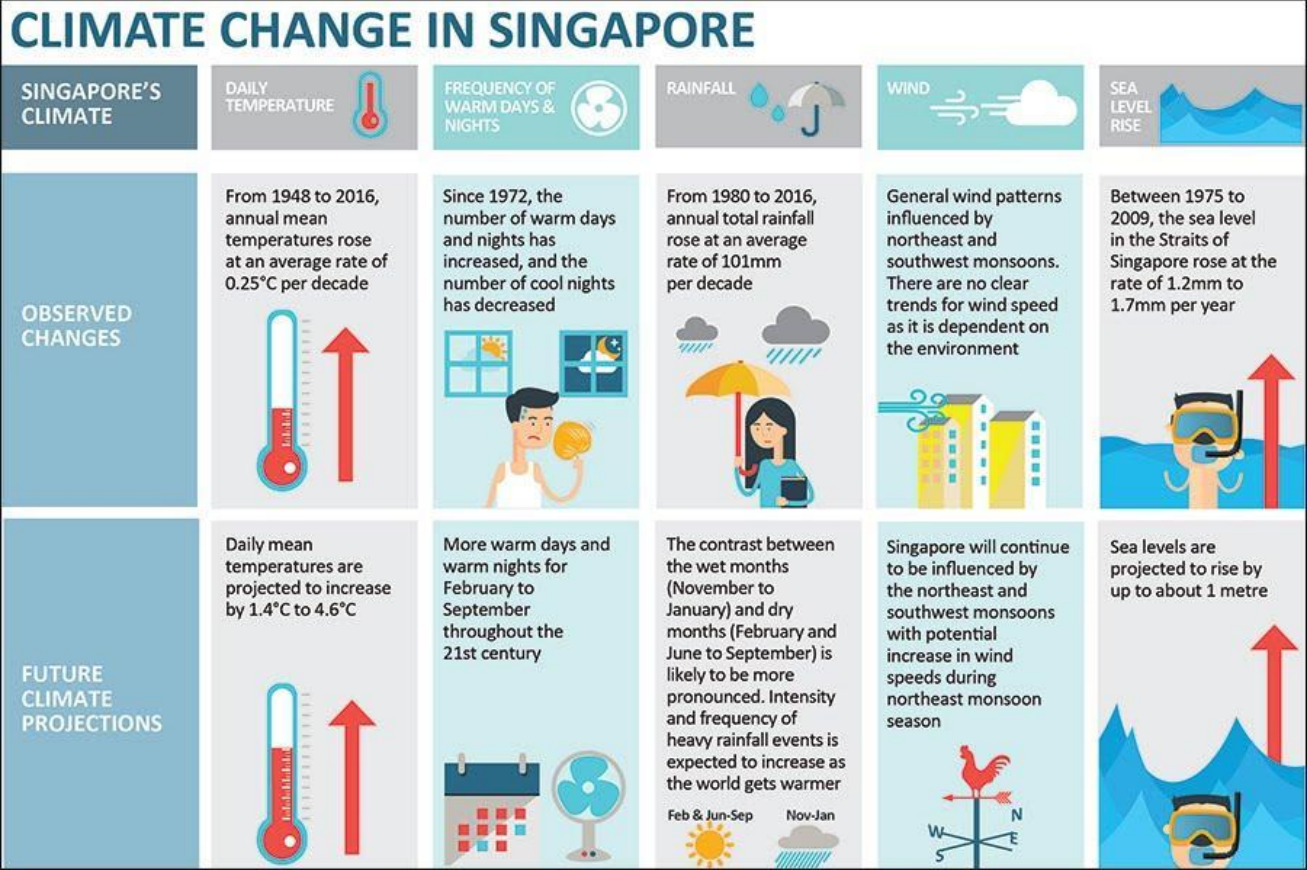


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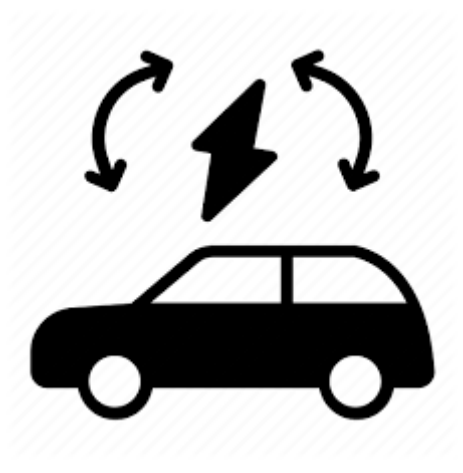


