



CC6 Notes (23:24)

Sustainability: Society, Economy and Environment (Nanyang Technological University)



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Week 1: Introduction to Sustainability

Why Sustainability?

- Long term goal for humanity, economic development activity that strives to “meet the needs of the present without compromising the ability of future generations to meet their own needs”
- Rejects the notion of trade-offs between each dimension – sustainability can only be achieved when all 3 aspects are attained
- Currently, the lifestyles of rich countries are unsustainable, with consequences to nature, biodiversity, natural resources, human societies, livelihoods, peace, economic stability etc...

Complexity of Sustainability

- Long range of interconnected but unique problems
 - Multiple causes, hard to define “the problem”
- No generalisable solution, no right or wrong (only better or worse)
- Solutions tend to ramify throughout the system and take a long time to evaluate

Global Warming (Climate Change)

- Carbon dioxide is the main greenhouse gas (it traps heat in the atmosphere)
 - Occurs naturally
 - Human activities: burning of fossil fuels, chemical reactions like manufacturing cement
- Carbon dioxide removed naturally is by photosynthesising organisms like plants, in the process of photosynthesis which absorbs CO₂ and releases oxygen
 - Ocean acidification: Ocean takes up carbon dioxide too, increasing in acidity of waters
- Carbon dioxide concentration are now **close to 420 parts per million** and steadily increasing

- World leaders meet at climate change summits to discuss actions against climate change
 - 2015 Paris Agreement → world leaders signed it and agreed to work together to
 1. limit global warming (to preferably below 1.5°C)
 2. Make financial commitments to achieve this goal
 - Paris Agreement was updated at the COP 26 Summit in November 2021
 - In 2015, United Nations set up **17 sustainable development goals** (Agenda 2030) that Singapore also signed.
 - Universal call to action: end poverty, protect the planet, promote peace and prosperity to all people by 2030

- Singapore has given a voluntary national report, outlining how to tackle the 17 SDGs
- Intergovernmental Panel of Climate Change (IPCC) regularly produce assessment reports that provides the latest scientific, technical and socioeconomic knowledge on climate change (causes, potential impacts and responses)
- Singapore Green Plan: greener and more sustainable Singapore by 2030
- NTU sustainability office → aims for carbon neutrality (net zero carbon dioxide emissions) by 2035, AND reducing water and energy use by 50% by March 2026

3 Systems Approach:

- 1) Society
 - a) Environmental justice and unequal distribution of e.g. climate change effects
 - b) Understanding human behavior to implement changes for sustainability
 - c) Risk of political conflict or humanitarian crises due to climate change or environmental degradation
 - d) Singapore: Additional 200 hectares of nature parks for citizens (and wildlife) to enjoy, planting one million trees across the island (CO2 absorption, shade and cooler temperature), programmes to reduce human-wildlife conflicts
- 2) Economy
 - a) Needed: Sustainability accountants, for sustainable capital investments
 - b) Integration of financial decision making and sustainability work
 - c) Stating potential social and environmental impact on profits
 - d) Effect on valuation, investment
 - e) Singapore: GREEN ECONOMY: Enterprise Sustainability Programme, Carbon tax, Home-grown innovation
- ** Circular economy: 1. Eliminate waste and pollution, 2. Circulate products and materials, 3. Regenerate nature
- 3) Environment
 - a) Laws of nature govern processes of climate change and environmental degradation
 - b) Intrinsic value of nature
 - c) Human dependence on natural resources
 - d) Natural climate solutions, for example, mangrove forests protect against storms and flooding
 - e) Tree planting
 - f) Singapore: More green spaces, Education and appreciation for local wildlife, Limit pollution of water, Conservation initiatives

Week 2: No Poverty, Social Inclusion and Equality

UN SDGs: 1 No Poverty, 2 Zero Hunger, 10 Reduced Inequalities

Poverty

- **Lack of income and productive resources** to ensure sustainable living
- Hunger and malnourishment, social discrimination, exclusion and lack of participation in decision-making
- 2015: More than 734 million people in extreme poverty (making \$1.90/day or below)
 - around 10% of the population living in extreme poverty (lack of access to basic needs e.g food, water, education)
- Number of people living in extreme poverty has been declining gradually over the last 3 decades (1990 – 63% to 2015 → 10%)
- Covid-19 Pandemic → Pushed more than an estimate of 100 million people into extreme poverty due to income and job losses
- The World Bank new target: Having no more than 3% of the world population live below the poverty line by 2030
- Measurement of poverty: International poverty line is made using costs of basic food for adequate nutrition, clothing, healthcare and shelter in low-income countries (survival AND dignity)
 - Problems: costs vary from country to country. Solution: Purchasing Power Parity (PPP) estimates from low-income countries (theoretical exchange rates separate from market exchange rates)
 - New international poverty line: \$2.15 a day, as of 2022

Profile of Global Poor

- South Asia: Poverty rate in 2010 was about 30%, declined in recent times
- Sub-Saharan Africa: Poverty line is growing in this region
- Middle East and North Africa: 2.3% in 2013 to 10% in 2018
 - The poor are predominantly rural, young and undereducated.
 - Women are over-represented among the poor globally.

Ending Extreme Poverty: Sub-Saharan Africa

- Situation has been improving lately → growing in economy by 5% each year
- GDP per capita is used to measure
 - Population has been growing rapidly by 2.5% per annum, so growth of GDP per capita is slower
 - Recession in Sub-Saharan Africa due to Covid-19 (though it is predicted to improve in the coming years)
- Improvements to be made → decreasing fertility rate
 1. Farm Productivity – roll out government programmes to help the poorest farmers
 - a. $\frac{1}{2}$ ton to 1 ton of grain per hectare, which is very low compared to other countries. Farmers are too poor to buy soil refilling, fertilizer for decent yields.
 - b. Agriculture poverty trap: cannot spend to grow good yields, cannot grow good yields to bring themselves out of poverty
 2. Urban Productivity – mass electrification

- 3. National Infrastructure – roads, rails, power, ports and communication networks
- 4. Human Capital Investment – health and education

Ending Extreme Poverty: South Asia

- Improvements to be made → decreasing fertility rate
 - 1. Population and human development
 - a. rapidly growing population (high population density)
 - b. Child malnutrition (India has nearly double rates of Sub-Saharan Africa)
 - 2. Education
 - a. Primary education
 - 3. Gender Inequality
 - 4. Corrupt Governance
 - 5. Challenges of climate change

- Official Development Assistance (ODA) from 1970
 - Government aid nearly donated by high-income countries that promote and specifically target the economic development and welfare of developing countries
 - 1% of their GDP every year
 - 70% of ODA to come from government-to-government grants and low-interest loans
 - 30% of ODA to come from private contributions (corporations, foundations and charitable organizations)
 - 179 billion USD (all time high!) in 2021, but still quite less than intended ideal amounts
 - Mainly used for economic development in the poor countries: Build capital or capacity (paving roads, power grids, build clinics and schools, training and salaries for teachers and health workers, healthcare delivery)
 - Does it work? If not used well, aid is wasted.
 - Aid stimulates development in developing countries, until they do not need financial help.
 - China and Korea has grown from needing foreign aid to contributing to foreign aid efforts
 - Cannot be a permanent solution, a long-term way of life
 - Most effective way of aid distribution is through project-based approaches (financing a local business, building a well, or providing uniforms for girls to go to school), public health aid (offering vaccinations, developing cheap and effective drugs to treat malaria)
 - Observe development effects of different types of projects and practices to determine which ones to adopt or discard.

Social Inclusion and Equality

- A society that entails respect for human rights, cultural diversity, and democratic governance, and upholds principles of equality and equity (society for all)
- Broad-based prosperity, eliminating discrimination, equal protection under laws, ensuring that every human being can meet basic needs and enabling high mobility (e.g. child born into poverty does not have to end up in poverty)
 - Equal rights and opportunities for every individual → to fulfill their economic potential

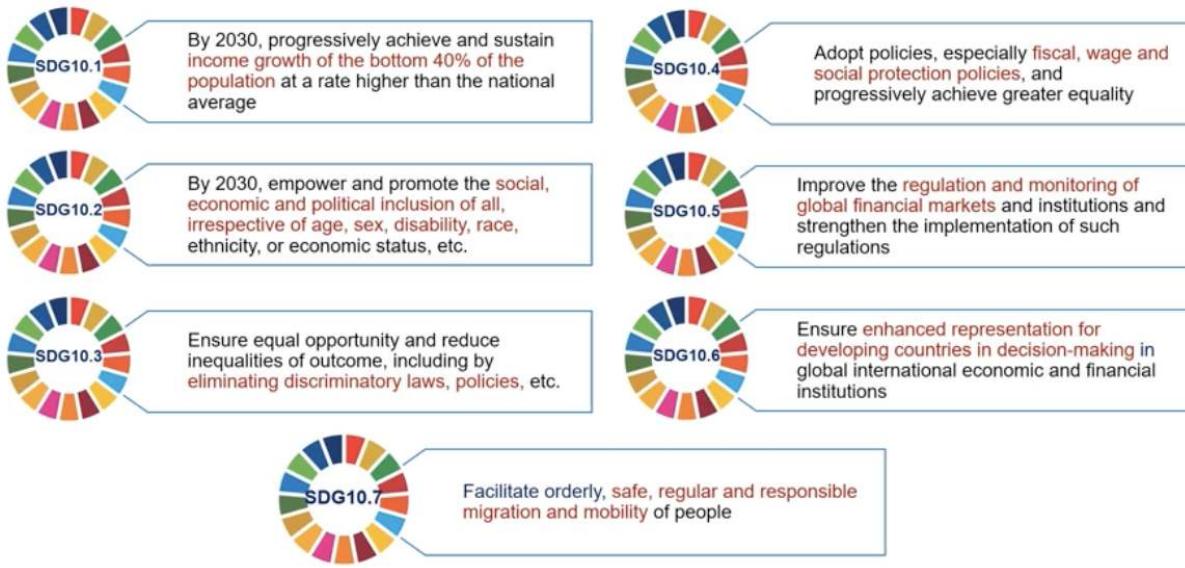
- Social exclusion and disadvantages are usually based on race, gender, ethnicity, sexual orientation, religion etc
 - Global events (e.g.: Covid -19 hit the lowest income the hardest)
- Social mobility: someone born in poverty does not have to remain in poverty

