

# UNIT 3

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# The concepts of environment, natural and anthropogenic biomes, land cover change, ecosystem structure and dynamics, biodiversity loss, climate change and sustainability

## DEFINITION: ENVIRONMENT

The term 'environment', means the living and non living elements of the Earth's surface and atmosphere. It includes human changes to the Earth's surface. For example croplands, planted forests, building and roads.

## DEFINITION: ECOSYSTEMS

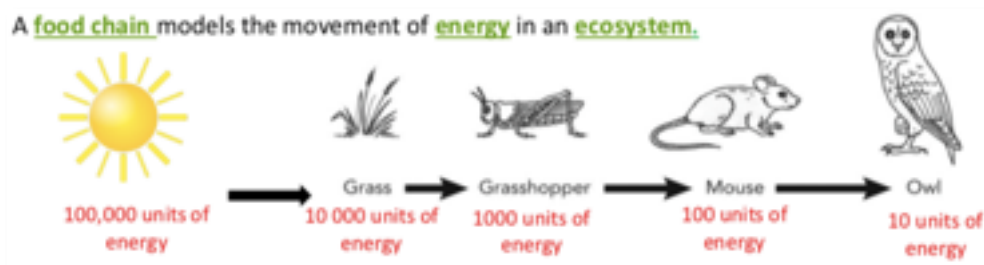
A biological community of interacting organisms (biotic) and their physical non-living environment (abiotic). Can range in size (spatial structure) and complexity from the very small to large bioregions and exist from short to long periods of time (temporal structure)

## ECOSYSTEMS

- No organism exists in isolation. Individual organisms live together in an ecosystem and depend on one another. In fact, they have many different types of interactions with each other, and many of these interactions are critical for their survival.
- All living and non living elements within an ecosystem interact and play a part in maintaining ecosystem balance
- These interactions can be localised, such as the interrelationships between the plants, animals, soils, topography and climate within the area

**EXAMPLE:** *Energy flow as a food chain*

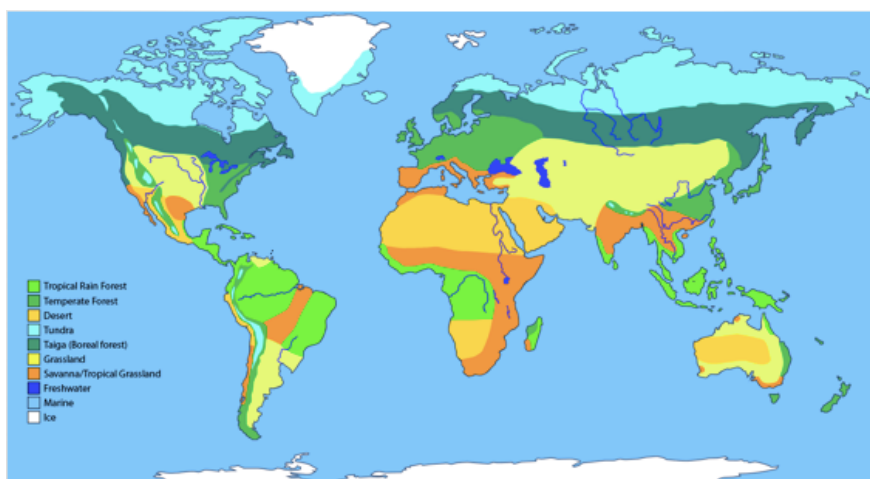
1. the sun is the principle source of energy for biological systems. Plants requiring the energy from the sun for photosynthesis to convert solar energy into chemical energy. Energy flows through ecosystems by means of food chains and food webs.



## NATURAL LARGE SCALE ENVIRONMENTS AND ECOSYSTEMS ARE KNOWN AS NATURAL BIOMES

### DEFINITION: NATURAL BIOME

A biome is a community of life forms adapted to a large natural area. May cover a region made up of a number of ecosystems and refer to the biotic components of that region. For example forest environments are a natural biome which cover apron one third of the world



## GENERAL SPATIAL DISTRIBUTION OF BIOMES

### SPATIAL DISTRIBUTION

- Biomes occur as broad belts across the continents, their boundaries correspond to lines of **latitude**
- Tropical rainforests are found near the equator (10 N/S)
- Grasslands between tropics and desert (15-20 N/S)
- Desert biomes tend to be located in the interior and along the western margins of continents. Generally they follow the two tropics. (25 N/S)
- Temperate Forests lie below coniferous forests. (around 40 N/S)
- Taiga/Coniferous lie below Tundra regions. (around 50 N/S)
- The Tundra is located in latitudes north of 60 N.

### OVER TIME ENVIRONMENTS CHANGE, THIS IS SIMPLY KNOWN AS LAND COVER CHANGE

#### KEY DEFINITION – LAND COVER CHANGE

Transformations to the land resulting from natural or anthropogenic forces and processes (LCC). Eg bushfires, floods etc. Anthropogenic- mining, agriculture.

#### LCC CAUSES NATURAL BIOMES TO BECOME ANTHROPOGENIC BIOMES

#### KEY DEFINITION - ANTHROPOGENIC BIOME

The changes resulting from direct impacts of human activity on natural biomes or environments (referred to as an anthrome)

- Human activities have drastically altered biomes and in reality there is no such thing as a 'natural biome' as there are only a few places untouched by modern human activity and most are on a small scale. However it can be argued that due to global warming, there is not places that is untouched by human activity.
- **EXAMPLES**
- Papua New Guinea: Tribes are living in this place, and this is a place where you can see a wide area of beautiful flora and fauna. Biodiversity is abundant, with scientists believe that there are still unidentified animals in its abundant jungle.
- Socotra, Yemen : This is very isolated in the civilisation, which is why it remains untouched by any development. One great evidence of its isolation is the fact that most of its animals and plants cannot be found in any other parts of the world.

#### ANOTHER CAUSE OF LCC IS CLIMATE CHANGE

#### DEFINITION: CLIMATE CHANGE

Is a change in the *statical distribution of weather patterns* when that change lasts for an extended *period of time*. Climate change is caused by *natural* factors such as biotic processes, variations in solar radiation received by Earth, volcanic eruption etc. Certain *human activities* have been identified as primary causes of ongoing climate change such as the burning of fossil fuels.

#### CLIMATE CHANGE

- Climate may move from wetter to drier conditions or from warmer to colder conditions. For example:
- There has also been a strong rise in average temperature across Western Australia by about 0.9 degrees over the past century
- Declines in rainfall over south-west Australia over the last 40 years

- A changing global climate threatens species and ecosystems. The distribution of species is largely determined by climate, as is the distribution of ecosystems and plant vegetation zones (biomes).

## **THEREFORE LCC AND CC CAN LEAD TO BIODIVERSITY LOSS**

### **DEFINITION – BIODIVERSITY LOSS**

Biodiversity refers to the *number, type* and *variety* of *biotic (living)* organism found within an environment or ecosystem. Biodiversity loss is when there is a decrease (loss) in the number, type or variety of living organism within an environment or ecosystem.

- **Habitat fragmentation** is the process by which habitat loss results in the division of large, continuous habitats into smaller, more isolated remnants.
- **Destruction of habitats** and **fragmentation** has occurred through human settlement including the construction of harbours, dams, reservoirs, roads, railways etc.

## **A SOLUTION TO THIS PROBLEM IS SUSTAINABILITY**

### **DEFINITION - SUSTAINABILITY**

Sustainability refers to the ability to meet the needs of current and future generations through simultaneous environmental, social and economic adaptation and improvement.’

### **SUSTAINABILITY**

- Sustainability recognises the need to conserve and improve the Earth’s resources so that the natural processes on which life depends are maintained for present and future generations. Human development and activities can be guided by the goals of sustainability so that they:
  - Have less impact on the Earth’s ecological systems
  - Use resources more efficiently
  - Promote the development of more equitable societies.
- Sustainability involved the triple bottom line consisting of the protection of the environment, while minting the economic development necessary to satisfy the needs of the people, and ensuring that the social development of people is not impaired so that they can continue to lead healthy and productive lives

## **The identification and classification of land cover changes with reference to global forests, agriculture and urban land cover**

### **ANTHROPOGENIC BIOMES IDENTIFICATION AND CLASSIFICATION OF LAND COVER CHANGES**

#### **WORLD LAND COVER CHANGE**

- On a global scale what are the major change in lang cover change?
- **Land use** and **Cover change** (LUC) can be considered with reference to
  1. Global forests
  2. Agriculture
  3. Urban land cover

The terms land use and land cover may seem to be interchangeable, but they are not equivalent

## LAND COVER

Refers to the physical characteristics of Earth's surface, captured in the distribution of vegetation, water, soil and other physical features of the land, including those created solely by human activities e.g. settlements.

## LAND USE

Refers to the way in which land has been used by humans and their habitat, usually with accent on the functional role of land for economic activities for example agriculture, urban areas and forestry.

## CHANGE

The concept of change involves both time and space. Geographical phenomena are constantly changing, and can often be best understood by investigating how they have developed over time periods ranging from a few years to thousands. The concept of change is important to help understand what is happening in the world and seeing that this world is dynamic.

## LAND COVER CHANGE

Changes that have taken place in the land cover of natural environments due to a variety of natural and /or human induced changes.

## LAND USE CHANGE

Involve either a shift to a different use or an intensification of the existing one.

### 1. GLOBAL FORESTS

- Between 1990 and 2015, global forest area declined by 3%, but the rate of loss has halved between the 1990s and the past five years.
- They also provide valuable habitat for animal and plants species. For example, tropical forests, while covering only 15% of the global land area, contain over 50% of land animals and plants.
- 17% of the Amazon rainforest has been deforested in the last 50 years.

### 2.AGRICULTURE

- We use roughly half of global habitable land for agriculture.
- With a growing population land used for agriculture is constantly changing and becoming more intense.
- It is estimated that agricultural land will grow by a further 15% by 2030

### 3.URBAN AREAS

- Roughly only 3% globally is taken up by urban areas
- This figure changes, but usually lower depending on definitions of Urban
- Rapid population growth means that urban areas are expected to triple by 2030
- Although small in size the effect of these urban areas on our planet is significant

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## **The use of remote sensing images, other spatial technologies, and fieldwork to identify and measure the location, nature, rate, extent and consequences of land cover change**

### REMOTE SENSING

- Remote sensing (RS) is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites.
- Remote sensing by satellite refers to the viewing of the earth's surface using sensing devices fixed onto satellites in orbit.
- Aerial photography is one of the most common and economical forms. It came into widespread use in the late 1930s

## TYPES OF REMOTE SENSING

1. Satellites orbit the Earth, collecting geospatial data that can be interpreted to create images of different areas on our planet.



2. A photograph of the earth's surface taken from a platform flying above the surface but not in orbit, usually an aircraft.



3. Radar imagery are images produced by recording radar waves reflected from a given target surface.



4. Ground level/horizontal photograph, are, as the name suggests, taken from the ground level perspective.



## **KEY WORDS USED TO DESCRIBE LAND COVER CHANGE**

- 1. Location**
- 2. Nature**
- 3. Rate**
- 4. Extent**

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### **The implications of anthropogenic biomes to the functioning of the world's ecosystems**

#### **ECOSYSTEM SERVICES**

1. Support Services – Create and replenish
2. Provisioning Services – Raw materials needed to live
3. Regulating Services – Controlling systems to provide life
4. Regulating biodiversity – Creating spaces of well-being

#### **EXPLAIN ONE IMPLICATION OF ANTHROPOGENIC BIOMES TO THE FUNCTIONING OF THE WORLDS ECOSYSTEMS**

Students may begin by defining the term ‘anthropogenic biomes’, which may, in itself, identify the general implication of these biomes to the world’s ecosystems. Otherwise, one implication of anthropogenic biomes to the functioning of the world’s ecosystems should clearly be identified and then explained accurately and in full sentences, using appropriate geographical language. Students should relate the cause and effect, making the relationship between anthropogenic biomes and the functioning of the world’s natural ecosystems clear. Students should also provide some specific supporting evidence (specific locations, examples of impact, statistical data, etc.).