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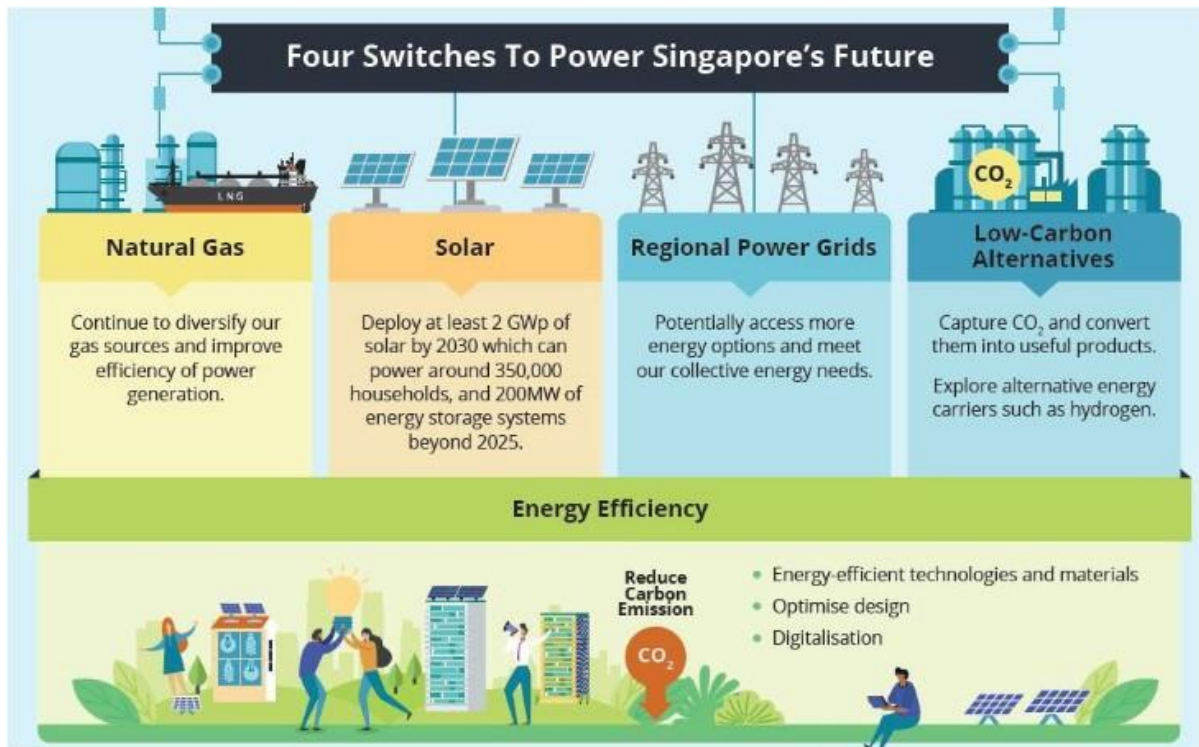


Figure.8



Figure.9



## Global Carbon Dioxide Emissions by Population Growth Scenario: 1990-2025

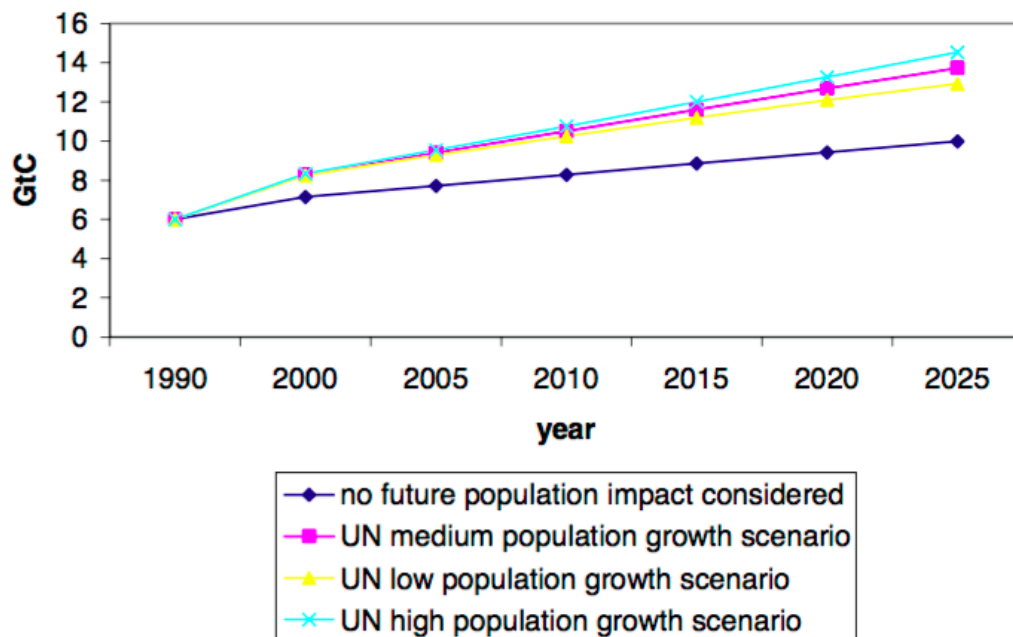
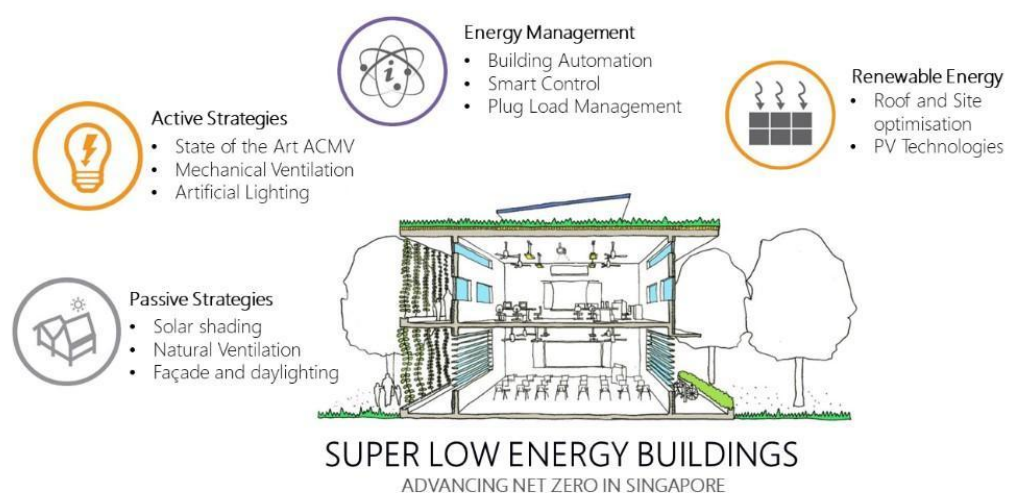