UN SDGs: 3 Good Health and Well-being, 4 Quality Education, 5 Gender Equality, 10 Reduce Inequalities, 11 Sustainable Cities and Communities, 16 Peace, Justice and Strong Institutions (*6 in total*)

Income Inequality

- Gini coefficient/index: statistically measure income distribution to measure income inequality within a country/social group
 - 0 = Perfect Equality (every citizen in a country has the same income)
 - 1 = Perfect Inequality (one resident is earning all the income and the rest is earning nothing)
 - USA and Turkey has Gini coefficient of ~0.39, but USA GDP per capita is much higher (~X8)
 - Problem: Gini coefficient does not tell the overall wealth/income of country, quality of life, general economic well-being
- Social and historical factors for inequality: racial, social, ethnic, gender discrimination
- With higher level of education, people have more advanced skills, leading to higher wages
 - Those with less education is left behind
- Digital revolution has led to increased use of data science, robotics, artificial intelligence and other information technologies → Eliminating middle-skill jobs, jobs involving repetitive work (packaging) or basic manufacturing
- Wealthy people use power of wealth to gain political influence, attempt to influence policy in their favor such as tax breaks, subsidies or favorable regulatory changes → which they use to earn more money
- Governments have historically mitigated inequality through redistribution policies such as (progressive taxes) and social transfer (such as public retirement benefits)
 - These are not being used effectively: high earning income households have to pay less tax
- Income inequality between countries is getting better, but WITHIN a country is getting worse (the top 10% keeps earning)

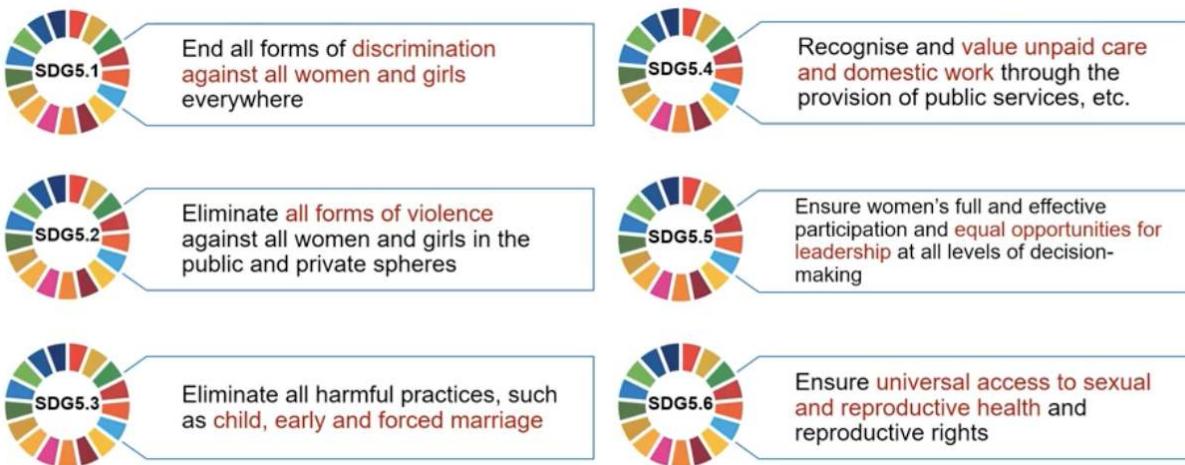
Ways to reduce income inequality:



Gender Inequality

- Slow progress in terms of gender equality
- What does it look like?
 - Labor force participation and **gender pay gap**
 - Double shift at home
 - Growing challenge from automation
 - Economic fallout due to pandemics and other shocks
 - Gender-based violence (1 in 3 women globally have been subjected to physical, sexual, or non-sexual violence at least once in their lifetime)
- Gender Development Index (GDI): Measures gender inequalities in achievement in three basic dimensions of human development – health, education and estimated earning income. The higher the GDI, the smaller the gap between women and men.

Ways to reduce gender inequality:



Week 3: Food Security & Global Food System

UN SDG 2 Zero Hunger

UN SGD 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

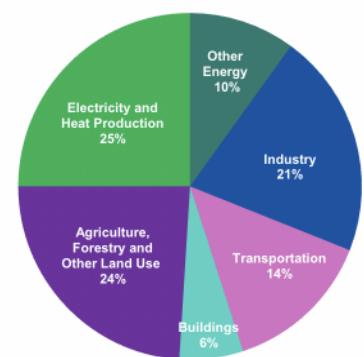
- Challenges
 - Feeding 10 billion people
 - Eradicating hunger
 - Being healthy
 - Promoting economic growth
 - Securing jobs
 - Saving the planet
- 2.37 billion people worldwide lacking food/unable to eat healthy diet on regular basis (2020)
 - 22% children stunted → lack of proper diet prevents normal growth and development
 - 6.7% children suffer from wasting (severe weight loss due to malnutrition, loss of strength/substance)
 - 5.7% children overweight → more likely to get cardiovascular diseases, type 2 diabetes, high blood pressure
- Food production increasing, but number of undernourished people also increasing → more than half of undernourished are found in Asia
- The global food system is at the center of global environmental problems, poverty and human well-being
 - Global food system is defined as: "the sum of actors, sectors, and interactions along the food value chain – R&D, input supply, production, harvesting, storage, transportation, processing, retailing, wholesaling, preparation, consumption and disposal of food"

How the world's land is used

Livestock	27%	<ul style="list-style-type: none">- Shows that more land is required to produce meat than crops- Producing plant-based food requires less land to be used for agriculture
Forests	26%	
Barren Land	19%	
Glaciers	10%	
Shrub	8%	
Cropland	7%	
Built-up Area	1%	

- World Food Programme (WFP) awarded the Nobel Peace Prize (2020) for
 1. Its efforts to combat hunger
 2. Bettering conditions for peace in conflict-affected areas
 3. Acting as a driving force in efforts to prevent use of hunger as a weapon of war and conflict
- Hunger and Armed Conflict
 - 60% of the people experiencing hunger live in war-stricken zones
 - Two-way relationship: War and Conflict \leftrightarrow food insecurity and hunger
 - War and conflict can cause food insecurity and hunger
 - Food insecurity and hunger can cause latent conflicts to flare up and trigger the use of violence
 - End war and armed conflict to achieve zero hunger → conflict is the single greatest challenge
- Hunger and Climate Change
 - Climate change directly and indirectly threatens food production and livelihoods, particularly in poor countries
 - Agriculture contributes to a quarter of GHG emissions (24%)
 - Changes in land use (deforestation and loss of carbon from soils)
 - Methane gas produced in guts of ruminating animals (like cows)
 - Climate change effects → disturbance to the stable conditions that agriculture relies on
 - Risk of conflict and migration as people's livelihoods are threatened
- Large scale effect: Sea Level Rise in low-lying coastal areas (Bangladesh and Vietnam)
 - Issue: increased salinity levels, floods and water logging (from cyclones and typhoons), prolonged drought periods
 - Impact: significant shortages of water for drinking and irrigation, increased soil salinity = rice yields decline

Global Greenhouse Gas Emissions by Economic Sector



Food Security

- Exists when people at all times have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life

Stability	Utilization
Secure population/household/individual access to adequate food at all times, protected from sudden shocks or cyclical events that can threaten availability of access to food resources → having resilience in the food system and plan B if things go wrong (e.g. stored food)	Utilizing food in conjunction with adequate diet, clean water, sanitization and healthcare to a state of nutritional well-being, demonstrating the importance of non-food inputs for food security
Food Availability	Food Accessibility
The availability of sufficient quantities and appropriate quality of food products that are either locally produced or supplied by imports, including food aid → availability of different supply chains to get food	Adequate access to food resources for a nutritious diet → distributing food to those who need it, having fair trade agreements, developing systems in place to protect vulnerable people

Case Study: Singapore

- Food security in SG
 - 90% of food is imported
 - 1. Diversify sources of food (the supply)

2. Boosting local production (produce 30% of nutritional needs by 2030 – 30 by 30 Plan), and food technology (artificial meat)
3. Help local companies expand and grow overseas to export food back to SG

The Agri-Food Industry

- World's largest economic sector & employs half of global workforce, creates economic profit at the expense of natural environment
 - Directly and indirectly responsible for about a 25-30% of global greenhouse gas emissions (meat production)
 - Uses 69% of freshwater (consumptive use)
 - Loss of biodiversity (single largest cause)
 - loading of nutrients (decrease biotic diversity in ecosystem)
 - Pollution (use of pesticides)
 - Deforestations, soil erosion, degradation in marine and terrestrial ecosystems
- Generates social injustice between countries
- Need to cut down on environmental impact, but also increase the production of food for growing population
 - In addition to increased populations, individual consumption & demand for food is likely to increase
 - Economic growth ↑, per capita food consumption ↑ (as people get richer, they consume more food. Higher quality food, i.e. meat)

Meat Consumption (major contributor to GHG emissions & environmental degradation)

- Meat is good source for energy & nutrients , BUT overconsumption can lead to health issues (eg. cancer)

Most harmful environmental impact	Least harmful environmental impact
<ul style="list-style-type: none"> - Beef (Beef Herd) - Lamb/Mutton - Beef (Dairy Herd) - Farmed Crustaceans - Cheese 	<ul style="list-style-type: none"> - Nuts - Peas - Other legumes - Peanuts - Tofu

Strategies to Produce More Food Sustainably

1. More sustainable agricultural practices
 - Increase production with minimal expansion of agricultural land & avoid degenerative practices
2. Shifting diets towards more plant-based food
 - More energy available at lower levels of energy pyramid (producers = plants)
3. Food technology
4. Reducing food waste
 - ⅓ of all produced food wasted globally (2020); SG's food waste increased by 38% within last 10 years
 - Great losses along production line (in shops, places where food is consumed)
 - Concept of Circular Economy → no end of product life, only the next stage in the cycle (eg. reusing or recycling)
 - Food waste can be turned into something valuable → closed food loop within SG. e.g.: NUS researchers developed a method to use larvae of black soldier flies to convert food waste into nutritious compost, which can then be used to grow local food/used as animal feed

Week 4: Availability and Sustainable Management of Water Resources

UN SDG 6: Clean water and sanitation

Water is one of the essential requirements for life, is $\frac{1}{3}$ of the Earth.