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### **World population growth, growing affluence, advances in technology and their impact on the nature, rate and extent of land cover change and biodiversity loss**

#### **WORLD POPULATION GROWTH, GROWING AFFLUENCE AND URBAN EXPANSION**

- The human demand for biologically productive land will increase with the growth in population.
- More affluent diets tend to have higher rates of dairy and meat consumption and hence there is a demand for the expansion of intensification of agriculture and forestry.
- The demand for fossil energy, nitrogen and phosphorous as well as fresh water will impact on the use of land.
- Finally, arable land is lost through desertification and/or the encroachment of human settlement due to poor land management and climate change.

#### **KEY FACTS –POPULATION GROWTH**

- The world’s population grew faster during the 20<sup>th</sup> Century than at any other time in human history. As a result, the rate of land cover change has been rapid, with 6 million hectares of primary forest land cover lost each year.
- China, India, Indonesia and Brazil now have a combined population in excess of 3 billion people and rapid urbanisation, particularly in megacities, has been a major driver of land cover change in these locations and other parts of the developing world.

- Every day approximately 2500 people are born. To feed them we expand our agricultural production size by 35 hectares

World Population Growth	Growing Affluence	Advances In Technology
Between 1900 and 2000 the World Population multiplied 3x faster than in all of previous human history.	Affluences is having a great deal of money and wealth	The Industrial Revolution in the 18th Century saw the introduction of technology and machine development which allowed for large scale production.
As population grows there is an increase demand for resources.	The higher the level of wealth in the country the higher the demand for resources and technologies.	As technology has advanced so has a capability to clear land.
Longer life expectancy also increases the demand.	Currently 20% of the worlds population consumes 80% of the worlds resources.	The bulldozer can clear large areas of <u>forest</u> land in under a day.
Increase in deforestation for wood as a resource and land for agriculture	More affluent societies have a higher demand for meat and dairy	Increases deforestation rates for agriculture
	Increase in deforestation for agriculture	

### KEY FACTS – BIODIVERSITY LOSS

- The large scale clearance of natural habitats and the exploitation of resources to support population growth have increased the rate of biodiversity loss, with the rate of extinction as much as 1000 times the natural average. As the rate and extent of land cover change has increased, so has the extent of biodiversity loss. Globally, an estimated 18,000 species are threatened with extinction.

### Predicating Changes in Global Land Cover

	Sea level rise	The Cryosphere	World forests	Agricultural land	Urban areas
<b>Nature</b>	Thermal expansion - as water heats up it expands combined with cryosphere melting	Increased global temperatures	Decrease due to logging, room for homes, increase due to replantation		Increasing population and movement of people from country to city
<b>Rate</b>	By 2090, sea levels ... higher than 2005	Per decade	0.06% decrease per year by 2030	by 2030	by 2030
<b>Location</b>	Australia	Global glacier volume	Global forest land cover	globally	india and china



	Sea level rise	The Cryosphere	World forests	Agricultural land	Urban areas
<b>Extent</b>	45 - 82cm higher. 470-760 million coastal residents inundated globally	15% decrease	13 million ha lost annually	extra 4.9 million ha will be needed to feed worlds increasing population	Triple (3x)

The differences in the process of land cover change between countries due to factors such as government policy, institutional arrangements, land ownership, type of economy, ideology and culture

AUSTRALIA	CHINA
<p><b>POPULATION SIZE AND DENSITY</b> 24 million 88.9% of Australia's population is urbanised</p>	<p><b>POPULATION SIZE AND DENSITY</b> 1.4 billion In china, in 1985, there were 324 cities and by 1996 there were 666 cities. Approx 57% of Chinas population lives in urban areas</p>
<p><b>SOCIO- ECONOMIC LEVELS - LIVING STANDARDS</b> Australia has the 12th largest economy (based on GDP) in the world. It heavily relies on agricultural and mining exports for income</p>	<p><b>SOCIO- ECONOMIC LEVELS - LIVING STANDARDS</b> After USA, china is the second wealthiest country in the world. Housing and manufacturing created land use change by the clearing of land for development 3 Gorge Dam Project</p>
<p><b>PROTECTION POLICIES</b> Individual legal ownership The environment Protection and Biodiversity Conservation Act 1999 protects native areas. The aboriginal and Torres Strait Islander Heritage Protection Act. However, Australia's forested area has diminished at a rate of 0.1% per year</p>	<p><b>PROTECTION POLICIES</b> With China's rapid development there have been many ecological problems as it has largely gone unchecked by the Ministry of Environmental Protection. However between 1990-2015 china also replanted forest rapidly, increasing its area by 1.1% a year</p>
<p><b>TYPE OF ECONOMY</b> Australias economy is described as a mixed market economy which means it has a mixture of capitalism and socialism. It therefore allows for personalised economic freedom, however the government can interfere in economic activities.</p>	<p><b>TYPE OF ECONOMY</b> China is a socialist market economy which means it's largely a state owned economy because of its communist ideology. China's economy is largely a manufacturing economy. It is the largest exporter of goods in the world and the second largest importer.</p>

**Processes of land cover change (deforestation, the expansion and intensification of agriculture, rangeland modification, land and soil degradation, irrigation, land drainage and reclamation, and the growth of urban settlement, industry and mining)**

- In reality there is no such thing as a 'natural biome', because people have changed all areas of the earth's surface. Land cover change occurs as a result of population growth and the consequent increase in the need for food and shelter.

- Land cover can be defined as physical and biological cover such as water, vegetation, soil and artificial structures.
- Land use can be defined as agriculture, forestry and building construction that may change the biogeochemistry, hydrology and/or biodiversity of an area.

### **1. Deforestation**

- Deforestation is the action of clearing a wide area of trees to use the land for other purposes
- This is happening because deforestation occurs for many reasons, the main ones being trees used for fuel to make land available for housing / urbanisation to harvest timber for commercial items such as paper, and furniture and to create room for cattle ranching
- For example this is occurring in Australia, 45% of open forest has been cleared in the last 200 years

### **2. The Expansion and Intensification of Agriculture**

- Expansion and intensification of agriculture is the occupation concerned with cultivating land, raising crops, feeding, breeding and raising livestock, farming
- This is happening because of the growth in the world's population. Agriculture is what produces more food for our growing population. As developing countries get wealthier their demand for better quality meat also grows
- For example India's growth in agrifood imports toward 2050 are projected to reach US \$47 billion

### **3. Irrigation**

- Is to water crops by bringing in water from pipes, canals, sprinklers, or other man-made means, rather than relying on rainfall alone
- This is happening because it allows farmers to grow more product and to grow better quality produce
- For example this is occurring in New Zealand irrigated farmland generates at least three times as much production as an equivalent area farmed under dry land system.

### **4. Land Drainage and Reclamation**

- The gain of land from the sea or wetlands or other water bodies and the restoration of productivity or use to lands that have been degraded by human activities or impaired by natural phenomena
- This is happening because more land is needed. As population increases there is a higher need for land for agricultural and urban uses
- By the late 1950's 11 million hectares of land had been reclaimed in the Soviet Union.

### **5. Rangeland modification**

### **6. Land and Soil Degradation**

### **7. The Growth of Urban Settlement**

### **8. Industry and Mining**

## **Describe land cover changes that has occurred with reference to two (2) of the following**

- Global forests
- Agriculture
- Urban land cover.

'Deforestation is a process of land cover change that involves the permanent removal of trees (usually in a forest) and often their associated vegetation. Rates of deforestation are high in parts of the developing world such as Brazil and Indonesia, where drivers of land cover change include logging for timber, the clearing of land for broad-scale agriculture or urban development. These are caused by an increase need for wood and food as a resource from increased population growth and the need for land to produce meat to feed the population increase. Forests cover approximately 30% of the Earth's surface but deforestation is reducing their area at the rate of 13 million hectares per year. This will only continue in the future as deforestation continues at a global rate of 1 hectare every second. The effects of deforestation can include an increase in the rate of biodiversity loss and reduces the greenhouse gas absorbing capacity of the Earth's forests.'

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# **Indigenous peoples' land management practices and their impact on land cover over time, including those of Aboriginal and Torres Strait Islander Peoples**

## **HOW INDIGENOUS PEOPLE MANAGED THE LAND**

- Aboriginal people traditionally created a sophisticated system of patchwork burnt and re-growth areas.
- People practiced 'firestick farming' which involved the cool, mosaic burning of land cover in order to regenerate areas of bush, promote opportunities for hunting or to help manage the risk of wildfire.
- Over time, the impact of this practice on land cover meant that native plant species developed adaptations to help survive low intensity fires.
- Examples of these adaptations include the lignotubers and epicormic buds found within species of eucalypt.

### **EPICORMIC BUDS**

- Epicormic buds on the tree's branches and trunk which sprout when triggered by stress, such as wildfire, which can severely damage the crown. These buds, in the outer sapwood, are protected from fire damage by the tree's bark. They quickly sprout if a eucalypt loses its crown.

### **LIGNOTUBERS**

-Many eucalypt have woody swellings called lignotubers at the base of their stems. They can reshoot at ground level after a fire.

## **Describe one impact of indigenous peoples' land management practices on land cover over time.**

Some of Australia's aboriginal people practiced 'fire-stick farming' which involved the cool, mosaic burning of land cover in order to regenerate areas of bush, promote opportunities for hunting or to help manage the risk of wildfire. Over time, the impact of this practice on land cover meant that native plant species developed adaptations to help survive low intensity fires. Examples of these adaptations include the lignotubers and epicormic buds found within species of eucalypt.

## **ASSIGNMENT**

*The key elements of the following natural systems - heat budget (including greenhouse effect), hydrological cycle, carbon cycle and atmospheric circulation and the ways in which they interact to influence Earth's climate. **Choose one of the natural systems from the syllabus dot point above. Draw a diagram (illustrate) and describe the key elements of this system (8 marks)***

### **The Hydrological Cycle**

Natural systems are a combination of processes that occur without human intervention. The hydrological cycle is an example of a natural system. It is the continuous movement of water as a liquid, gas and solid throughout the land, oceans and atmosphere.

The water cycle has been occurring for billions of years and is essential for life on Earth. The driving force behind the water cycle is solar energy, which powers evaporation. The hydrological cycle consists of three main processes; evaporation, condensation and precipitation.

**Evaporation** is the process of water changing its physical state from liquid to gas and requires an input of energy to occur, usually solar energy. When the sun heats water in rivers, oceans or lakes, the rate of

evaporation increases. The majority of evaporation is from the oceans as they cover 70% of the earth's surface, with smaller amounts coming from other water bodies such as rivers and lakes. When ocean water evaporates it leaves behind salt, minerals and metals so only fresh water makes its way into the atmosphere. Once it has been evaporated, water molecules tend to spend around 10 days in the air (on average). Approximately 80% of all evaporation is from the oceans with the remaining 20% occurring from inland water sources. Winds transport the evaporated water molecules around the globe. Most evaporated water exist as a gas outside of clouds and evaporation is more intense in warmer climates, e.g the strongest evaporation is occurring over the oceans near the equator.

**Condensation** is the process of water changing its physical state from gas to liquid. As water vapour rises, it becomes cooler and its physical state changes back into tiny liquid water droplets. In this process, the suppressed heat of evaporation is released back into the atmosphere. Even when there are no visible clouds in the sky, water is still present in the form of water vapour and droplets that are too small to be seen. Depending on weather conditions, water molecules will combine with tiny particles of dust, salt, and smoke in the air to form water droplets, which consolidate, grow and develop into clouds. Water droplets vary greatly in size, from 10 microns to one millimetre and to in some cases five millimetres. As clouds develop precipitation may also occur. A common example of condensation is dew forming on grass in the early morning.

**Precipitation** occurs when rain, snow, sleet or hail falls from the sky. Once a sufficient amount of liquid water has condensed and the atmosphere cannot support its weight, gravity ensures that the water falls from the clouds back to the Earth's surface. This water can take a liquid form (rain) or a solid form (snow, sleet or hail) depending on the air temperature. Virga is when precipitation evaporates before it reaches the earth's surface. The Himalayas get rain from the monsoon winds blowing in from the south. These winds are full of moisture picked up from the Indian ocean. As the winds are obstructed by the Himalayas, they condense and give heavy rainfall to the southern slopes of the mountains. As most of the moisture in these winds get exhausted before they cross over the top of the Himalayas, the Trans Himalayan regions receive very little rainfall. This is known as the rain shadow effect.