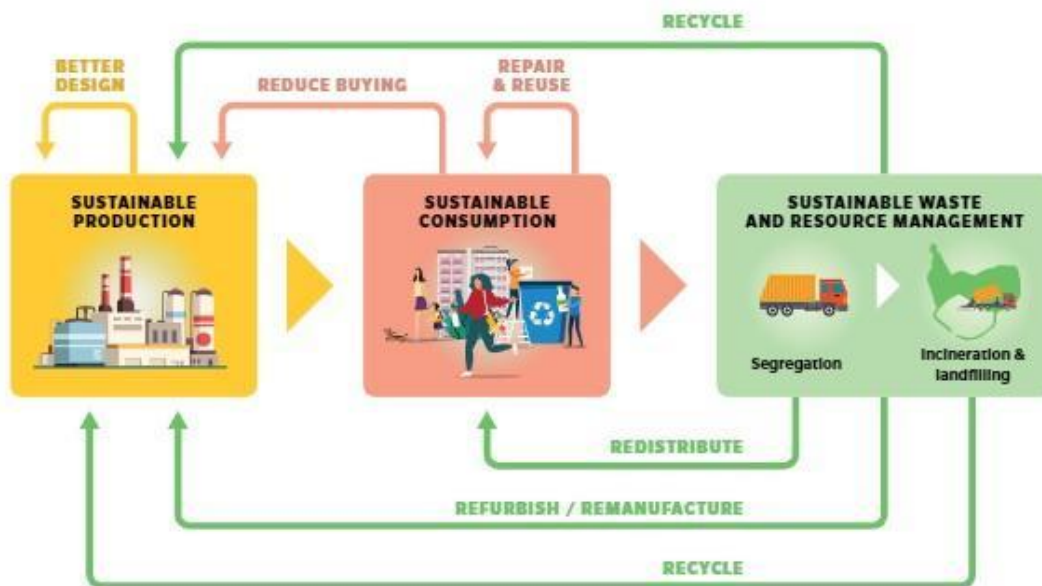
Figure.10



Features of SLE buildings

Figure.11

**A circular economy approach will require measures to be taken across the entire value chain**



*The circular economy approach outlined in the Zero Waste Masterplan Singapore*

Figure.12

Between **2001** and **2016**, **Singapore** lost **1.38kha** of tree cover. This loss is equal to **7.4 %** of the area's tree cover extent in **2000**, and equivalent to **80.8kt** of CO<sub>2</sub> emissions.

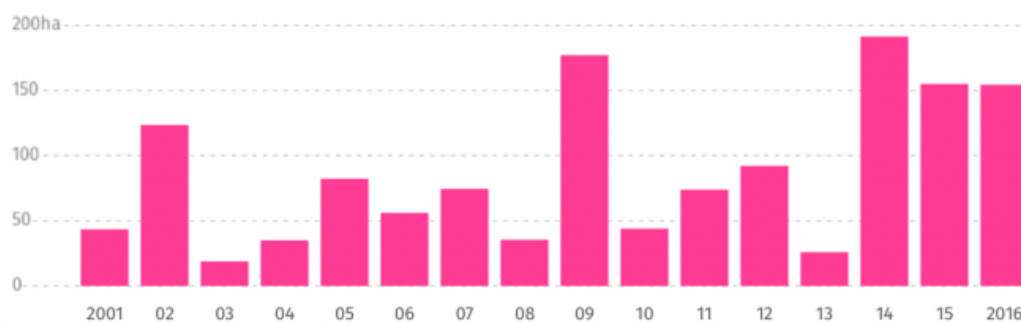


Figure.13