- Having access to adequate sanitation and hygiene for all
- Improves overall water quality, and water use efficiency
- Reducing, Eliminating and minimize harmful pollutants

Water is a human right.

- $\frac{1}{3}$ people do not have access to safe drinking water
- $\frac{1}{4}$ people do not have a primary hand-washing facility with soap and water
- More than 670 billion people still practice open defecation

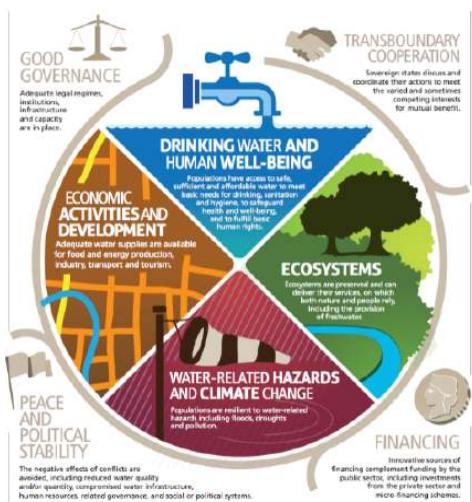
Major concerns in the world

1. Water stress levels
 - 17 countries face high levels of baseline water stress
 - 44 countries face high level of stress
 - India: underground water resources were severely drawn for agriculture purposes
2. Unaffordable and inaccessible to water during pandemic
 - Mainly due to social and physical constraints
 - Unexpected shutoffs and cross contamination = no more handwashing (threat to hygiene)
 - Example: Brazil (semi-arid environment): Limited handwashing despite having abundant resources

Global concern:

1. Water pollution (contaminated water)
 - Invisible crisis, does more damage than natural disasters
 - Diarrhea (caused by drinking unclean water) has resulted in more than $\frac{1}{2}$ million deaths annually (mostly young children)
 - More than 300,000 children in Africa have died from consuming unclean water + desertification
 - Affects income inequality
 - Women and girls in developing countries are tasked with securing water → takes time away from learning, earning an income
2. Diseases caused by drinking polluted water
 - More than 80% of waste water released without being treated (bacteria and viruses that can cause diarrhea and hepatitis A left to fester)
 - Use of nitrogen has increased by more than 700% since 1960
 - Rising use of fertilizers and pesticides used for urban development → may result in economic inequality
 - Existing water treatment can remove 90% of microplastics, but nanoplastics are unable to be removed due to it being too small and fine
3. Competition for water demand (food production)
 - Agriculture is the biggest user of water + overgrowing population (9 billion by 2050)
 - Issue: Shortage of funds to maintain facilities

- Solution: Economic development + infrastructure planning = Expansion by 70% by 2050
 - World Bank: Treating water as an economic good.
 - Encourage water savings and generate revenues
 - Market-driven pricing strategy, volumetric charges, and treatable water rights should be bumped up the priority list for developing countries
4. Water scarcity in urban areas (non-traditional threat)
- Issue: more than 40% of residents in Global South (developing countries) lack quality water daily. They buy piped-in water = private sources or bottled water (super expensive)
 - Families forced to sacrifice health and time and other needs (food, electricity, healthcare, etc to buy water)
 - Example: South Africa water crisis in Cape Town – 90 days away from cutting off tap water
5. Transboundary water conflicts
- Future wars may be over water, as water diversion is an issue of life and death.
 - South Asia, Middle East and South East Asia usually are major hotspots for violence
 - Lack of communication over natural resource can be a bad sign for cooperation → upstream activities impact downstream economies disproportionately
 - Issue 1: Debate over water may cause international tension (political strains)
 - Downstream countries are usually at a disadvantage (receive all the pollutants)
 - Example: India and Bangladesh
 - Issue 2: Lack of communication = may signify bad cooperation
 - Needs a framework to resolve tension before it escalates
6. Global Effort: Implementing water security & sustainable development framework



- Collaboration of all groups of people (individuals, decision-makers, national and international organizations) and **coordinated efforts** are required
- Water must be the foundation of all sustainability goals
- Entry points can be via any of the 8 components stated below:
 - Drinking water and human well-being
 - Ecosystems
 - Water-related hazards and climate change
 - Economic activities and development
 - Good governance
 - Transboundary collaboration
 - Financing
 - Peace and political stability

Managing Water Resource in Singapore: Innovation and Technology

1. Singapore currently has a total of 17 reservoirs (latest ones: Serangoon and Punggol)
 - Catchment area = $\frac{1}{3}$ of entire country → 90% of land by 2060 through using stormwater collection systems
2. Water demand and management
 - 430 million gallons per day, and increases with population and economic growth
 - Singapore aims to gradually reduce NEWater water demand by 2060 from 45% to 30%

****Addition of 5 water plugs aims to meet >50% of Sg's needs****

- Current channels of water (4 National Taps) + closed loop of water:
 - Water from local catchments (rainwater harvesting)
 - Imported water (will not be included in the future) → Based on 1962 agreement with malaysian government where contract expired 31 Aug 2021
 - NEWater – high grade purified and cleaned water, 5 NEWater plants
 - Desalinated water (goes through reverse osmosis, which is incredibly energy intensive) → cost is more than double of NEWater
 - 3 Cs of 4 National Taps:
 - Challenges
 - Capacity
 - Cost
3. Deep Tunnel Sewage System (DTSS)
- Water collected is sent to NEWater facilities
 - SG aims to complete expansion by 2050
4. Overall recommendation:
- Continue using the 4 taps which aims to supply 100% of population with 100% water sanitation (no longer rely on imported water)
 - Strict regulations to ensure social cohesion and promotes individual responsibility
 - Encourage water conservation
 - Introduce water conservation tax
 - Integrate water and urban water planning (ABC Programme)

Week 5: Energy and Climate Change (I) Background, Technologies and Policy Instruments

UN SDG 1 End Extreme Poverty, 7 Affordable and Clean Energy , 8 Decent Work and Economic Growth, 11 Sustainable Cities and Communities, 13 Climate Action

Context for Energy Needs

1. Crowded planet → Poverty
 - 8 billion people generate 80 trillion goods and services in the world economy.
 - The estimated world population on Earth by 2040 is 9 million.
 - Prosperity VS Poverty → unequal distribution and income disparity.
 - Similarity between all countries regardless of income disparity - the constant struggle for improvement
 - High income per person: USA, Canada, Australia, some countries in Europe → look for higher levels of well-being with the help of technological advancement
 - Upper and lower-middle income per person: Asia, Middle East, Latin America → look for better opportunities for themselves and children
 - Low-income per person: Sub-saharan Africa and some parts of Asia → look for basic needs
 - 2 main blocks of the Economy: Production and Consumption ⇔ Environment overexploitation
 - Threat to our own well-being
 - GDP – the monetary total value of g&s produced within a country during a certain period. It is used to measure the size of an economy, economic performance and respective growth. It includes total consumption, investment, government expense and net exports.
2. Global greenhouse gasses emissions → Global Warming and Natural Disasters
 - 6 major GHGs: CO₂, CH₄, N₂O, 3 fluorinated gasses.
 - Parts per million (PPM) of atmospheric CO₂ - Unit used to measure atmospheric CO₂ concentration by stating the number of molecules in every one million molecules of air
 - Sectors of the economy with bigger contributor to CO₂ emissions:
 1. Electricity and heat generation - 44% of emissions come from electricity and heat generation.
 2. Transport - fossil fuels used to generate electricity and heat to run rail, road and transport forms.
 - During combustion, carbon in fossil fuels/coals combines with the oxygen in the air to release energy and CO₂.
 - Global CO₂ emissions are 180 times higher now than in 1850, when industrialisation started
 - 2000: 23 - 24 million tons of CO₂
 - 2020: 35 million tons of CO₂ (almost 50% increase in 20 yrs)
 - 2030: Project to around 37.5m tons of CO₂
 - 2040: Project to around 42m tons of CO₂
 - Intergovernmental Panel on Climate Change (IPCC) is a leading body of the UN that works to advance knowledge on human-induced climate change.