Some of the water that falls on the land soaks or infiltrates into the ground. It can then be collected by underground aquifers, this is known as groundwater. This water eventually seeps into rivers, creeks, lakes and other water bodies. Surface water is when the water runs off the ground and flows into creeks, streams, rivers and lakes that eventually flow into seas and oceans which allows the cycle to continue.

*The causes (natural and anthropogenic) and rate of global climate change.* **For both the natural and anthropogenic you are required to explain in detail how climate change has changed over time through three processes. In total you will have six processes that cause climate change - three natural and three anthropogenic** (12 marks)

Climate change is a change in the statical distribution of weather patterns when that change lasts for an extended period of time. Climate change is caused by natural factors such as biotic processes, variations in solar radiation received by Earth, volcanic eruption etc. Certain human activities have been identified as primary causes of ongoing climate change such as the burning of fossil fuels. Natural causes are processes that change an element of the Earth without human intervention whilst anthropogenic causes are when human's activities and actions cause a change to an element of the Earth.

The Earth in the past has been both cooler and warmer than it is today. For example the Cretaceous period (120-65 million years ago) was 5°C to 7°C warmer and CO<sub>2</sub> concentrations were much higher. Whilst there are many examples that support Climate Change occurring naturally, there is sufficient evidence to suggest that human activity is increasing the rate of which Climate Change is occurring, greater than 95% probability according to NASA.

Solar Variations is an example of a natural cause of climate change. The Sun is the driving force for life on Earth. It is responsible for providing the Earth with light, heat and energy that allows plants to grow in order to provide food and oxygen to Earth. As the sun ages (it is approximately 4.6 billion years old) its solar output

increases. Every one billion years the Sun's brightness increases by 10%. Sunspots are huge magnetic storms that occur on the Sun's surface that cause its magnetic field to break, which allows extra radiation to leave the surface of the Sun through solar storms. Sunspot activity occurs in an 11 year cycle with the sunspot numbers peaking at approximately 5 and a half years before declining again. During a solar storm, extra radiant energy is released as coronal mass ejections and solar flares. The extra radiation is sent out into the Universe, and if directed towards the Earth can affect the amount of insolation reaching Earth. The Sunspot cycle usually contains a fairly regular number of sunspots in each cycle, however there have been instances in the Earth's history when there has been irregularities. In the late 17<sup>th</sup> century, sunspot activity decreased where almost no sunspots were observed from 1650 to 1715. This period was known as the Maunder Minimum, which created a cooling effect due to the absence of solar activity that contributed to the Little Ice Age in Europe (winters in this period were about 1°C colder than they are today). Since the 1950's, increased warming and heat waves can be partially explained by a greater number of sunspots. The increasing amount of sunspots that occur on the surface of the Sun is creating a greater amount of solar activity and storms which is increasing the Sun's energy output. Therefore when sunspots occur and are directed to Earth, the global temperature will increase.

Changes to the Earth's orbit is another natural cause of climate change. During the year the Sun's apparent position through the year moves in a north - south swing of about 47° of angle, resulting from the Earth's 23.4° axis tilt. There is also an east - west component which is caused by the acceleration of the Earth as it approaches its closest point to the Sun (perihelion) and a reduction in speed as it approaches its furthest point (aphelion). The north south tilt is the main source for the Earth's seasons. The Milankovitch cycle impacts the seasonality and location of solar energy around the Earth, therefore impacting contrasts between the seasons. The shape (eccentricity), axial tilt (obliquity) and wobble (precession) of the Earth's orbit vary in several patterns, resulting in 100,000 year ice age cycles over the last few million years. Every 26,000 years the Earth axis goes through one full cycle of precession as it rotates on its axis. This shifts the dates of perihelion and aphelion forward by a day every 70 years. In approximately 13,000 years the Earth will be at its closest point to the Sun in July instead of January like it is currently. As a result of this, seasonal changes in solar intensity will then be greater in the Northern Hemisphere with warmer summers and colder winters, and in the Southern Hemisphere, milder summers and winters. An effect of this further strong Northern summer will be the magnifying of the Asian and Africa monsoons. The obliquity of the Earth's rotational axis varies by up to 3° on a 41,000 cycle. Currently the tilt is 23.4° and is decreasing. A greater tilt allows for a stronger summer Sun and weaker winter Sun. As the tilt decreases, the progressively cooler summers will not melt the past winters snow - this triggers the start of a glacial period. Increasing obliquity will end the previous glaciation, leading to an interglacial period. The Earth's orbit around the Sun resembles an oval. The eccentricity varies over time resulting in two cycles, a 100,000 year and a 400,000 year cycle. With the current orbital shape, the Earth is 3% closer to the Sun in January (perihelion) than in July (aphelion) resulting in approximately 7% more insolation in January. When eccentricity is at its highest, the insolation reaching the Earth can be more than 20% stronger at perihelion than aphelion. The climate impact of these extreme positions depends on the current wobble and tilt of the Earth's axis. Over the last million years the glacial-interglacial cycles have been in sync with the 100,000 year eccentricity cycle.

When a large volcano erupts or many small volcanos erupt at once, it can cause a change in climate. They can have an affect on the global climate due to the amount of gases (sulphur dioxide and carbon dioxide), dust and ash that are thrown up into the atmosphere. The dust and ash emitted into the upper atmosphere from a volcanic eruption creates a short term cooling effect due to the reflective properties of insolation. When millions of tonnes of sulphur dioxide gas reach the top of the stratosphere, the sulphur dioxide transforms into tiny droplets of sulphuric acid, known as an aerosol. The droplets reflect energy from the sun back into space, preventing some of the sun's rays from heating the Earth. Eruptions that add significant quantities of sulphur dioxide into the stratosphere will lower the global surface temperature. The conversion of sulphur dioxide to sulphuric acid aerosol takes months to occur, so maximum cooling occurs up to a year after the eruption. In some cases it takes several years before the cooling influence disappears, resulting in a volcanic winter. Mount Tambora in Indonesia erupted in 1815 which killed 71,000. This eruption caused a volcanic winter known as the 'Year Without a Summer' in 1816 in America and Europe. In 1816 the average global temperature decreased by 0.4°C - 0.7°C which caused crop failure and livestock deaths. The eruption of super volcano Lake Toba, 75,000 years ago caused eight hundred cubic kilometres of ash and 100 billion metric tons of sulphur dioxide to spill in to the atmosphere, resulting in a several year volcanic winter of

global cooling of 3.0°C - 3.5°C. This cooling nearly caused the extinction of many plant and animal species. During eruptions, carbon dioxide is released into the atmosphere which is not believed to cause long term climate change but can cause a short term warming effect.

There is sufficient evidence to link climate change to agriculture. According to the Intergovernmental Panel on Climate Change (IPCC), agricultural activities (including forestry and other land uses) are estimated to produce around 15% (in Australia) of anthropogenic global greenhouse gas emissions. Through agricultural activities, particularly wet rice cultivation and livestock, high amounts of methane and nitrous oxide are being released into the atmosphere. When growing rice, the fields are flooded which cuts off the oxygen supply to the soil, which results in anaerobic fermentation, which is when organic matter in the soil begins to break down due to the lack of oxygen and is decomposed by Archaea. As Archaea decomposes the matter, methane is produced as a waste by product. Through the roots and stems of the rice plants and directly from the field into the atmosphere when the water evaporates, the methane is released into the atmosphere. Rice production has increased by 41% in the past 40 years which contributes to 10% of the global methane emissions. Therefore, methane emissions from wet rice cultivation effects climate change through increasing the enhanced greenhouse effect.

Climate change is greatly impacted by the activities associated with urban land use, with these activities contributing to an estimated 76% of total anthropogenic greenhouse gas emissions. Power generation and transportation are generally associated with the use of fossil fuels and have the largest impact on Earth's climate. Power generation is the largest contributor of greenhouse gas emissions. 25% of global greenhouse gas emissions is from generating electricity. In order for electricity to be created, fossil fuels are extracted from the ground and burnt in power plants which releases carbon dioxide, sulphur dioxide and nitrous oxide. The natural greenhouse effect is extremely important in making the Earth warm enough to support life. Through increased concentrations of greenhouse gases in the atmosphere due to human activity causes an enhanced greenhouse gas effect. Carbon dioxide contributes to 60% of the enhanced greenhouse gas effect, methane 20% and halocarbons and nitrous oxide at 6%. These produce a radiative forcing. These changes in concentration of greenhouse gases is slowing the passage of radiation from the surface of earth back into space. The lower atmosphere thus absorbs and re-emits more radiation, some is directed downwards, increasing the heating of the surface. Some of the trapped heat accumulates in other elements of the Earth's climate system such as land, ice and oceans. For example the ocean warming dominates the increase in energy stored in the climate system which has 90% of the energy accumulated between 1971 and 2010 with 1% stored in the atmosphere.

Deforestation can cause climate change as forests store large amounts of carbon. Trees and other plants absorb carbon dioxide from the atmosphere as they grow. This is converted into carbon and stored in the plant's branches, leaves, trunks, roots and in the soil. When forests are cleared and burnt, the stored carbon is released into the atmosphere - mainly as carbon dioxide. Deforestation contributes to 18% of all global greenhouse gas emissions and forests cover 31% of our planet. Every year 46-58 thousand square miles of forest are lost to deforestation. When forests are cut down, not only does carbon absorption cease, but the carbon stored in the trees is released into the atmosphere as carbon dioxide if the wood is burned or if it is left to rot after the deforestation process. It is estimated that more than 1.5 billion tons of carbon dioxide is released to the atmosphere due to deforestation, mainly the cutting and burning of forests, every year. When forests are cut down, biodiversity decreases, the National Science Foundation stated that "If any one type is removed from the system, the cycle can break down, and the community becomes dominated by a single species". Forests are nature's atmospheric carbon sink; plants take in atmospheric carbon dioxide and convert the carbon into sugars and plant materials through the process of photosynthesis. The carbon is stored within the trees, vegetation, and soil of the forests. Burning or cutting down trees reverses the effects of carbon sequestration and releases greenhouse gases into the atmosphere. Deforestation also changes the landscape and reflectivity of earth's surface, i.e. decreasing albedo. This results in an increase in the absorption of light energy from the sun in the form of heat resulting in increasing global warming.

Climate change can be seen through both natural and anthropogenic causes such as through Solar Variations, the Earth's orbit, Volcanic eruptions, agriculture, urban land use and deforestation.

*One major type of evidence of climate change through geological time and one major type of evidence for climate change in recent human history.* **Identify and explain two pieces of evidence for climate change. One should explain how climate change can be shown throughout thousands of years of history with the other focusing on how climate change is evident in recent years.**

(8 marks)

Climate change is a change in the statical distribution of weather patterns when that change lasts for an extended period of time. Climate change is caused by natural factors such as biotic processes, variations in solar radiation received by Earth, volcanic eruption etc. Certain human activities have been identified as primary causes of ongoing climate change such as the burning of fossil fuels. One way of showing climate change is through ice cores are long cylinders of glacial ice recovered by drilling through glaciers in Greenland, Antarctica, and high mountains around the world. Scientists retrieve these cores to look for records of climate change over the last 800,000 years.

Ice cores allow scientists to study 800,000 years into past climates and therefore discover the effect of climate change in this period. The worlds oceans are warmer and sea level is higher than they have ever been. Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy between 1971 and 2010 whilst mean sea levels have increased globally in the last 150 years.