- IPCC shows that global surface temperatures have increased by 1 degree centigrade since industrialisation. This increase is associated with an increase frequency and intensity of heat, extreme events, heavy rainfall, reduction in ice cover in Arctic)
 - Extreme weather patterns will disrupt our food and water production and supply
 - Natural disasters are natural, but humans increase frequency and intensity of them
 - 1980 - 1999: >4000 natural disasters, 1.19m reported deaths, 1.63 trillion of financial loss
 - 2000 - 2019: ~7,400 natural disasters, 1.23m reported deaths, 2.97 trillion of financial loss
 - Indonesia and Haiti have the highest number of reported deaths. ~190,000 and ~230,000 people killed respectively due to climate-fuelled disasters.
 - Other countries with high number of deaths: Pakistan, India, China. US also has high but comparably fewer deaths

3. Energy poverty

- Energy poverty is the lack of access to sustainable modern energy services and products
 - In 2010, 1.2 billion people had no access to electricity. In 2020, 771 million people do not have access to electricity.
- Some countries are consuming critical resources that leave little for future generations, while some consume so little they are on the brink of hunger and death.
 - OECD countries (richer ones - America, Europe, some parts of Asia) use more electricity per person than the global average at around 7 - 8 thousand kWh per capita, while Africa and other parts of Asia people live in the dark with per capita consumption at 1 - 2 thousand kWh per capita-> Extreme energy disparity across the globe
 - An estimated 771 million people do not have access to electricity. 95% of them live in Africa and Asia.
 - 10% of the world's population (around 734 million people) live in extreme poverty.
 - About 690 million people globally are undernourished, and about 14 million children under the age of five suffer from severe acute malnutrition.

Solutions:

- IPCC states the first step to deal with this problem is to limit global temperature increase to 1.5 degree centigrade. The present average temp increase is 1.1 degrees. Exceeding this limit would lead to long-lasting and irreversible impacts such as losing ecosystems forever eg; forest (carbon sinks) and marine ecosystems. Since the 1960s, forests have soaked around 25% of total CO₂ emissions contributed by fossil fuel burning.
 - Largest tropical rainforest in the world: Amazon forest. Deforestation and climate change impact the ability of the Amazon forest to soak up carbon.
 - National Institute for Space Research in Brazil show that significant parts of Amazon have emitted more CO₂ than they absorbed.

Regardless of whether you have contributed to climate change, you will be negatively impacted from it due to wide geographical spread of natural disasters.

- However, rich countries can deal with the impacts better due to more resources, well-functioning government, excess to advanced tech and skilled workforce while poor countries have no buffer of wealth and infrastructure → poorer countries suffer earlier and more

Potential actions to take:

#1 - Emissions mitigation and adaptation

- Objective: reduce exposure to climate risks
 - Mitigation - to deal with climate change, long-term and effective solution to slow down spread
 - Adaptation - keep us safe and buy us time until we implement measures and eliminate problem subsequently, reduce vulnerability
 - Eg; building new flood defense, barriers against storm surges, protect crops from high temp and draughts with new tech advances
 - Analogy: Covid-19. Vaccines are mitigation measures while staying at home, buying groceries online, wearing masks etc are adaptation measures. Mitigation and Adaptation complement each other. Even after mitigation measures, should not abandon adaptation. This is because even after we stop emissions, GHG will still remains in the atmosphere for ~1000 years.
- Mitigation: 2 Methods
 - Method 1: Energy-efficiency
 - Use of technologies, systems or methods that require less energy → eliminating energy waste
 - Convert energy input to useful energy output with minimal energy lost during this conversion → reduce loss improves efficiency
 - Benefits: lower emissions, reduce reliance on other countries. (SG imports almost all gas used to generate electricity), save money. Although energy-efficient appliances cost more, they are cheaper in the LR as their useful lifetime is longer and money on electricity bill can be saved
 - Possible to adapt in all sectors of the economy
 - cannot rely on technology alone: need to change behavior such as cutting down no. of AC hours
 - Method 2: Low carbon transition - Transition economy into version that uses low carbon
 - Decarbonise energy system by using cleaner energy resources
 - Make shifts in major contributing sectors
 - Eg; transport. Switch from petrol/diesel powered vehicles to electric vehicles, which are powered by clean hydrogen fuels.
 - use fossil fuel-powered generation systems in a cleaner way with technology.
 - Eg; capture CO₂ onsite and store it in an underground storage site for a longer time. kiv researchers so they

become technically and commercially viable. *Innovation plays a major role in ensuring success for emission mitigation.

#2 - Accelerate adoption of clean energy and energy efficiency

- External measures (policies to accelerate the adoption of clean energy and the overall decarbonisation of the economy)
- Renewable sources of energy - never run out, do not release GHGs, generate massive employment (mitigates loss of employment from shutting down of fossil fuels), immune to market fluctuations (important for countries like SG who rely on imported fuel energy)
 - International Renewable Energy Agency 2020 - 12m ppl are employed in the renewable power sector.
 - Solar PV has 4m jobs. They are GREEN jobs that ensure large access to electricity in remote and energy-poor countries.
 - Renewable power plants can be installed at a smaller scale and decentralized operation instead of being connected to a large power grid to get electricity -> supply electricity to remote locations.
 - 3 main aspects of energy sources and the inherent trade-offs
 1. Cost
 2. Energy input-output
 3. Feasibility

Aims:

- Reduce fossil fuel burning -> Reduce CO2 emissions -> reduce the increase in temp
- Sustainable development for all with social inclusivity and economic growth where everybody in the world has access to clean, affordable and sustainable energy without poverty and malnutrition (grow together without harming the planet). To take only what we need and leave enough for future generations.
- Adaptation/Climate Resilience: To prepare ourselves to live w climate change impacts to some extent safely

General concerns:

- not available all the time
- some renewable systems have reached grid parity - occurs when an alternative energy source can generate power at a leveled cost of electricity that is less than or equal to the price of power from the electricity grid
 - Eg; generating electricity from solar PV costs the same as generating electricity from conventional sources
 - needs land area, which countries like SG lack
 - not fully socially acceptable yet, but public awareness and acceptance have improved overtime

*need to come up with innovative approaches eg; generating in neighbor countries and transmitting it to our own, rooftop areas, water bodies

*everybody has a role to play. Governments can invest in R&D to overcome constraints

Adoption of renewable energy remains low and behind our target. 29% of our total electricity is generated from renewable energy, with the remaining from fossil fuels

Week 6: Energy & Climate Change (Background, Tech, Policies)

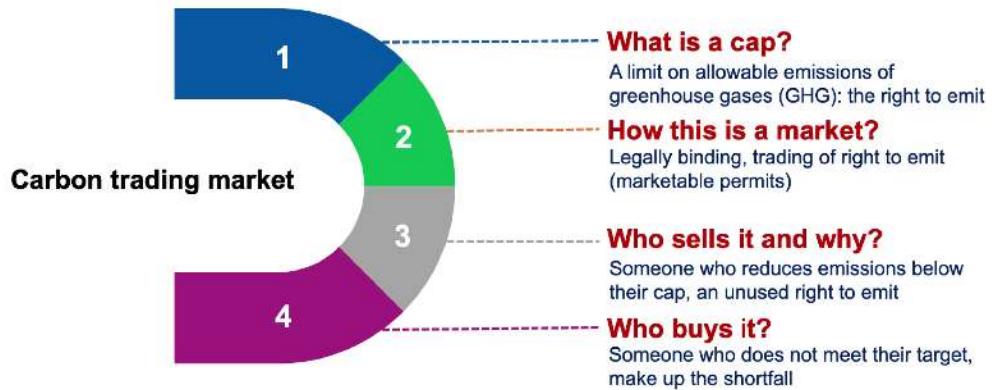
Policy Instruments

- Mitigate CO2 emissions
- Accelerate adoption of clean energy & energy-efficient technologies

4 Policy Measures

- Institutional & Regulatory Measures
 - Traditional
 - Used to control all kinds of emissions (e.g. ozone, SOx, NOx)
- 1. Institutional Approaches (Institution-based)
 - Aim: Internalize the negative impacts of emissions
 - Specification of Liabilities
 - E.g. public harmed by pollution can sue polluters
 - Development of Social Responsibility
 - E.g. green ticks on electrical appliances
- 2. Command and Control (Regulatory)
 - Government/Regulatory authorities take direct control over polluters
 - Ask polluters to A) stop polluting, B) pollute below a limit or C) sell something that meets certain performance benchmarks
 - E.g. Singapore's min. Energy performance standards - from 2022 onwards, min. For green energy ticks on certain appliances are 2 ticks
- Flexibility and Economic Incentive-based Measures (Innovative measures)
 - Ask Polluters to pay
 - No incentives for business to stop emitting CO2 outside out ethical and moral responsibilities - reducing CO2 emissions is a pricy choice
 - Should not leave the decision to stop emitting to the ethical and moral code of a business - you pollute, you pay
 - But this should be flexible payment to not harm the economy
 - Low-income countries must be allowed to grow their income per capita and narrow the income gap
 - To reduce CO2 emissions, businesses can:
 - Invest in clean and new technology
 - Offset emissions via investing in emission reduction projects
 - Do nothing and pay the government fines for polluting, typically through emission taxes
 - Close down the business
- 3. Market-based tools
 - Cap and trade
 - Allows businesses to reduce carbon emissions at the lowest cost possible
 - Businesses are rewarded for hitting under their CO2 cap by being able to sell unused CO2 permits, while businesses who exceed the cap are punished by having to buy CO2 permits from the trade market.

Cap and Trade: How does it work?



4. Non-market Mechanism

- Carbon tax

- Any industrial facility in SG that emits $\geq 25\text{kT}$ of CO₂ in a year must pay carbon tax
- How does carbon tax work?