Bubbles trapped within the ice capture the gas concentration of the atmosphere from the time it froze, this allows scientists to study 800,000 years of past climates. Ice cores have clear layers caused by the snow falling on the ice sheets, with each layer containing a different texture and different chemistry. During summer when the sun is visible for 24 hours a day, the top layer of the snow changes in texture. When winter arrives and it becomes dark and cold, new snow falls on top of the summer snow, forming distinct layers, which help scientists study the climate of each year. Ice cores are the only environmental data available for scientists to reconstruct the climate from hundreds to thousands of years ago. The most well known ice core is the Vostok ice core, gathered by a joint Russian, U.S and French team working at the Russian Vostok Station in Antarctica in 1987. The European Project for Ice Coring in Antarctica drilled a core 3,190m long, making it the longest ice core on record, where the ice has been found to hold 800,000 years of data and revealed 8 glacial cycles in this time period. Ice cores can tell scientists about the temperature, precipitation and atmospheric composition e.g carbon dioxide levels, volcanic activity and wind patterns. Scientists can study the thickness of the each layer which tells them how much snow fell in that year and therefore whether it was a warm or cold year. Through studying cores taken from nearby locations, scientists determine wind patterns based on where the snow drifted that year. Through testing trapped air bubbles in the layers, the chemical composition of the snow can show the temperatures in that area, as colder temperatures show a higher concentration of heavier oxygen in the snow. Seasonal dust and large volcanic eruptions can spew large quantities of dust into the atmosphere that accumulates in the ice. The dust layers, and the chemical composition of the ice allow scientists to date the age of the ice cores and the climatic conditions of that time.

The ocean is one of many ways that scientists use to study climate change. Since 1990, 3881 Argo floats have been sending information about the temperature, pressure and salinity of the ocean from depths of 2000m below the ocean surface, up to a satellite. This program is run by many countries with Australia managing 346 active Argo floats. Ocean temperature data can also be gathered through satellite remote sensing using NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) satellites which have been producing global sea surface temperature data since 2000. These satellites can sense surface temperatures everywhere unlike buoys which can only sense in the areas that they are placed. Satellites can also measure the height of the sea surface through sending microwaves to the ocean surface. Water expands and contracts as it heats and cools, therefore so does the height of the sea surface, allowing scientists to measure the sea level and ocean temperature. Sound can travel long distances under water, with the speed changing depending on the temperature. Therefore scientists can study how long it takes sound to reach a certain depth underwater and then return to the surface, therefore allowing them to determine the average temperature of the water in that area. Ocean warming is largest near the surface, with the upper 75 meters warming by 0.11°C per decade from 1971 to 2010. More than 60% of the net energy increase in the climate system was stored in the upper ocean (0-700m) during 1971 to 2010. It is likely that regions with high salinity where evaporation is high,

have become more saline e.g North Atlantic. While regions of low salinity such as Southern ocean around Antarctica have become fresher since the 1950's. These regional trends in ocean salinity provide evidence that evaporation and precipitation over oceans have changed. Thermal expansion of the oceans and the melting of glaciers and ice sheets have been responsible for the majority of observed global sea level rise. Rates of sea level rise vary around Australia, with higher sea level rise in the north and rates similar to the global average in the south and east. Global sea levels fell in 2010 - 2011 due to an intense La Niña event. Exceptional high rainfall over land resulted in floods in South East Asia, northern South America and Australia. It took a long time for water from inland Australia to return to the ocean. Since 2011 sea levels have rebounded to the long term trend.

Ice cores are the main way for scientists to study climate change from thousands of years ago whilst studying the ocean and its temperature and surface level can give scientists data about how climate change is occurring now.

*The interrelationships between land cover change and climate, including changes to surface reflectivity (albedo) and the process of natural carbon sequestration. **Identify and explain the interrelationships between land cover change and climate. Illustrate (create a flow chart) for both surface reflectivity and carbon sequestration to show how land cover change and climate change are interlinked. Explain the interrelationships with evidence for both surface reflectivity and carbon sequestration*** (12 marks)

Climate change is a change in the statical distribution of weather patterns when that change lasts for an extended period of time. Climate change is caused by natural factors such as biotic processes, variations in solar radiation received by Earth, volcanic eruption etc. Certain human activities have been identified as primary causes of ongoing climate change such as the burning of fossil fuels. Carbon sequestration is the process in which CO<sub>2</sub> is removed from the atmosphere and stored for long periods of time. Radiative equilibrium assumes that incoming radiative energy from the Sun is equal to the outgoing radiation emitted by the planet. Land cover change is transformations to the land resulting from natural or anthropogenic forces and processes.

When the Sun's rays hit the Earth, a certain percentage of that energy is reflected back into space. The amount of radiation that is reflected by a surface is called albedo, and can range from a value of 0 (no reflection) to 1 (100 percent reflection). Different land features have different albedos such as forests (0.6 - 0.15) and snow and ice (0.85). Land cover / land use has a major role in climate change at global, regional and local scales.

The Earth reflects nearly a third of insolation back into space. The cryosphere is a very effective mechanism that reflects energy back into space. However since the cryosphere is melting at a faster rate than it is refreezing, more darker surfaces are appearing where the ice once was. This causes the dark surfaces to absorb heat rather and reflect it into space like it once did, therefore increasing the global temperature. Global temperature is relatively stable when the sum of the gains is approximately equal to the sum of the losses. When there is an increase or decrease in the amount of incoming or outgoing energy, the Earth's radiative equilibrium is disturbed and therefore the global temperature rises or falls in response. The cryosphere reflects insolation back into space. Due to the decrease of snow and ice cover, globally there has been a consistent increase in global temperatures over the past century. This results in less energy being reflected and therefore more being absorbed by the ground and water, causing an increased warming and therefore an increase in snow and ice melting which is changing the snow and ice land cover. This is known as the ice-albedo feedback. When snow and ice disappears, less of the sun's rays are reflected back into space, causing the heat to be absorbed into the land and oceans, further warming and therefore increasing the rate of ice and snow reduction.

Urban heat islands are caused by a combination of decreased albedo, reduced atmospheric circulation, and by the waste heat from urban processes. The dark surfaces of urban areas (e.g roads and buildings) absorb



and store significantly more solar radiation than surrounding rural areas which causes suburban areas to be warmer. This causes a change in the energy budget of the urban area, which leads to higher temperatures than surrounding rural areas. The lack of trees in this area decreases the amount of shade and the cooling effect of trees and the removal of carbon dioxide. Buildings have multiple surfaces that reflect and absorb sunlight and also block wind flow which slows cooling and prevents pollution from dissipating. Waste heat from cars, trucks, air conditioning, industry and many other sources also contributes to the increased urban temperature. High levels of pollution in urban areas can also increase the urban heat island effect as many forms of pollution change the radiative properties of the atmosphere. Many cities that exhibit a heat island effect have the largest temperature difference at night. The typical temperature difference is several degrees between the centre of the city and surrounding areas of rural and natural vegetation. Cities with 1 million people or more can be 1.0°C - 3.0°C warmer than surrounding areas.

When vegetation is cleared through deforestation or agricultural reasons, the bare surface reflects more sunlight into space therefore creating a cooling effect. However deforestation and biomass burning release carbon dioxide (CO<sub>2</sub>) into the atmosphere which impacts carbon sequestration and therefore climate. The vegetation that normally would have absorbed the carbon dioxide is gone. The initial cooling caused by the increased albedo of cleared/modified land is followed by a warming trend. Land cover change affects processes that occur within the carbon cycle. To create agricultural land, forests are usually cut down to provide the land for these farms. When trees are cut down and burnt / left to decompose, the carbon that was stored in the tree is released into the atmosphere. Presently, deforestation and the resulting carbon release into the atmosphere is occurring in the tropics, as this area is very fertile and therefore prime area to grow crops such as soy. However, since the mid 1900's, a lot of the less productive agricultural land in the US and Europe have been able to regrow forests. This has resulted in the natural sequestration of carbon from the atmosphere through carbon accumulation into the wood and soil.

At a global scale, land use and land cover change is responsible for releasing greenhouse gases to the atmosphere which drives global warming. Globally, soils contain an approximate 1500 giga-tonnes of organic carbon equivalent to a depth of one metre which is more than the amount found in vegetation and the atmosphere. Through the disturbance of terrestrial soils and vegetation, an increased rate of CO<sub>2</sub> can be released into the atmosphere. The major cause of this increased rate is deforestation especially if the land is then used for agriculture. Brazil is the second largest producer of soybeans which are used to feed livestock. As the demand for meat increase, soybean farmers are deforesting at an increased rate to accommodate for this demand increase. Modification of agricultural practices have become a method of carbon sequestration as the soil can be an effective carbon sink, offsetting 20% of CO<sub>2</sub> annually.

*The effects of climate change on land cover in natural and anthropogenic biomes (vegetation, ice sheets, glaciers, coastal system and coral reefs, agriculture, urban settlement and industry). **Identify and explain how the climate is affecting both natural and anthropogenic biomes. How does an increase in global temperatures affect global ice sheets (natural biomes)? How does an increase in global temperatures affect agricultural patterns (anthropogenic biomes)?***  
(12 marks)

A natural biome is a community of life forms adapted to a large natural area. May cover a region made up of a number of ecosystems and refer to the biotic components of that region. For example forest environments are a natural biome which cover approximately one third of the world. An anthropogenic biome is the changes resulting from direct impacts of human activity on natural biomes or environments. Glaciers are thick masses of ice that can move slowly over land, whilst an ice sheet is a mass of ice that covers an extensive area of land (usually more than 50,000km<sup>2</sup>).

Climate is the main factor that controls the distribution of plant species and vegetation. Rapid climate change is likely to lead to major changes in the distribution of plants and therefore biomes and habitats. Habitat loss is the principle cause of species extinction however climate change is becoming a key threat. Some species of plants and animals are capable of moving to follow the shifts in climate however most are

not and face extinction. Temperature and sea level increases, along with changes to precipitation patterns and the frequency and intensity of extreme weather events, will cause changes to both the built environment and to human activities and its associated land cover.

The land cover of ice sheets, glaciers and sea ice has decreased due to climate change. According to NASA's observations and data, the increasing global temperatures has decreased the ice accumulation and greater ice melts occurring with 50% of glacial ice lost since the start of the 19<sup>th</sup> century. 400 billion tonnes of glacier ice has been lost in the Arctic since 1994, as well as 13.4% decline in sea ice per decade. Mountain glaciers found on the Alaskan Ranges, Rocky Mountains, Andes, Alps, Himalayas and Fox and Frans Josef glaciers in New Zealand are all experiencing large declines in their land cover. The Fox and Frans Josef glacier has retreated 2.5km in the last 100 years. The Quelccaya Ice Cap in the Andes has retreated at a rate of 30m per year, whilst the Arikaree Glacier in the Rocky's has retreated approximately 1m per year. With the projected rate of glacier and ice sheet decline continuing to increase, it is estimated that all sea ice and half of all mountain glacier ice will disappear by 2100.

Marine organisms worldwide are face rising ocean temperature extremes, progressively lower oxygen levels and high rates and magnitudes, of ocean acidification. Coral reefs are highly vulnerable to these changes. Coastal systems and low lying areas are at risk from sea level rise, which will continue even if the global temperature is stabilised. These changed conditions resulting from climate change are decreasing coastal and coral land cover, with a southward and northward shift of coral formations away from the equator in order to locate more optimum ocean conditions. Rising sea levels will bring significant change to Australia's coast. Over the last 100 years, the global average sea level rose by 1.7mm per year, increasing in recent years (1993-2013) to 3.2mm per year. There is a lack of knowledge on how many environments will respond to sea level rise, but the risk of beach loss, salinisation of wetlands and inundation of low lying areas and reef will be high. Terrestrial and aquatic plants and animals that rely on coastal habitat are likely to be affected by sea level rise, increases in sea surface temperature and ocean acidification. Most at risk are estuaries and associated wetlands, coral reefs, tidal flat communities and salt marshes, and beaches where there is a lack of sediment available for replenishment. The Kakadu mangroves in Northern Australia are at high risk as rising sea level will inundate the mangroves. The Great Barrier reef is experiencing bleaching and acidification to an extent that corals are destroyed by storms or not growing quickly enough. It has lost half of its coral land cover in the last 30 years, with 48% of this loss occurring from storm damage.