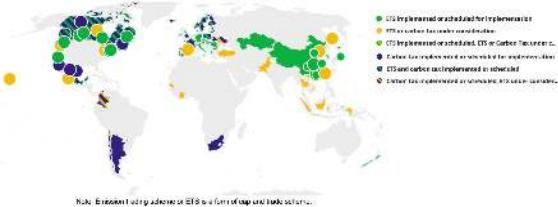
1. Gov puts price on carbon (\$5/ton in SG)
2. Pay tax or Reduce emissions
 - a. Reducing emissions takes time - immediate step would be to pay fines which increase production costs which companies try to offset by passing cost off to customers
→ price increase for same product
3. Customers will try to save costs by either changing the companies they buy from or reducing the use of the energy-intensive service/product or come up with their own energy-efficient product (e.g., installation of their own solar panels)
4. When everyone switches to clean energy sources, this will create a demand in the market → **Clean energy investments becomes more profitable**
5. Creation of incentives to carbon-intensive industries to shift to cleaner alternatives
6. Emissions fall
- Gov will generate huge revenue from carbon taxes, can:
 - Compensate low-inc families for increased costs of services
 - Invest in climate protection projects or public projects
- Gains of carbon tax:
 1. Carbon emissions go down and polluters pay
 2. Creation of financial incentives for switching to clean energy
 3. Gov generates revenue that can be used in climate protection programmes

Carbon tax: How does it work?



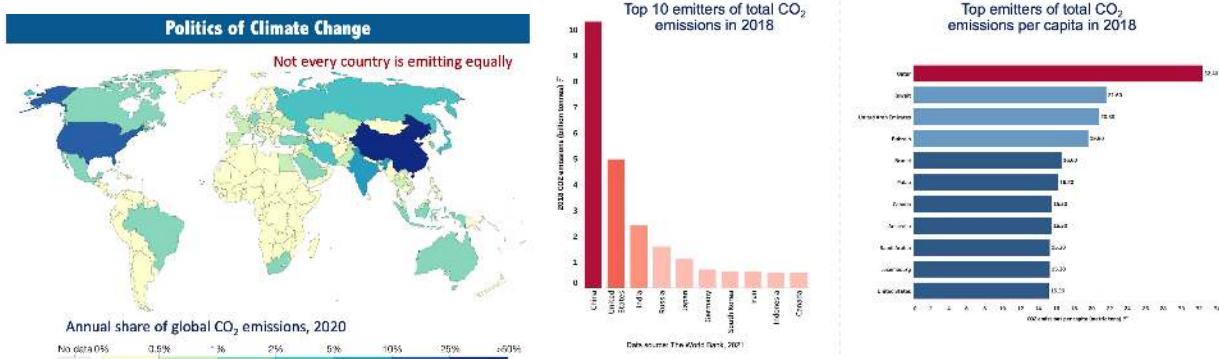
Worldwide Carbon Pricing Initiatives

64 Carbon Tax and ETS initiatives : Implemented, scheduled, or under consideration



Economics of Climate Change

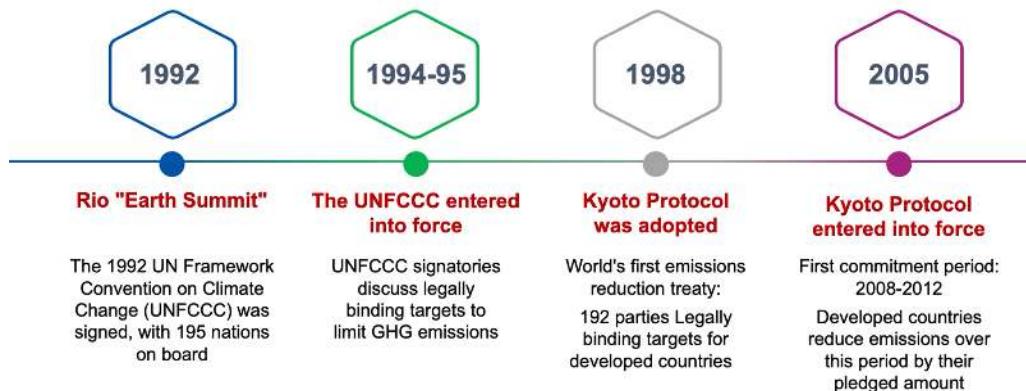
- Economics Rational Agent Theory
 - Economics believes that all humans are rational agents - only do things that benefit or make financial sense for us
 - Every decision driven by cost and benefit calculation
 - In the context of climate change, the gov will be telling the common people that taxpayer money is being invested to mitigate the risks of climate change that won't be seen or have much effect until a few decades down the road; most people unwilling to pay for something so far off into the future
 - Cost and benefit of climate change cannot be calculated using usual methods
 - Climate change has long term impacts → calculations are based on future projections where future effects and costs are not fully known; unable to quantify or decide its future monetary value.
 - Too much human tragedy involved for quantification → millions of people suffer from flooding, droughts, etc; unable to put a price to that suffering
 - Many low and high probability outcomes involved (e.g. A 3 degree increase in global temp will have devastating consequences, but the exact impacts on human well-being and the economy will be unknown. The actual impact may be much higher or lower than the est. which will compromise cost benefit calc)
 - Stern's numbers to take action against climate change
 - Acting now: 1% of global GDP/year
 - Delay: 5% of global GDP or no recovery at all
 - Climate Change as a Global Issue
 - Countries not taking responsibility until someone else does it first
 - Low-income countries think high-income countries created the mess and therefore will not move until they move



- Political and ethical dilemma
 - Sub-developing countries (e.g. India, China) argument - their emissions are growing because the country is currently in development → aims to increase income per capita to attain a living standard that developed economies have already attained

- Developed countries polluted heavily in the past, generating the climate crisis, but are now shifting the blame to low-income countries
- Poor countries are the most vulnerable to climate change impacts - suffer the earliest and worst
 - Despite having the least contributions to climate change, they have to take significant action in their country's interest
 - Dealing with climate change is a pro-growth strat in the longer term
 - Poorer countries will need help taking actions against climate change in their own countries, and richer countries will be required to step up to provide that support
- Rich countries have to...
 - Provide financial support for low-carbon development in poorer countries
 - Make significant cuts in their emissions
 - Emissions reduced by 60 - 80% by 2050
- Divided public opinion
 - Powerful fossil fuel industries (biggest biz interest inv.) have every reason to want to sway climate change policies
- Politics
 - US - Democrats are pro-climate change actions, Republicans are not
- Global treaty
 - Even if some individual countries started acting on climate change on their own, it wouldn't be enough
 - Global world with connected economies means indiv economies will still be vulnerable to climate change unless the world economy averts the climate crisis#
 - Problem of Free-riders
 - Some countries take advantage of others' efforts; if everyone started thinking they could freeload off of other's work, nothing would get done
- Plan #3: International Collaboration
 - International agreement to limit global carbon emissions started as early as 1980s

International climate accords



- UNFCCC formed in 1992 with 195 nations on board

- First Global Emissions Reduction Treaty (Kyoto Protocol) was adopted in 1998 after years of negotiation in Kyoto, Japan
 - Most developed countries agreed to take legally-binding targets to reduce their emissions
 - First commitment period of this protocol ended in 2012
- Following 3 years of negotiation, the next protocol was adopted in Paris, France in 2015 (Paris Agreement)
 - Most countries ratified the Paris Agreement in 2018
 - Agreed to limit global warming to well below 2 degrees centigrade
 - Provide financial and technological support to low-income countries
 - US withdrew in 2020, but rejoined in 2021
 - DRAMA: Recent Glasgow meeting → Commitment to phase OUT fossil fuels became phase DOWN fossil fuels

2015

Landmark agreement in Paris



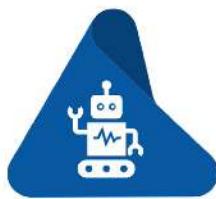
- Limit global warming to well below 2, preferably to 1.5 degrees Celsius
- Almost every country takes the target to reduce their GHG emissions, submit national plans by 2020, five-year cycle of submit, review and revise
- Financial, technical, and capacity-building support to countries in need
- Mobilize USD 100 billion/year by 2020, extend this until 2025
- Enhanced international support to developing countries for adaptation

Are the efforts enough?

- It LOOKS like we're starting to move in the right direction
- Many developed countries planning to achieve net zero greenhouse gas emissions by 2050
- Most experts say the actions currently taken are not enough; moving too slow
 - Climate pledges are not enough to stop global warming to sufficient levels; effects not visible on the ground when emissions are still rising rapidly
 - Countries are not on track to meet their reduction targets

3 major plans to tackle climate change

Overarching plan to address unprecedented challenge of climate change



- Advanced technologies
- Low carbon/clean electricity
- Switching to clean fuel
- Energy-efficiency



- Financial and technical assistance to low-income countries to meet their emission reduction goals and be part of the sustainable development
- Behaviour change: every individual has a part to play
- Participation of civil society, research institutes, non-profits, etc.



- Large-scale R & D plans to tackle the technical challenges of low carbon future
- Policies to accelerate the decarbonization of the economy
- Market tools for efficient reduction of GHG emissions

Week 7: Pollution: Air, Light, Noise and Microplastic

Pollution: presence of substances and heat in environmental media (air, water, land) whose nature, location, or quantity produces undesirable environmental effects

Air Pollution

UN SDG Addressed	3 Good Health and Well-being 7 Affordable and Clean Energy 11 Sustainable Cities and Communities
Historical Background of Air Pollution	<p>Air pollution was already reported in the 17th century.</p> <ul style="list-style-type: none"> - From the Medieval London to Pea-souper (distinctive yellow fog) - increased during industrial revolution in UK - The Great Smog of London was a severe air pollution event in December 1952 <ul style="list-style-type: none"> - caused by the burning of low grade coals, which produce more pollutants, to generate heat - Resulted in premature mortality of approx. 12,000 people → led to the introduction of the Clean Air Act in 1956 - 1990s to 2010s: East and South Asia, and other developing countries and increased emissions <ul style="list-style-type: none"> - Air qualities in these areas were reported to be equal to the polluted levels in Great Smog of London - Beijing haze events in January 2012 <p>7 million people die every year from air pollutants</p> <ul style="list-style-type: none"> - 4.2 million caused by outdoor air pollution - 3.8 million caused by cooking with polluting fuels such as kerosene, animal dung, crop waste and coal
Policies	<p>Europe, America, Japan and other developed countries → Clean air legislation</p> <ul style="list-style-type: none"> - Target ambient levels and emission sources of primary pollutants - Remarkable progress in sulfur dioxide <p>Richer countries can better manage air pollution but the situation in poorer countries is getting worse.</p> <p>22 September 2021: WHO updated global air guidelines, adjusted the standards for</p> <ul style="list-style-type: none"> - 6 pollutants: particulate matter, ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide → helps with decision making processes to have measures that are more sustainable
Impact of Air Pollution	<p>Health</p> <ul style="list-style-type: none"> - Chronic obstructive lung diseases on the list of top 10 causes of death in Singapore and worldwide <ul style="list-style-type: none"> - Asthma and childhood cancer - Air pollution affects neurological development and cognitive ability - WHO Figure: 9/10 people worldwide breathe polluted air, the poor are disproportionately affected

	<ul style="list-style-type: none"> - Vast majority of people die prematurely due to air pollution - around 600,000 children under 15 years old breathe air that is so polluted → seriously risking their health and development - More susceptible to chronic and cardiovascular diseases later in life - pregnant women → more likely to give birth prematurely to children with low birth weight - Adults → Pollutants penetrate into the lungs and cardiovascular systems, resulting in stroke, heart diseases and lung cancer - Food access in tropics and subtropics decrease as laborers face reduced workdays due to breathability worsens and heat rises <ul style="list-style-type: none"> - Reduced food production - Rising cost of food <p>Food</p> <ul style="list-style-type: none"> - Air pollution effects on crops appear in the long run: reduced growth, crop injury, premature crop death - Global warming: significantly responsible for up to 40% of global warming → negatively affect crops worldwide, be it to the drops directly or affecting farmers <ul style="list-style-type: none"> - Crop staples (maize, rice, wheat) yields will decrease by 10% per degree Celsius
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Light Pollution

Historical Background of Light Pollution	Human illumination of the planet is increasing in range and intensity by 2% per year → 20% in 10 years, which is a rapid change in living environments
Impacts of Light	<p>Benefits</p> <ul style="list-style-type: none"> - Safety: incidents of accidents and injuries decrease - Well-lit areas have less crimes, and perceived as more accessible <p>Disadvantages</p> <ul style="list-style-type: none"> - Light controls all living beings' diurnal rhythm (what makes us feel sleepy or awake) <ul style="list-style-type: none"> - Thus, disrupts natural rhythm - Nocturnal species are affected <ul style="list-style-type: none"> - D - Correlates with urbanization that couples with other factors to give environmental stress to animal behavior, reproductive success and survival of their species <ul style="list-style-type: none"> - Insects → impact pollination, and food sources for other animals - turtles use the moonlight to guide them to the sea after they hatch, however when there is artificial street lamps, it wrongly guides the sea turtles to civilisation

Noise Pollution

Historical Background of Noise Pollution	Natural Environment is noisy <ul style="list-style-type: none"> - Animals have adapted to the noise, but humans add unnatural
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	<p>noise, changing the acoustic environments</p> <ul style="list-style-type: none"> - Population and diversity of bird populations are changing due to human urban environment → making it difficult to hear, find food, locate mates and communicate - Australian pobblebonk frogs → usually hear up to 800m away, but reduced to 14m in noisy areas - Prairie dogs → hard to find food and communicate along USA highways - Disrupting noise under the surface → shipping traffic, industrial noise from oil and gas exploration, military sonar, seismic surveys <ul style="list-style-type: none"> - Cause hearing loss for dolphins, porpoises and whales - Interfere with sonar and navigation systems, communication and finding food <p>NTU EEE has developed a device that can reduce noise pollution entering buildings through open windows → Anti Noise Control Window</p> <ul style="list-style-type: none"> - Promises to cut noise levels by 10dB - Mounted onto window grills - Emits “anti noise” to counter the sound waves from the outside - Windows can be left open for fresh air and reduce need for air con - 2 challenges <ul style="list-style-type: none"> - Speakers obstruct view of window - Need to be bigger to be useful in apartments
Policies	<ul style="list-style-type: none"> - Singapore Law: 90 decibels as an average of over 5 minutes at residential buildings - NEA recommended limit: 67dB averaged over 1h - Safe sound pressure prescribed by WHO: 55 dB - Need to establish quiet technology - Undertaking detailed environmental assessments before and after construction
Impact of Noise Pollution	<p>Singapore: 218 workplace noise-induced deafness cases per year</p> <ul style="list-style-type: none"> - HDB received 15,000 noise-related complaints in 2020 <ul style="list-style-type: none"> - Furniture, feet running, music, construction, bird calls - Average outdoor sound levels: 69.4dB throughout the day - Mature estates have higher road densities, so louder residential areas <ul style="list-style-type: none"> - Design of the areas contribute to acoustic environment <p>Health</p> <ul style="list-style-type: none"> - Prolonged exposure to urban noise will lead to: cardiovascular disease, stress and anxiety, risk of hypertension, cognitive impairment - Sound loud enough to cause damage to the inner ear: loud music in enclosed spaces, earphones <ul style="list-style-type: none"> - Physical damage to the inner ear (cochlear hair cells cannot regenerate when damaged, which causes permanent hearing loss) - Hearing loss (acute or permanent) <p>Environment</p>

	<ul style="list-style-type: none"> - Noise pollution affects marine life as marine animals have evolved to be able to interpret
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Plastic Pollution

UN SDG Addressed	14 Life Below Water
Historical Background of Plastic Pollution	<p>Also known as white pollution because of the white plastic bags and single use tableware which people discard into the environment</p> <ul style="list-style-type: none"> - Since 1964, plastic production has increased 20 fold, reaching 311 million metric tons in 2014 - Between 1950 to 2015 → more than 6,700 million metric tonnes of plastic were produced <p>The Great Pacific Garbage Patch → a lot of plastics end up in the oceans</p> <ul style="list-style-type: none"> - Marine debris in the North Pacific Ocean → waters from the west coast of North America to Japan - Bounded by North Pacific subtropical gyre of 4 currents rotating clockwise around 20 million km² (swirling ocean currents) <ul style="list-style-type: none"> - Vortex of non-biodegradable plastic waste and debris accumulate there, and are broken into microplastics (instead of wearing down) - Nearly 50% of it is made of synthetic fishing nets due to ocean current dynamics and increase in fishing activity in the Pacific Ocean (from 2018 study) - Contains bits of microplastic, and does not show visible giant patches of garbage on satellites. Instead, looks like cloudy soup - 80% of ocean plastics are estimated to come from land-based sources. 205 from boats and other marine sources
Policies	<p>No internationally agreed upon standards and protocol to curb plastic pollution and the presence of microplastics (NOT LEGALLY RECOGNISED)</p> <ul style="list-style-type: none"> - UN Environment Program (UNEP) is currently developing methodology to measure marine plastics on beaches and shorelines, using citizen science data as primary source of information <p>Companies are ignoring their responsibility to reduce the production of plastics for revenue, market expansion and profit</p> <ul style="list-style-type: none"> - Sachet market → small sachets of powder, coffee etc being the biggest contributor to plastics <p>2021, Singapore only recycles 4% of the plastics in the country</p>
Impact/Properties of Plastic	<p>Benefits</p> <ul style="list-style-type: none"> - Plastic packaging: 26% of plastics produced - Economical to produce: low weight = fuel saving during transport <p>Disadvantages</p> <ul style="list-style-type: none"> - Single use for plastic packaging (utility can be measured in weeks/months) - Plastics can continue to exist for centuries

	<ul style="list-style-type: none"> - Exist as the product in landfills and littering the natural environment <p><u>Microplastics</u></p> <ul style="list-style-type: none"> - Tiny plastic particles that are less than 5mm in size (grain of rice to microscopic) <ul style="list-style-type: none"> - Primary microplastics → meant to be very tiny (plastic beads for exfoliation, plastic powder for toothpaste and sunscreen) - Secondary microplastics → big plastics ground down over time (bags, bottles food containers, paint, adhesive, coating, electronics, washing clothes made of synthetic fibres) - Found in oceans, lakes, air, waterways, soil and FOOD - Small enough to travel through water bodies into the ecosystems of marine organisms <ul style="list-style-type: none"> - Easily ingested - Will accumulate in bodies - Gets passed along the food chain - Present in drinking water - Number will only increase due to the large amount of plastics in the environment - Negative effects: disrupt reproductive systems, stunt growth, diminish appetite and cause tissue inflammation and liver damage <p>Nanoplastics → no official definition (does not use same materials etc)</p> <ul style="list-style-type: none"> - Scientists suggest: one nanometer to one micrometer <ul style="list-style-type: none"> - Can only use current research right now - Intentionally manufactured for cosmetic products or research - Mismanaged plastic waste may lead to secondary nanoplastics - Undergoes environmental transformational practices: agglomeration with other particles, accumulating in various environmental compartments
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Week 8: Waste Management: Responsible Consumption and Production

From Access to Excess

- Nowadays, consumption is the process of using up a resource.
- Consumerism is when you're buying things that you don't necessarily need for the sake of buying them.