Most plant species cannot naturally shift their geographical ranges sufficiently fast enough to keep up with the current and high projected rates of climate change in most landscapes. Future vegetation risk is indicated to be high, based on the observation that past natural global climate change, at rates lower than current anthropogenic climate change, caused significant ecosystem shifts and species extinctions during the past millions of years. Increased temperatures have extended the growing season and increased humidity. Both factors have led to some additional plant growth. However, warmer temperatures also stress plants. With a longer, warmer growing season, plants are needing more water to survive. Plants in the Northern Hemisphere are slowing their growth in the summer because of warm temperatures and water shortages. Dry, water-stressed plants are also most susceptible to fire and insects when growing seasons become longer. The warmer temperatures has meant that Pine Beetles are now active between May and October, instead of the usual two weeks, allowing them to inhabit and kill more trees. In Alaska these beetles have damaged more than 2.5 million acres of spruce trees. In the north, where the increase in temperature has the greatest impact, the forests have already started to burn more e.g the 2016 Canadian wildfires, releasing carbon from plants and the soil into the atmosphere. Tropical forests may also be extremely susceptible to drying. With less water, tropical trees slow their growth and take up less carbon, or die and release their stored carbon to the atmosphere. The number of extreme fires release carbon from burnt plants into the atmosphere, these fires also realise carbon that has been stored in the soil. It can take a hundred years or more for any post fire regrowth to balance out the CO<sub>2</sub> that has been released by the bushfire. High intensity fires can also sterilise the soil, making regrowth slow and sometimes impossible.

Agricultural activities depend on the characteristics of the environment to survive. Farming processes such as irrigation, genetically modified organisms and fertilisers are able to an extent, replace what is not found naturally in the area. However these supplements are both financially and environmentally costly and often require the use of greater quantities of fossil fuels. It is predicted that between 2003 and 2080, there will be

an increase in agricultural land cover in the Northern Hemisphere, satellite data shows increased plant growth in the past 30 years in the same area. Northern Russia is expected to have a 150% increase in arable land due to the changing climatic conditions. Northern Russia will also see an increase in frost free days by 20 days per year, which increases the production of wheat, maize, corn and livestock. If all conditions are met (most important are water and nitrogen), additional CO<sub>2</sub> can stimulate plant growth. Whilst areas within temperate regions are expected to have an increase in agricultural land cover, areas that are tropical and subtropical are expected to see a decline in the amount of arable land e.g Namibia, Mexico, India, Thailand and Australia. In Australia the current and projected increase in droughts and temperatures, as well as decreasing rainfall (especially in the South West) is affecting livestock and crop production and therefore land cover, as areas are becoming unsuitable for agricultural activities. It is projected that in Southern Europe by 2050, agricultural activities and land cover will decline rapidly due to a reduction in its suitability, with a shift and expansion into Northern Europe.

The world's urban areas are growing by three million new residents every week. By the end of 2050 66% of the world's population will reside in urban areas. Globally, approximately 360 million urban dwellers live in coastal areas within 10 metres of sea level. These urban settlements are generally located on deltas, floodplains, coastal plains and coastal lowlands, which are at a high risk of being affected from rising sea levels, increased coastal erosion, and increased extreme weather events. Island nations including the Maldives, are being affected by climate change. These urban settlements are seeing a rapid decrease in land cover as the islands are 'sinking' with rising sea levels. The Carteret Islands, are seeing their urban land cover shrink as a result of climate change related to sea level rise. The combined effects of sea level rise, erosion, storm surges and salinity of the soil is making the Carteret islands uninhabitable, destroying crops and contaminating their water supply. In 2003, Carteret became the first island nation to begin total evacuation, with 2700 islanders being relocated to Bougainville. The Intergovernmental Panel on Climate Change predicts that by 2050, approximately 150 million people across the world could be displaced by rising sea levels and be made climate change refugees, mainly in Asia and Africa due to loss of urban land cover.

Most industries have a high capacity for adaptation, as long as climate change is gradual, thus having minimal impact on industry land cover. Climate change will have direct impacts on economic activity in the industry, energy, and transportation sectors, as well as impacts on markets for goods and services and impacts on the natural resources on which industrial activity depends. The interconnectedness of economic activity also means that many impacts will be indirect and be transmitted between and within industrial sectors. Agricultural products, water and energy in particular will transmit climate sensitivity throughout the economic system. For example, Agro-industries dependent on products such as grain, sugar and rubber are vulnerable to changes in precipitation patterns and the frequency/intensity of extreme weather events. In many developing countries agro-industry, together with agriculture, constitutes the bulk of economic activity. These impacts may have severe consequences for the economies in these countries as the amount of suitable land required for this industry declines. Sea level rise will increase the cost of protecting transportation infrastructure and industrial plants located in coastal regions. Coastal protection will provide a market opportunity for the construction industry.

The land cover of ice sheets, marine systems and plant species will all be affected greatly by an increase in global temperature. Climate change on the anthropogenic processes of agriculture, urban areas and industries will also have a significant impact.

### **DEFINITION : SPATIAL DISTRIBUTION**

The arrangement of a phenomenon across the Earth's surface and a graphical display of such an arrangement

### **DEFINITION: TEMPERATURE**

The degree or intensity of heat present in a given area shown in degrees C

### **DEFINITION: PRECIPITATION**

The fall of water, ice or snow deposited on the surface of the Earth from the atmosphere expressed in mm.

## **NATURAL SYSTEMS THAT DRIVE THE EARTH'S CLIMATE**

- The Earth's atmosphere processes are solar powered system. Due to the Earth's spherical shape not all areas receive an equal amount of insolation. The equatorial regions receive more and polar receive less
- Top of Earth's axis is tilted and it revolves around sun, different areas of the Earth are heated and cooled at different rates (seasonal patterns)
- There are many systems that interact to create the Earth's climate patterns. Systems include heat budget, natural greenhouse effect, hydrological cycle, atmospheric circulation, ocean currents and carbon cycle

### **HEAT BUDGET**

- World's ocean is crucial to heating planet. While land areas and the atmosphere absorb some sunlight, the majority of the sun's radiation is absorbed by the ocean. Ocean helps distribute heat around globe. Outside Earth's equatorial areas, weather patterns are driven by wind and ocean density
- Currents are movements of ocean water in continuous flows, created largely by surface winds. Major current systems flow clockwise in North Hemisphere and anti-clockwise in Southern Hemisphere, in circular patterns that trace coastlines, like a conveyor belt, moving warm water / precipitation from equator to poles / cold to tropics. Thus regulate global climate, helping to counteract the uneven distribution of solar radiation reaching Earth's surface without currents, regional temperature would be more extreme (super hot at equator / cold at poles therefore Earth would be inhabitable)
- Short wave solar energy from sun travels 149 million km through space to Earth
- Takes 8 minutes. Globally about half the light from sun that arrives at the top of the atmosphere reaches surface of planet - absorbed by land and sea and is main source of long wave energy that heats the atmosphere. Process of radiation, conduction, convection and evaporation transfer this heat energy into the atmosphere, which is heated from the ground up
- Lower parts of the atmosphere are most effective in absorbing and retaining this terrestrial radiation as it contains the greatest density of gases. Not all of the atmosphere's gases can hold heat energy and those that can are classified as greenhouse gases (CO<sub>2</sub>, water vapour, methane and nitrous oxide)
- As water evaporates it absorbs heat. This energy then passes into atmosphere this way (other methods: conduction and direct radiation)
- Conduction is the passing of energy from one atmospheric gas molecule to the next
- Radiation is the passing of long wave energy through the atmosphere as infra-red light radiation
- Both G.H.G.E and heat budget vary overtime and from place to place. These variations help explain why the world has different climates and why there are wide differences in local weather patterns.
- Longer term or more persistent changes in the heat budget and the greenhouse effect will result in a shift in temperature producing either global warming or cooling - impacts on the rest of the climate system causing changes in hydrological cycle and atmospheric structure and dynamics

### **GREENHOUSE EFFECT**

- Greenhouse effect = radiation balance during force of all other climate
- SWR - High in energy, pass through atmospheric easily
- LWR - Cannot easily pass through atmosphere
- Natural GHE - 15% terrestrial radiation absorption. Essential to retain heat and keep the planet warm to sustain life. Earth will become 30C cooler without it
- More GHG - more LWR trapped

### **HYDROLOGICAL CYCLE**

- The movement of water as a liquid, gas and solid throughout the land, oceans and atmosphere is an important part of the Earth's climate systems

- The Sun is the driving force. Evaporation is the process of water changing its physical state from liquid to gas. As water vapour rises, it becomes cooler and changes back into physical state back to tiny liquid water droplets (condensation). Depending on weather conditions, water molecules will combine with tiny particles of dust, salt and smoke in the air to form clouds. Precipitation occurs when rain, snow, sleet or hail falls from the sky
- As the water falls back to Earth, some of it soaks or infiltrates into the ground and this known as groundwater.
- Groundwater will eventually seep back into water stores. Run-off occurs when water does not soak into the ground, but rather flows across the land instead
- Plant roots may also absorb water in the ground or leaves intercept precipitation. The combined evaporation from the soil and transpiration from plants is known as evapotranspiration

### **CARBON CYCLE**

- Most of the Earth's carbon is stored in rocks, with the remainder in the ocean, atmosphere, plants, soil and fossil fuels.
- All known living organisms are built of carbon compounds. It is the fundamental building block of life and an important component of many chemical processes. As such all animals and plants exhale CO<sub>2</sub>.
- The burning of plant materials also produces CO<sub>2</sub>. Processes that produce CO<sub>2</sub> are called sources while those that absorb CO<sub>2</sub> are called sinks. CO<sub>2</sub> is removed from the atmosphere by natural processes such as erosion and sedimentation and stored in layers of sediment on the ocean floor. CO<sub>2</sub> is only a very small part of the atmosphere (0.04%) it plays a large role in energy balance of the planet - greenhouse effect. Carbon is exchanged or cycled among Earth's oceans, atmosphere, ecosystem and geosphere in 2 cycles - fast carbon cycle which acts within a single lifespan and the slow carbon cycle which operates over a 100-200 million year cycle.
- Over the long term, the carbon cycle seems to maintain a balance that prevents all of Earth's carbon from entering the atmosphere or from being stored entirely in rocks. This balance acts like a thermostat to keep Earth's temperature relatively stable. This means that for shorter time periods Earth swings between colder glacial / warmer interglacial periods on these time scales. Parts of the carbon cycle may even amplify these short term temperature changes. Changes that put carbon gases into the atmosphere result in warmer temperatures on Earth.

### **ATMOSPHERIC CIRCULATION**

- Atmospheric circulation is the large scale movement of air, and controls the distribution of thermal energy across the surface of the Earth. The wind belts circling the planet are organised into 3 cells : Hadley cell, Ferrel cell and Polar cells.
- Hadley cell and the Polar cell are responsible for the climate at the equator, tropics and polar regions. When the air reaches the polar areas, it has cooled considerably and descends as a cold, dry high pressure area, moving away from the pole along the surface but veering westward as a result of the Coriolis effect to produce the polar easterlies.
- The Coriolis effect is the movement of air around the Earth as a result of our turning planet. It causes the air to spiral. The polar cell can create very cold conditions at the surface, resulting in the coldest temperature recorded on Earth (-89.2C at Vostok station in Antarctica 1983) located between the Hadley and polar cells are Ferrel cells

## **NATURAL CAUSES OF CLIMATE CHANGE**

### **MILANKOVITCH CYCLE**

- Eccentricity - change in the shape of the Earth's orbit around the Sun. Currently our planet's orbit is almost a perfect circle. Over a 95000 year cycle, the Earth's orbit around the sun changes from a thin ellipse (oval) to a circle and back again. When the orbit around the sun is most elliptical there is larger difference in the distance between the Earth and the sun - a larger difference would modify the amount of solar energy received and cool the Earth. This would result in periods of interglacial activity

- Obliquity / tilt - On a 42000 year cycle, the Earth wobbles and the angle of axis with respect to the plane of revolution around the sun, varies between 22.1 degrees and 24.5 degrees. Less of an angle than our current 23.45 degrees means less seasonal differences between North and South hemispheres while a greater angle means greater seasonal differences.
- Precession - 12000 years from now the Northern hemisphere will experience summer in December and winter in June because the axis of the Earth will be pointing to the star Vega instead of its current alignment with the North star or polaris. This seasonal reversal won't happen suddenly but the seasons will gradually shift over thousands of years

### **PLATE TECTONICS**

- On the longest time scales, plate tectonics will reposition continents shape occurs, build and tear down mountains and generally serve to define the stage upon which climate exists
- The supercontinent Pangaea, which existed 225 million years ago divided causing the movement of land closer to the poles which led to the development of large scale ice sheets. This increases the albedo effect which leads to periods of global cooling.
- During the carboniferous period, plate tectonics may have triggered the large scale storage of carbon and increased glaciation.
- The growth of the Himalayas has also contributed to regional changes in atmospheric circulation. The huge mountain chain created a wall that has blocked rain from the central Asian plains of Mongolia for the past 8 million years. This has helped create the Gobi and Mongolian deserts.