For example,

Consumption choice → Different between buying ferrari and stepping into morning shower

- Both cost money and involve the use of resources.
- "The matter of choice comes with symbolic power" VS "a daily routine that is taken for granted".

Consumerism is heavily linked to access or excessive consumption activities. In Singapore, the amount of ways disposed has increased 7 fold over the past 40 years. About 7.7 million tonnes of waste was generated in 2017. This amount is enough to fill 15,000 Olympic-size swimming pools

Today's definition of consumerism, which is often expressed in derogatory terms:

These days, the term "consumerism" is directly related to the environmental damage, which is escalating over the recent years; and the contradictions between the claims made by capitalism and the existence of economic, social, gender, and racial inequalities that are to be found with it.

"Material footprint"

- The total amount of raw materials extracted to meet final consumption demands.
- A key indication of the pressures placed on the environment to support economic growth and satisfy people's material needs.

"Global material footprint"

- Rose from 43 billion metric tonnes in 1990 → 73.2 billion metric tonnes in 2010 → 85.9 billion in 2017.
- A 100% increment since 1990 (the material footprint per capita increased at an alarming rate)
- In 1990, about 8 metric tonnes of natural resources were used to satisfy an individual's needs.
- In 2017, rose to 12 metric tonnes (increase of 50%)

"E-waste"

- Electronic products and discarded devices which help us improve living standards.
- However, the demand is outpacing our capacity to recycle/dispose safely.
- These products that have power/battery supply are likely to join the growing mountain of e-waste after use.
- From 2010 - 2019, e-waste grew by 38%, but less than 20% is recycled.
- By 2030, the global total estimated amount of new e-waste in 20 years is double this amount.
- Without a reliable waste management system
 - Toxic substances (mercury, chlorofluorocarbons (CFCs)) are more likely to be released into the environment.
 - Mercury
 - Mainly found in computer monitors, fluorescent light bulbs.
 - Can be easily emitted into the air and eventually settle into water/land.

- Human exposure to mercury is through ingestion of seafood, which contains methyl mercury aka most toxic and bio-accumulative form.
 - People working in mining, electrical equipment manufacturing, waste management industries, and e-waste dumping sites, have higher risk of exposure to elemental or inorganic mercury through inhalation of the vapor.
- Contribute directly to global warming
 - Temperature exchange equipment found in fridge & aircon can slowly release greenhouse gasses (CFC),
 - Destroy UV-shielding ozone
 - Trap heat in the low atmosphere, causing earth to warm, climate and weather change.

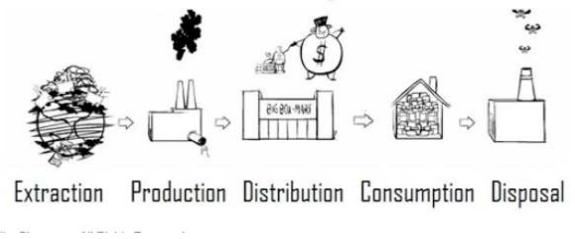
"North VS South"

- Economists and historians argue that there is a marked hemispheric difference between the North and the South.
 - There are underlying patterns of colonial appropriations that continue to define the global economy and extraction of resources.
- **North** (Rich countries) rely on tens of billions of tonnes of raw materials and hundreds of billions of hours of human labor embodied in primary industry bodies and high-tech industrial goods.
 - Overwhelmingly produced in the South over the past few decades.
- **Global South** is a dumping ground for the world's e-waste, either illegally or underground.
 - Lack of facilities for e-waste processing and uniform protocol in handling the waste put workers in extreme danger.

"Consumption as Waste Making"

Consumption and overconsumption drive and reinforces the problems with geographic inequality and environmental pollution.

- Buying too much products → many wastes to throw
 - This repetitive process is called "**Material Economy**".
 - Go through a system from "Extraction → Production → Distribution → Consumption → Disposal".



This system is starting to backfire (not only on human health, natural resources, but economy & economic prospect)

- Such a linear system is starting to cause troubles to the earth's resources, which are finite.
 - Impact the societies, economies, and environment.
- As a consumer,
 - There is invisible tension among people who love shopping and those who want to protect the environment, as well as internal dilemmas as individuals want to help the environment but at the same time want to wear nice clothes etc.

"Five main driving forces that influence consumption"

Economic factors	- Income is the driving force that influences consumption.
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	<ul style="list-style-type: none"> - Consumption capabilities affected by income.
Social factors	<ul style="list-style-type: none"> - Human = social beings. - Living around many people influences our buying behavior. - Humans are influenced by other humans through imitation to be socially accepted. <p>For example,</p> <ul style="list-style-type: none"> - Increase pressure to spend more due to the definition of success. Spend more not only for themselves but also for their families; make their parents proud.
Demographic factors	<ul style="list-style-type: none"> - Larger families spend more than smaller families. - Family composition also affects spending behavior. <p>For example,</p> <ul style="list-style-type: none"> - Diff spending behavior across diff fam units.
Cultural factors	<ul style="list-style-type: none"> - Fundamental values, needs, wants, preferences, perceptions and behaviors, observed and learned by consumers from their family members and other important people around them. <p>For example,</p> <ul style="list-style-type: none"> - We consume more during religious or cultural holidays.
Psychological factors	<ul style="list-style-type: none"> - Consumer's behavior is not easy to measure, but powerful enough to influence a buying decision. - Based on a consumer's attitude towards a product and brand image. - Companies attempted many ways to design their marketing campaigns to influence buying decisions psychologically. <p>For example,</p> <ul style="list-style-type: none"> - Influenced by "sales psychology". - Placement of products in supermarkets, complementary goods placed together, candy near the waiting area, eye level goods, to maximize consumption.

"From Imitation to over-consumption"

- Entering a stage of "faster, newer, cheaper"
- The competition is often based on price, substitution and imitation (consumers can purchase something newer at a cheap price) → lure consumers into buying more. → increase the rate of purchase and discard.
- Imitation intensifies and accelerates the cycle of manufacture, purchase, use and discard, and compounds its environmental or social effects across the global logistic chains, from production site to store.

Sometimes, what is 'newer, sooner and faster' might not be better.

- The manufacturer further reduces the lifespan of what is being produced.
- For example,
 - Electronic goods by leveraging the fact that their warranty expires will not guarantee insurance over phone failure for the consumers.

- **(Positive feedback effect)** Fear of phone failure becomes an incentive for consumers to upgrade to newer goods. Consumers also retain loyalty with the brand by doing so.

Yet, the correlation between consumption and human well-being reduces beyond a certain point. Affluence does not guarantee happiness as after basic needs are satisfied, the effect of additional income on happiness becomes negligible.

Consumption paradox → “ You cannot buy happiness!” Social participation and community relations essential for social and psychological well-being become eroded as society grows more affluent. It does not take more of a simple act of insight to realize that infinite growth of material consumption in a finite world is an impossible action.

One of the most significant global challenges according to the United Nations Environmental Program :-

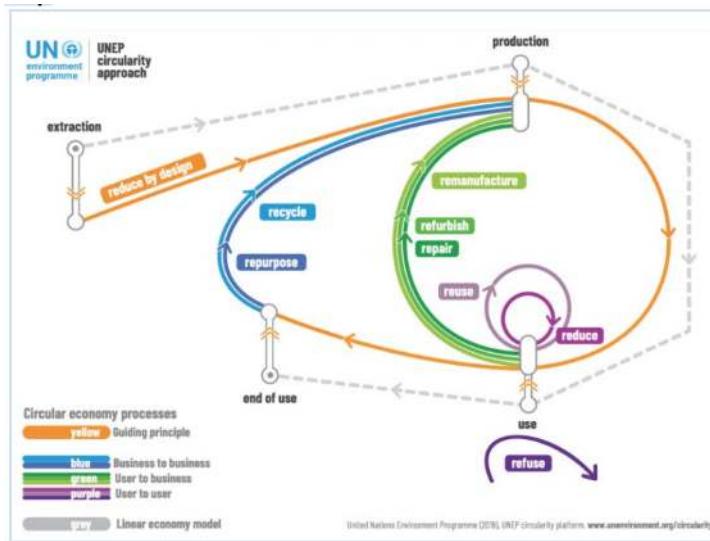
- Refer to Integrating environmental sustainability with economic growth and welfare by decoupling environmental degradation, from economic growth and doing more with less.

Resource decoupling and impact decoupling are needed :-

- To promote sustainable consumption, production patterns and transition towards a greener and more socially inclusive global economy.

UN Sustainability Goal 12: Responsible Consumption & Production :-

- Refer to the use of services and later products which respond to basic needs while minimizing the use of natural resources, toxic materials, the emission of wastes and pollutants over the lifecycle of the service/product so as to not jeopardize the needs of future generations.
- Fully aligned with a **“circular economic approach”** which builds upon value retention loops.
 - Reduce by design leads to design of products and services using fewer materials per unit of production and/or during their use.
 - Reduce by design influences all stages of the life cycle of product or services.
 - Less raw material is extracted → The production has been designed to use less material.
 - Consumption patterns and end of life of such products and services leads to less impact and less waste.



- Other retention processes → refuse, reduce, reuse, repair, refurbish, remanufacture, repurpose and recycle.

3 significant gains to be won from reducing waste of food, energy and water if it can be integrated into the circular economy → maintain in economy for as long as possible.