### **VOLCANIC ERUPTIONS**

- Millions of tonnes of sulphur dioxide gas may reach the top of the stratosphere, almost 50km into the upper atmosphere. Once there the sulphur dioxide transforms into tiny droplets of sulphuric acid, known as aerosol. These droplets reflect energy from the sun back into space, preventing some of the Sun's rays from heating the Earth.
- Volcanic eruptions that add significant quantities of sulphur dioxide into the stratosphere lower global surface temperature which can take a year to take place. One example from recent history is the eruption of mount Tambora in 1815.
- On the island of Sumbawa in Indonesia, erupted in 1815 with an immediate death toll of 71000. Caused a global climate anomaly when it released huge amounts of sulphuric acid aerosols into the stratosphere. The volcanic winter that followed resulted in what is known as the year without summer.

## **ANTHROPOGENIC CAUSES CLIMATE CHANGE**

### **BURNING OF FOSSIL FUELS - CARBON CONTRIBUTIONS**

- The Industrial revolution has caused the increase of burning coal and oil (predominantly) for human development
- Coal is mainly used in the manufacturing industry. Power stations burn coal to produce energy which is then used on large scale to produce goods and services. A by product of burning coal is carbon dioxide which is then released into the atmosphere. CO<sub>2</sub> is a greenhouse gas so takes in the long wave radiation reflecting back from the Earth causing the planet to gradually become warmer.
- Worldwide CO<sub>2</sub> contributes about 60% to the enhanced greenhouse effect. Oil is mainly used by the developing world. Different modes of transport burn oil to produce energy which is then used to power the vehicle. A by-product of burning oil is CO<sub>2</sub> which is then released into the atmosphere

### **FARMING - METHANE CONTRIBUTIONS**

- The agriculture revolution has caused the increase in the production of methane. In the developed world humans have increased their meat production because of an increase in population and affluence

- More people means more food is needed but a greater affluence means more people can afford meat when cows 'break wind' they emit Methane into the atmosphere therefore more cows equals more methane
- Methane is a greenhouse gas so takes in the long wave radiation reflecting back from the Earth and releases it slowly in every direction. This means that some heat is reflecting back to the Earth causing the planet to gradually become warmer. Worldwide Methane contributes about 20% to the enhanced greenhouse effect. In the developing world rice is a staple part of the human diet because of the climate needed to produce rice and because it is cheap to produce.
- As the population is increased in the developing world so is the production of rice. Methane is given off from rice paddies and added to the atmosphere. The green revolution caused an increase in the efficiency of producing rice, therefore more rice was grown. India adopted a semi-dwarf rice variety developed by International Rice Research Institute that could produce more grains per plant when grown with certain fertilisers and irrigation. The semi-dwarf rice yielded about 5 tons per hectare under optimal conditions. This was 10 times the yield of traditional rice.

### **DEFORESTATIONS - REMOVAL OF CARBON STORES**

- Whilst deforestation doesn't directly add to greenhouse gases in the atmosphere the removal of trees greatly affects the greenhouse effect
- Naturally trees take in CO<sub>2</sub> and emit oxygen therefore reduce the warming impact of the greenhouse effect.
- As trees are removed their ability to take in CO<sub>2</sub> is reduced so more CO<sub>2</sub> is a greenhouse gas so takes in the long wave radiation reflecting back to the Earth causing the planet to gradually become warmer.
- As a general statistic a soccer field a second is deforested from the world's rainforest

## **EVIDENCE FOR CLIMATE CHANGE**

### **EVIDENCE OVER GEOLOGICAL TIME - ICE CORES**

- Ice cores are realistically the only long term measure of CC
- Bubbles trapped within the ice capture the gas concentration of our atmosphere while the ice itself records the properties, providing a window onto 800,000 years obtain info by using special drill that bores down into ice sheets like Antarctica or Greenland and removes a cylindrical tube called an ice core.
- Most well known is the Vostok ice core, obtained by a joint Russian and French team at Russian Vostok station in Antarctica in 1987. Cores have distinct layers in them, that go throughout the years. Each year snow falls over the ice sheets and each layer has different texture and different chemistry with winter snow differing from summer snow.
- In summer when sun is up for 24 hours the top layer of snow changes in texture. As winter arrives and it turns cold/dark new snow falls - new layers.
- Each layer provides vast amount of info about climate each year. Can tell temperature, precipitation, atmospheric composition, volcanic activity, wind patterns. Thickness of each layer allows to determine how much snow fall seasonal dust, large volcanic eruptions anywhere in the world spews dust into atmospheres.

### **EVIDENCE FROM RECENT HUMAN HISTORY - CRYOSPHERE**

- 3 types of approaches used to measure
  - 1. comparing ice melt to snowfall accumulation
  - 2. Observing changes in glacier
  - 3. Using satellites to map the changes of ice sheets / glaciers
- The launch of 2 new satellites in 2003 and Grace led to vast improvements in measures of ice sheets over time. With a combination of these three methods it was shown that the ice sheets were losing mass at an increasing rate by end of 2000's
- Over the last 2 decades, Greenland and Antarctica ice sheets have been losing mass, glaciers have continued to decrease worldwide. And Arctic sea ice and Northern Hemisphere spring snow

cover have continued to decrease in extent. Annual mean Arctic sea ice extent decreased over the period 1979 to 2012 with rate between 4% per decade.

## **INTERRELATIONSHIPS BETWEEN LAND COVER CHANGE AND CLIMATE**

### **DEFINITION SURFACE REFLECTIVITY**

- The proportion of the radiation that is reflected by a surface, measure from 0-1 (100% reflectivity)

### **SURFACE REFLECTIVITY (ALBEDO) - melting cryosphere**

- The amount of reflected energy changes with surface changes, especially at the poles or where snow and ice have traditionally dominated
- Bright snow and ice are very effective at reflecting sunlight back into space. There has been a consistent increase in global temperature over the last century and a corresponding decrease in snow and ice cover. This results in less energy being reflected and more being absorbed by the ground and water, causing increase warming and more snow / ice melt.
- Therefore when snow / ice disappears, less of the sun's rays are reflected back into space and instead the heat is absorbed by land / sea. This causes further increase in warming

### **SURFACE REFLECTIVITY - URBAN HEAT ISLAND**

- Urban heat islands are caused by a combination of decreased albedo, reduced atmospheric circulation, and by the waste heat from urban processes. The dark surfaces of urban areas (e.g roads / buildings) absorb and store more solar radiation than surrounding rural areas which causes suburban areas to be warmer. This causes a change in the energy budget of the urban area

### **DEFINITION : CARBON SEQUESTRATION**

- A natural or artificial process by which CO<sub>2</sub> is removed from the atmosphere and held in solid or liquid form

## **EFFECTS ON NATURAL BIOMES**

### **VEGETATION**

- Shifting ecological boundaries: shift in rainfall patterns and increased temperature will impact on natural biomes. The extent and distribution of these ecosystems will change over time as climate conditions prevail e.g coniferous forests will move further North and invade areas of tundra.
- Some species will become extinct as they will not be able to cope with shifting climate regions. With rising temperature and a drier climate the number of fire weather days are projected to increase in Southern and Eastern Australia increasing the likelihood of more high intensity bushfires. This will significantly impact on vegetation and its ability to recover after a fire

### **ICE SHEETS**

- The cryosphere is all those areas of the Earth where the surface is frozen including the polar ice caps, continental ice sheets, glaciers, sea ice and permafrost.
- Climate change has a strong effect on the cryosphere. Warmer temperature will result in less ice which will decrease albedo leading to further heating.
- The melting of ice sheets is of particular importance because of the huge size of these ice sheets, has great potential for changing sea level. The Greenland ice sheet is water than the Antarctic ice sheet and as a result, global warming could produce serious melting on Greenland will have less effect in the Antarctic. As the ice melts, the regions albedo or reflectivity changes. Ice and snow reflect away about 90% of the sunlight that hits it, but as the ice softens its structure changes, lowering the reflectivity and absorbing more heat. As it melts away more water and land are exposed, both of which are darker and both absorb more heat. This in turn will melt more ice creating a feedback loop that can accelerate quickly
- Glaciers: warmer global temperature further reduce glacier ice. Glacier National Park Montana USA was created in 1910. It is predicted that within 30 years most if not all the parks glaciers will disappear. In the Antarctic 70% of the glaciers are retreating

### **CORAL REEFS**



1. Coral reefs are extremely sensitive to climate change
2. Sea temp increases and coral stress from other impacts may increase corals where ability to bleaching. Bleacher corals die if the stress persists. Coral reefs that have high rate of coral death following bleaching can take many years or decades to recover
3. More co2 dissolving into sea water is change the pH of seawater and this is leading to ocean acidification which is having a negative impact on corals
4. The world famous Ningaloo reef and Great Barrier reef along with the multimillion dollar tourism industry they support face significant long term risks from a changing climate

### **COASTAL SYSTEMS**

- Rising sea levels will bring significant changes to the coastal zones. Already sea level increase have been observed in both Australia and globally by approx 2mm per year since the run of the 20th century - two main factors that have caused this increase include
  5. melting ice (ice sheets / glaciers)
  6. Thermal expansion caused by global warming
- Warmer water expands and the oceans therefore tea cup a greater volume. Range of impacts on coastal systems is being observed
- Higher sea levels increase the risk of coastal erosion. Coastlines become vulnerable to higher storm surge flooding which adversely affects coastline habitats. e.g coastal plant species being lost though inundation. Surface water quality of coastal waterways such as estuaries are also becoming an issue as they become more salty and silted.

### **CLIMATE CHANGE PROJECTIONS**

- By 2100 all areas of the world are predicted to have increased in average global temperatures by between 10C to 60C.
- High latitudes of then Northern Hemisphere area expected to increase the most and this will result in further melting of polar ice resulting in sea level rise. It is forecast that there will be significant changes in rainfall patterns with some areas becoming wetter and other areas becoming drier. There will be an increase in extreme weather events
- As sea levels rise, some island groups could be completely covered by rising sea levels (Kiribati tuvalu, Maldives.) resulting in the climate change refugees
- Coastal location of many major cities (NY, London, LA, Mumbai) will also become seriously vulnerable to rising sea levels and may result in the displacement of millions of people
- Warmer temperatures will contribute to an increase in extreme weather events such as cyclones and floods suitable habitat for a range of iconic species including the Quokka, Carnaby's black cockatoo and tingle tree is likely to be substantially reduced as the climate changes.

### **LAND COVER RESTORATION AND REHABILITATION**

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**Describe the approaches to land cover restoration and rehabilitation, and the mitigation of future land cover changes, including preservation strategies**

#### **DEFINITION: RESTORATION**

- The returning of the natural landscape and habitat with ecosystems back to their original state

#### **DEFINITION : REHABILLIATION**

- Is the actual process of retuning that particular area of land to some degree of its former state including the services and overall productivity

**Mitigation of future land cover changes  
ALCOA MINING COMPANY (example)**

- **Location** : LCC has occurred through the introduction of Bauxite mining the Darling Scarp that first began around Jarrahdale in 1963. Shortly after this projects in Huntley and Willowdale opened and were fully established by 1984.
- **Problem** : Bauxite is mining by surface methods known as open cut mining which see the removal of all vegetation followed by the removal of topsoil before bulldozers and scrapers remove the raw material. Every year approximately 50km<sup>2</sup> is cleared
- **Solution** : The two present operational mines in the Darling Scarp are Huntley and Willowdale and supply nearly 50% of all Australia's aluminium. After each mining pod is exhausted ALCOA undertakes a major rehabilitation program to help restore the forest ecosystem by aiming to achieve full plant riches in the area. Each year 600 hectares are mined and rehabilitated at ALCOA's two WA mine sites
- **Process** : Begins before the mining commences with the collections of seeds from the original site that is to be mined. After the vegetation has been removed the top soil is put to one side to be reused after the bauxite collection. This is known as stockpiling.
- **After ming** : Replacing the soil - The 1<sup>st</sup> process after the mining is general landscaping and shaping of the land. Removing the steep walls and flattening the base of the mine. The next step is arguably one of the most important for the rehabilitation of the site. 1.5m of the compacted soil is ripped up known as pre-ripping. This aerates the soil which has been compacted during the mining which will allow water infiltration and root penetration. The topsoil that was stockpiled earlier is then replaced back in to the mine and is also scarified to a depth of 30cm to provide surface drainage and reduce the potential of erosion. The area is then replanted with both Jarrah and Marri trees which are grown from seedlings in local nursery's and are planted in the wetter months. Has to occur as mining is taking place. Grasses / sedges are grown from cutting at Marrinup Nursery and are planted by hand in the rehabilitated area. Accounts for 20% of the rehabilitated area. A fertiliser is applied to enhance growth. Thus us a combination of superphosphate, traces of copper / zinc and is applied as evenly as possible by helicopter.
- **Mitigation into the future** : After the initial stages of rehabilitation a mitigation progress against future change is essential to make sure that the land cover fully rehabilitates. Done through a systematic monitoring system that is required access the establishment of the vegetation, the re-establishment nutrient cycles and the retune of fauna to to this habitat. The initial vegetation must establish the building blocks for a self sustaining system. The combination of native species to protect the soil should work but in some cases a protective crop / layer may need to be planted in the 1<sup>st</sup> year for protection. e.g Mulches / manure
- **Mitigating vegetation** : With the rehabilitated land cover in a fragile state it is important to minimise the spread of disease and non-indigenous species that could contaminate the area. Strict hygiene measures are required to minimise the spread of disease (maining the Jarrah die-back fungus) through the provision of wash down stations to reduce the possibility of vehicles transporting contained soil throughout the forest. Cleaning footwear is also necessary, while road / rail closure may be necessary to completely reduce the traffic to that area.
- **Mitigating fauna** : Animals will move back into rehabilitated areas once the vegetation is similar to surrounding areas. Further methods can be employed by transporting grass trees, re-spreading mulch and branches to provide shelter for reptiles and by establishing old dead trees that provide hallows, crevices and exfoliating bark. Baits can be implemented to get rid of any invasive non-endemic species and regular spaces counting can ensure the gradual rehabilitation of fauna in the area.
- Alcoa's key environmental objective is to restore 100% of the species richness in the native forest one year after rehabilitation is complete. Once successful rehabilitation is complete and meet the satisfactory standard of the 'completion criteria' outlined by the government the leased land is given back to the department of parks and wildlife for future management.

### **Second case : Restoration and rehabilitation - Belier Wetlands**

- Due to urban and agricultural activities, including that of horse agistment and grazing, the wetlands areas within Bibra Lake known as the Beelie wetlands became severely degraded. Since the removal of these land uses, restoration and rehabilitation strategies have occurred. The city of Cockburn, in conjunction with the Cockburn Wetlands Education Centre and community volunteer organisations have conducted annual revegetation projects, starting in 1985 in order to restore the Bibra lake area and wetlands to its original state. Each year 5,000 to 10,000 endemic native plants area established, including both

understory and overstorey plants. Additional strategies that are also employed to assist in the restoration include

- Annual watering program of seedlings
- Removal of introduced pests and weeds, including the melaleuca nesophilar and the European rabbit
- On going maintenance and checks of regrowth
- The restoration and rehabilitation strategies put in place within the wetlands has meant that over 5.5 hectares has been successfully restored to its original state since 1985

### **Reforestation projects - Rwanda**

- With population density in Rwanda being over 480 people per square km, the pressure to use land for agriculture is very high.
- The landscape is mountainous and annual rainfall in the capital of Kigali is 1028mm per annum. This leads to high levels of erosion once the natural vegetation has been cleared.
- Topsoil is washed off down the steep slopes and terracing is needed to reduce soil loss and sedimentation of rivers and streams.
- Land cover is being stripped and nutrient rich volcanic soils are being lost, making natural ecosystem recovery and rehabilitation slow. Succession by anthropogenic biomes has also resulted in declining biodiversity
- Reforestation projects are underway to encourage the planting of eucalyptus and other exotic trees.
- Australian tree species are often used in African countries because they grow quickly in water environments
- Recent reforestation efforts in Rwanda have increased the area of the Gishwati forest, once the second largest indigenous forest in Rwanda to 1,000 hectares. However, there is still a long way to go to get the forest back to its original size of over 100,000 hectares.
- Continual restoration and rehabilitation has meant to gain over 50% more forest cover between 1990 and 2011.
- Forest specialists work with Rwandans to develop rehabilitation projects but even these are often unsustainable as they are not ensuring that social, economic and environmental improvements and being affected from the use of non-indigenous plants, turbidity levels in waterways are still high and agricultural land and activities are under increasing pressure to expand land cover due to population increase.

### **DEFINITION: MITIGATION**

- Mitigation refers to all the efforts and actions put in place to reduce or alleviate completely the severity and effects the phenomena being studied through targeting the causes.

#### **Local**

- A local scale study of a small area for example, a neighbourhood, village or small town

#### **Regional**

- A regional scale study of a smilier geographically divided areas for example Perth City or the State of WA

#### **National**

- A national scale study is a study of a national geographic boundaries for example Austrlia and USA

#### **Global**

- Global scale study is a study of the whole or geographical concepts that occur across multiple countries

### **DEFINITION: PREVENTION**

- The most common mitigation approach is that of preservation / preventions strategies that attempt to maintain natural environments that have no already been altered by humans

### **Example - notes**

Mitigation in Australia - Perth Metropolitan area

- Direction 2031 and beyond in the name of the planning document that looks at preservation and mitigation strategies. The main areas identified are preventing urban growth and the removal of vegetated areas.

#### **Prevention**

- Urban growth boundaries have been put in place to preserve areas and therefore restrict forest land cover change
- Almost 400,000 hectares of green space is protected including Kings Park, Bold Park and Whiteman park

- The bush forever programme is also a strategic plan within Directions 2031 to maintain the bushland of WA. It aims to protect 51,000 hectares of natural land cover within its 287 bush forever sites
- Urban infill is a strategy put in place to limit further urban development and growth outside of Perth's already existing shape
- Each year 880 hectares is cleared for housing with the target to reduce this by nearly 50%
- Houses have to be built on already existing site or build upwards

#### Busselton - Augusta region

- The coastal scrublands and heathlands of this region support hundreds of different plants per square km, many of them endemic and endangered, as well as a wide range of native invertebrates.
- In the south, forests and woodlands with high rainfall also provide habitats for a highly diverse range of plants and animals
- The Tuart Forest National Park lies immediately north of Busselton. It is the purest stand of the unique Tuart Eucalypt which found nowhere else in the world except in coastal patches between Jurian bay and Busselton in WA
- Boranyup Karri Forest near Margaret River is the Northern most and only west coastal patch on the unique Karri Tree, another species endemic to the south west of WA
- Changed fire regimes, pressure from over grazing and habitat fragmentation have affected these landscapes.
- Viability of specie such as Carnaby's Black Cockatoo, and Chuditch and Brush Tailed Phascogale has become threatened by these changes
- The area also has many caves systems with significant aquatic invertebrates found only in WA
- Changes in groundwater movement could potentially cause significant stress to the threatened cave communicates

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### **Examine the current and proposed strategies, at local to global levels, implemented to mitigate the adverse effects of global climate change**

#### **INVESTIGATING LAND COVER MANAGEMENT**

##### **Current strategy Local Level:**

##### **Renewable Energy**

- Renewable energy relates to energy which is derived from resources that are inexhaustible and replenished rapidly by natural processes
- Wind power involves generating electricity from the naturally occurring power of the wind through the use of wind turbines
- In Australia, wind power is the fastest growing renewable energy source, producing 33.5% of the country clean energy and supplying 7.1% of Australia overall electricity in 2018
- Australia has 94 wind farms with over 3000 turbines
- The **Walkway Wind Farm** is located 12 km inland from the Indian Ocean and 30 KM south of Gerelton. Wind power from this farm powers 64000 homes which would otherwise be powered by coal burning power station
- This mitigates CC by then reducing the enhanced greenhouse effect which in turn should reduce global warming
- By reducing global warming this then reduced the effects of global warming
- The Walkaway wind farm is Western Australia's largest renewable energy project and provides 90 megawatts of power into the grid that supplies Perth and the south west. The wind farm has 54 wind turbines.
- Each year the wind farm generates energy that would normally produce 400,000 tonnes of greenhouse gases.

## **Future strategy Local Carbon Capture and Storage**

- Carbon capture and storage is a relatively new concept to mitigated climate change that works by capturing CO<sub>2</sub> from large sources such as power plants and then transfers it to a storage site
- Reduces the amount of anthropogenic CO<sub>2</sub> emitted into the atmosphere
- CO<sub>2</sub> is typically stored in geological formations (underground) known as Geo- Sequestration
- Typically the CO<sub>2</sub> is removed either before or after and then transported via pipelines to its storage sites
- If this is applied to conventional power plants then emissions could be reduced by 90%
- The UN predicts that just over 50% of total world carbon could be captured by 2200 using this method
- In Australia there are a number of carbon storage programmes with the biggest in the world set to become operational in 2019 - formally 2017
- The Gorgon project is set to become operational by the end of the year, located on Barrow island
- The CO<sub>2</sub> will be captured and transported via pipelines to the Dupey formation 2km below the island
- It is estimated that over the life of the project over 100 million tonnes will be reduced from the atmosphere
- Carbon Capture and Storage (CCS) is a technology that can capture up to 90% of the carbon dioxide (CO<sub>2</sub>) emissions produced from the use of fossil fuels in electricity generation and industrial processes, preventing the carbon dioxide from entering the atmosphere.
- The CO<sub>2</sub> Injection Project will inject and store reservoir CO<sub>2</sub> into a deep reservoir unit, known as the Dupuy Formation, more than two kilometres beneath Barrow Island.
- The removal of carbon from the atmosphere once it has been generated from anthropogenic sources involves sequestration strategies. These may include locking carbon up in vegetation and soils through the use of different farming methods or reforestation. It may also include the removal of CO<sub>2</sub> from fossil fuel emissions and its storage underground in a process called geo-sequestration. Unlike carbon reduction this method does not require changes towards a low carbon economy; however it cannot guarantee that the captured carbon will be permanently removed from the cycle.
- Current Federal Governments approach to climate change is the direct action policy. Part of this policy is to finance projects that help reduce carbon emissions as well as removing carbon. These projects include reduction of CO<sub>2</sub> from landfill sites, changes to farming activities that reduce CO<sub>2</sub> output and sequestering carbon in the soil and vegetation, conservation carbon capture projects.

## **Current Global Strategy Eden Project**

- Eden concept began in Ethiopia in 2004
- “Eden Reforestation Projects” was launched in order to attempt to reverse environmental devastation that negatively impacted families and local culture whilst trying to have a positive impact on the environment
- Expanded into Madagascar in 2007, Haiti in 2010 and Nepal in 2015.
- The Eden Project began its work in Ethiopia in 2005, and its phase-one project at the Udo 3 Hills Project site was completed on 2014 with 16,000,000 trees planted. Villagers who cut down the forests in order to cultivate crops on the land, and produce charcoal for cooking and heating drove much of the destruction in this area. These destructive practices had quickly turned productive land into desert
- The Eden Projects began planting in Madagascar in 2007. The mangrove projects are replenishing the enormous Malagasy mangrove forests at a rate of over 2 million trees per month
- Is involved in 5 countries currently
- 82 project sites currently
- 239,303,884 trees planted
- By the year 2020 our objective is to plant a minimum of 100 million trees each year and to offer hope through the employment of tens of thousands of people in countries where extreme poverty is rampant.
- Forest level partners (\$100,000) include travel and transport, globe, ecosia
- 10% of Madagascar original forests remaining today - 75% of species do not live anywhere else
- Since we began over 250 million trees have been planted around the world in Ethiopia, Madagascar, Nepal, Haiti, Indonesia, Mozambique.