Approaches :-

1. Reduce food waste by increasing food available without increasing production and use of agricultural land area. This efficiency can improve security and nutrition, and contribute towards environmental sustainability.
2. Reduce energy consumption in homes such as turning off lights, appliances when you do not need them. (Not necessary purchase the energy efficient products)
3. Reduce the release of chemicals and all waste to water sources to minimize adverse impacts on human health and the environment. (might release fiber and micro plastic particles into water)
4. Apply the sustainable economy model in which the products and materials are designed to be reused, remanufactured, recycled, or recovered.

In 2019, Singapore mapped out a “**Zero Waste Master Plan**” to build a sustainable, resource efficient and climate resilient nation.

For Example,

- NEA introduced mandatory packaging reporting in 2020 for producers of packaged products and supermarkets. This aims to manage packaging waste by 2025.
- Packaging-free grocery stores have reduced the cost of their products by an estimated 10%. This reduction in costs allows consumers to save both money and the environment.
- Finding recycling convenient and developing a habit of recycling is important. We can go beyond and extend out from households to build a growing recycling industry in tandem. This efforts will help to close the loop on waste streams as we adopt circular economy approach

“NTU's waste management efforts”

- NTU's 15-year sustainability plan not only to half campus carbon emission, but also to half waste and net energy and water use by March 2026 compared to baseline level in 2011.
- In 2019, NTU and NEA jointly developed a waste-to-energy research facility built to turn domestic waste from NTU's campus to electricity and other useful resources.
- Plastic bags have not been given out for free on NTU from October 2018 → save nearly million plastic bags a year.

SDG12 → ensure sustainable consumption and production practices entail the respective biophysical boundaries of the planet and reduce current global consumption rate to fit biophysical capacity to produce ecosystem services and benefits.

Possible benefits of sustainable consumption and production

Environmental benefits	<ul style="list-style-type: none"> ● Reduce air, water and land pollution ● Better and safer management of hazardous materials ● Reduce use of natural resources
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	<ul style="list-style-type: none"> ● Optimal use of water and energy
Social benefits	<ul style="list-style-type: none"> ● Improve awareness about environmental issues ● Enhance social welfare and well-being ● Eliminate waste-making and social competition consumerism
Economic benefits	<ul style="list-style-type: none"> ● Reduce or eliminate risk by replacing hazardous or toxic substances with environmentally friendly products ● Reduce the cost of waste management by avoiding waste, reusing and recycling waste ● Reduce the unit cost of energy, water and raw materials through better process efficiency

Week 9: Sustainable Cities

UN SDG 11 Sustainable Cities and Communities

Over 50% of the world's population live in cities.

- Lifestyles of urban citizens drive many unsustainable practices – cultural or economic
- Many cities are vulnerable to environmental changes – extreme weather, warming, lack of fresh water
- Sustainable agenda for the future is formed in cities

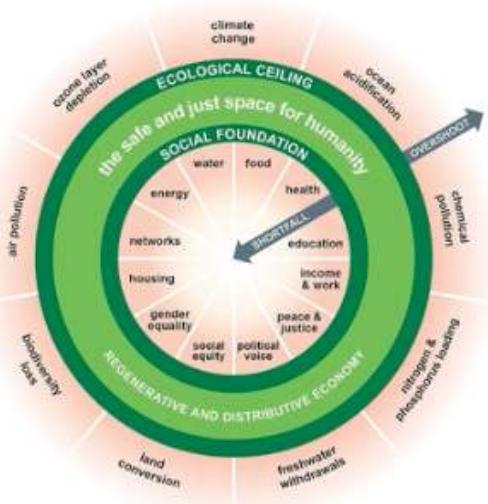
The Urban World

- Population growing very fast
 - 2018: 55% in cities, and more than 1 in 5 people live in cities with at least 500,000 inhabitants
 - 2050: 68% (projected, 7 in 10 people), and 1 in 3 people will live in cities with at least 500,000 inhabitants
 - **Megacities** – cities with a population of over 10 million – will be growing (increase from 33 to 43 by 2030). Megacities are concentrated in Asia and Africa
 - US and Europe cities are shrinking
 - Japan population is declining
- Urban land use globally projected to increase 1.2 million km² by 2030
 - Cities occupy 1% of land globally → environmental impact is very disproportionate
- Lifestyle of urban populations
 - Urban populations tend to have higher living standards → lead to change in lifestyle and more consumption (access to such services is highly unequal, i.e. for informal dwellers who live in areas with low access to these services. 1 in 3 people)
 - Higher electricity access
 - Access to improved sanitation and drinking water
 - Access to clean fuels for cooking and heating
 - Urban population correlates to higher economic growth and production (looking at GDP per capita)

Doughnut Economics: developed to move beyond GDP matrix

- A compass for human prosperity in the 21st century

- 2 concentric rings
 - Social foundation (mapped to SDGs): to ensure that no one is left falling short on life's essentials
 - Want to meet for every person on the planet/cities
 - Ecological ceiling: ensure that humanity does not collectively overshoot planetary boundaries
 - overexploiting natural resources
 - The Earth can only do so much to provide for populations



How do cities impact our environment?

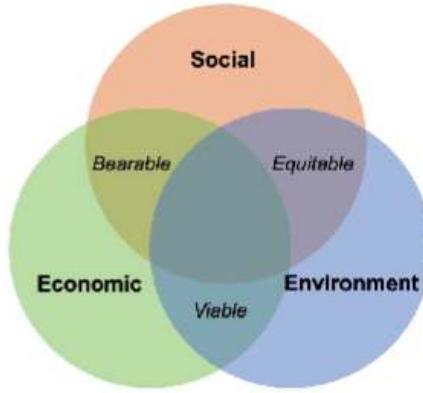
- Direct impacts:
 - Urban development comes at the expense of clearing natural plantations and land
 - In Singapore, Orchard Road had a lot of plantations
 - Pollution impacts: Consumption
 - Unmanaged waste (littering) pollutes land, rivers, oceans
 - generating waste water in highly concentrated ways
 - air pollution from cars and productions happening in cities
 - Humans depend on the healthy ecosystem to sustain life (eg: obtaining food and natural resources)
 - Known as ecosystem services
 - carbon sequestration by forests that mitigates climate change
 - pollination by insects to ensure the longevity of plants → which is used to grow food
- Indirect Impacts: Contributing to climate change
 - High energy consumption in cities (up to 80% as urban lifestyle is energy intensive)
 - A lot of carbon emissions → 70% of global emissions. If reduce impacts on cities, can reduce impacts worldwide
 - Contributed by individual lifestyle and behavior in cities

How do cities depend on our environment?

- Cities contribute to climate change and are vulnerable to climate hazards
 - Cities vulnerable to climate change and natural hazards because of the high population density and amount of man-made infrastructure
- Urban Heat Island (urban areas are warmer than surrounding rural areas)
 - Due to how well surfaces of each environment absorb and retain heat
 - Urban environment with less trees and more infrastructure are more likely to have a higher temperature
 - Public health implications during heatwaves, everyday lives and economy
 - SG → with every degree of difference, increase in energy consumption due to air-conditioning. So reduced urban heat island effect, reduce energy consumption
- Urban flooding
 - Flooding experienced due to lack of drainage → lots of built-up areas prevent rainwater from infiltrating the ground and being stored
 - Increase in rainfall intensity (due to climate change) increases flooding
 - Investments in drainage systems is expensive
 - Implement careful urban planning to reduce the need to invest in expensive drainage systems in the first place
 - SG → PUB expects more flooding overwhelming SG drainage systems, and invested in flood response vehicles that can operate in water up to 17 cm, forecasting and monitoring technology

Sustainable cities

- a city that **manages all resources** it is dependent on in ways that guarantee **the well-being of current and future generations**, ensuring **distributional equity**



- Many organization have interpreted this challenge in practice (frameworks)
 - Collecting information worldwide, like WWF, and then give short case studies on how certain themes are tackled
 - Work as guidelines for urban practitioners around the world to find their own solutions
 - International Standard Organisation
 - Developed a standard for consulting companies to use as a general guide for sustainable development of communities based on: attractiveness, environment, resilience, resource use, social cohesion and well-being
 - Singapore Green Plan 2030, Singapore SUstainability Blueprint
 - Specific indicators about green and blue spaces to address environmental, social (keep population healthy) and economic (reduce heat, reduce energy used to cool environment) dimensions
 - Building dimensions for energy efficiency
- UN SDG 11 deeper dive
 - Provides directions and indicators
 - Target 6: reduce the adverse per capita impact of cities in air quality and municipal and other waste management
 - Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
 - Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
 - Target 7: provide universal access to safe, inclusive and accessible, free and public spaces (for women, children, older persons and persons with disabilities)
 - Target 11a: support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning
 - Allows for decision makers to make sound decisions regarding sustainability issues
 - Urban planning
 - Singapore: Building and Construction Authority has the Green Mark Certification
 - Urban Redevelopment Authority (URA) can decide on how to build more sustainably
 - Blue and Green infrastructure in cities

- An area or system made of naturally occurring or engineered ecosystems that manages to provide benefits for people and the environment
 - Reducing the urban island effect and reduce urban flooding

There is Not One Recipe for Sustainable Cities...

- **Cities are complex systems:**

- Multiple actors, structures, processes, functions, ...



- ... but some common opportunities

- Cities can help change individuals' behaviour.
 - E.g., improving public transport so that people use their cars less
- Cities are innovation and creativity hubs.
 - Social or technological progress
 - Concentration of financial resources
- Cities can benefit from scaling effect.
 - Economies of scale (lower per capita resource use, e.g., efficient use of infrastructure)