## **FUTURE STRATEGY - UN PARIS 2015**

### **back ground info**

- Parties to the UN Framework Convention on Climate Change (UNFCCC) reached a landmark agreement on December 12 in Paris

- The new treaty ends the strict differentiation between developed and developing countries that characterised earlier efforts, replacing it with a common framework that commits all countries to put forward their best efforts and to strengthen them in the years ahead
- This includes, for the first time, requirements that all parties report regularly on their emissions and implemented efforts, and undergo international review
- 150 presidents and prime ministers, the largest ever single day gathering of heads of state attended
- **3 goals**
- 1. Reaffirm the goal of limiting global temperature increase well below 2 degrees C while urging efforts to limit the increase to 1.5 degrees. The agreement reaffirms the long term goal of keeping average warming below 2 degrees C while also urging parties to 'pursue efforts' to limit it to 1.5 degrees, a top priority for developing countries highly vulnerable to climate impacts
- 2. Establish binding commitments by all parties to make nationally determined contributions (NDC's) and to pursue domestic measures aimed at achieving them. With respect to countries individual mitigation efforts, the agreement prescribes a set of binding procedural commitments: to prepare, communicate and maintain an NDC; to provide info necessary for clarity and transparency; and to communicate a new NDC every five years. It also sets the expectation that each successive NDC will represent a progression beyond the previous one and reflect a parties highest possible ambition
- 3. Reaffirm the binding obligations of developed countries under the UNFCCC to support the efforts of developing countries, while for the first time encouraging voluntary contributions by developing countries too. The core mitigation commitments are common to all parties, but there is some differentiation in the expectations set: developed countries "should" undertake absolute economy-wide reduction targets, while developing countries "are encouraged" to move toward economy-wide targets over time. In addition, developing countries are to receive support to implement their commitments.

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## **Explain how human activity has adapted, or may be required to adapt, to climate change**

### **DEFINITION - ADAPTATION**

Adaptation is when humans make alterations or adjustment in response to a changed environment. These alterations are generally to do with human behaviours and processes that are out in place in order to reduce the potential risk of damage and cost or to benefit from new conditions

### **Evidence of the Problem**

- WA climate has changed over the last century, particularly over the last 50 years. Average temperature has risen about 1 degree. Rainfall has declined along the west coast and over the lower south west by 20%
- Between 1910 and 2013 average annual temp increased by 1.1 degrees with similar increase in average daily max and min. Seasonal average temp are also generally warmer
- The environmental changes have been further amplified by Perth growing population which has increased by 1.6 million in the last 50 years
- The decline in rainfall over the south west is consistent with increasing greenhouse gas concentrations and cannot be explained sole by natural climate variability or changed land use ,such as land clearing

### **DEFINITION: Desalination**

Desalination is the process of removing salt and other minerals from saltwater or other water sources in order to make the water suitable for drinking and irrigation

#### **Location and initial set up cost**

- The Perth Seawater Desalination plant, located in Kwinana, produces 45 billion L a year of fresh drinking water, Finished in 2006 and cost 387 million
- Southern Seawater Desalination plant located in Binningup, produces up to 100 billion L of fresh drinking water a year. Finished in 2011 and cost 1200 million

- over 48% of Perth's water supply comes from these plants, about 150 billion L
- Process works by reverse Osmosis where the pressurised water is sepalled through a membrane

#### **How does desalination work**

- Seawater desalination is the removal of salt and impurities from seawater to produce fresh water. Desalination plants use a reverse osmosis process
- Seawater is pumped into the desalination plant from the ocean and passes through pre-treatment filtration to remove majority most of the land and small particles
- The filtered seat ware is then forced under pressure through special membranes whereby the osmosis process that normally occurs in nature is reversed. The pores in the membrane area so tiny that salt, bacteria, viruses and other impurities are separated from the seawater. In essence they act like microscopic strainers
- About half of the water that enters the plant rom the sea becomes fresh drinking waer. The salt and other impurities removed from the seawater is then returned to the ocean via diffusers, which ensures it mixes quickly and prevents impacted the marine environment
- The desalinated water is then subject to further treatment to meet drinking water standards before it reaches our customers.

#### **Looking into the future**

- In late 2017 Perth started to look at the feasibility of new desalination plants north and south of the Swan River, one near Kwinana close to the existing Perth Seawater Desalination Plant and the other in the Northern suburb of Alkimos
- At this stage there is no form timeframe for building a new desalination plant for Perth's Integrated Water Supply Scheme. The timing depends on annual rainfall and how fast our climate continues to dry, how much water we use each year and population growth

#### **Positives**

- It doesn't lead to further depletion of other water supplies and sea is plentiful
- They provide an abundant source of rainfall regardless of the amount of rainfall
- They stop the need for other solutions such as expensive dams and piping water throughout the state
- The state looked into options of piping water from the Kimberly region to Perth but were able to snap the plans as they were expensive but also unnecessary due to the success of the desalination plants

#### **Negatives**

- They are very expensive to build and operate leading to the cost being passed onto the public. Perth water charges have nearly seen a 50% increase. Desalination sources of water are more expensive to supply than surface water e.g the cost of supplying desalination water is approx. \$2.20 kilo-liters compared to \$0.20Kl from surface water dams
- Require a lot of energy to run, with both of Perth's plants running of coal and gas however the Binningup plant does use the Alinta Wind Farm for some of its energy requirements
- Desalination plants produce brine as a by product which could have an impact on marine life

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- **Describe a program designed to address the impacts of land cover change on local and regional environments. Evaluation of the program, giving consideration to environmental, economic and social benefit and costs**

#### **Agroforestry**

**Location :**

WA Wheatbelt

**Operated by :**

Department of parks and wildlife

**What is it**

- Land management system where trees and shrubs are grown around or among crops and pasture lands

**Why do we need it**

- In areas such as wheatbelt in Wa land clearance for agriculture has resulted in a change of land cover and has had a negative impact environmentally.
- Environmental impacts include
  - Loss of habitat and biodiversity
  - Soil erosion and degradation - particularly salinity (amount of salt in the soil)

**Reasons for Environmental impact**

- With the increase demand for food production the wheatbelt has been extensively deforested to provide areas for agricultural. Native trees are cut down on a large scale not only for the land but to allow for large modern scale farming machinery. Fields surrounded by trees simply do not make it easy for large scale agriculture.
- The lack of large trees and regular irrigation keeps the water table very high. This can increase soil salinity which in return decreases the production capacity of the agricultural area. The tree roots also played an important part in binding the soil together and stopping soil erosion.

**The plan**

- The plan is known as the Oil Mallee Project. This is where farmers are provided with a grant to plant the mallee eucalyptus tree. This tree was chosen as it grows well in low rainfall areas, isn't harmful for livestock and will reduce the impact of soil salinity

**Addressing the impacts - the plan**

- Currently over 900 farms are involved in the plan
- Farmers are encouraged to plant the tree on 10% of their land
- one plant in Yearling has planted over 86000 trees since 2000
- Lindsay Corke the owner has reported a significant decrease in soil salinity from the lowering of the water table
- She also notes increase productivity on the farm and more shelter from the wind

**Economic positives**

- The grant provides an extra income for farmers at the beginning of the program. If the program is successful the extra yield production will also boost the income for the farmer. This money flows into the economy of local rural areas and increases the circular flow of money
- The tree itself provides huge economic potential through eucalyptus oils, bio energy and activated carbon. If a tree is sold another can be planted to ensure sustainability

**Economic negatives**

- Despite the grants all financial implications in the long term for the responsibility to maintain and manage the trees in on the farmer. Any machinery required the farmer has to purchase themselves
- The farmer has to give up 10% of their land which could be used for agricultural production. This means that they are giving up 10% of their agricultural profits. With the project in its early stage it is unknown whether the farmer will get the return from the environmental improvement.

**Social Positives**

- There have been a number of employment opportunities which obviously increase the quality of life of individuals. Seed nurseries have had to be set up to plant the native trees and agroforestry organisation have been set up
- Farmers have the opportunity to develop new skills and socially develop through networks produced to improve communications throughout the project

**Social negatives**

- With the project still in its early stages farmers are under pressure to see economically viable results. If the program starts to fail then stress levels and anxiety amongst the farming community will rise

**Environmental positives**

- Through revegetation there is a reduction in the ground water level. It also improves soil management through added protection reducing wind and water erosion
- Revegetation restores habitats and habitat corridors therefore increasing the biodiversity of the area
- Replanting the trees also provides a carbon sink



### **Environmental negatives**

- With the economic potential of the trees (mentioned earlier) there is the chance that the demand for harvesting will increase if there is a need for economic growth. If this occurs there will be increase rated of deforestation reducing all the benefits mentioned earlier.

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## **Evaluate at least one alternative approach to the management of land cover change in the area being studied, using the concept of sustainability to determine the extent to which the approach has the potential to address the issue into the future**

**Strategy** - Eco Tourism and sustainable farming

**Location** - WA - Kimberly Region

**Operated by**- Private land owners

### **What is it**

- Ecotourism is ecologically sustainable tourism with a primary focus on experiencing natural areas that fosters environmental and cultural understanding, appreciation and conservation

### **Environmental issues**

1. The land is becoming barren due to extensive cattle farming. Short horn cattle have been a way of producing money but they have increase environmental degradation. They are fussy eaters and travel a lot to find their food source. This increase trampling and soil erosion
2. 2. Foreign weeds and feral animals have taken over the landscape completely changing the biodiversity. Weeds such as cocklebur and pests such as rabbits dominate the landscape
3. 3. Large scale bushfire area a problem as they are uncontrolled and have a devastating impact on the environment.

### **Solutions**

1. The change of the cattle used at El Quester has had a significant impact. Firstly the amount of cattle has been reduced and is no longer the primary source of income which has shifted to ecotourism. 8,000 Braham cattle has replaced Short Horn Cattle. They are less fussy eaters so don't move around as much combating trampling and soil erosion. They also emit up to 50% less methane gases combating CC.
2. Switching to eco-tourism as the main income for the ranch. This income has low overheads once set up and reduces the environmental strain on the area. The money gained from the projects is put back into restoration and rehabilitation projects such as the removal of weeds and feral animals
3. Indigenous fire regimes have been restored to manage the land and reduce the larger more intense bushfires that have occurred. The smelled more regular bushfire promote re-growth of indigenous plant species and limit larger more devastating bushfires.

### **Environmental positive**

- The preservation of marine parks and national parks in the Kimberley to boost ecotourism. The investment is part of the State Government's Kimberley Science and Conservation Strategy, which now has a commitment of \$103.6 million to protect the regions unique assets
- Creation of new marine reserves will increase the total area of the State's marine parks and reserves from about 1.5 million hectares to more than five million hectares since 2008 causing a 200% increase

### **Environmental negative**

- An increase in tourism to the Kimberley's increases the amount of people travelling there and bringing their vehicles. 4 Wheel Drives will replace the trampling of land from cows will re-increase the degradation of soil which was restored when they removed the cows from the land.

**Economic positive**

- Increasing ecotourism will bring more money into the government as it increases tourism and increases job opportunity. It causes the money to stay in the country as it is going to smaller and medium size businesses in Australia increasing circular flow of income
- Where with mining, the money is going to major corporations expending money outside to overseas investors and FIFO. Regional Development Minister Terry Redman said “Conservation and ecotourism is an important investment for Royalties for Regions as it attracts investment and creates business and job opportunities for regional communities”

**Economic negative**

- Government is putting lots of money to preserve the environment to boost ecotourism but if tourism doesn't increase and it doesn't work then the government has lost that money

**Social positive**

- Socially, bringing more money into the Kimberley's will increase stability of jobs and restores the environmental serenity making it a more visually and overall nicer place to live

**Social negative**

- People move to the Kimberley as they enjoy the isolation but by increasing tourism, there is an increase in people populating the region which in results causes the Kimberley's to become less of an isolated and remote areas

**Evaluation of Sustainability**

- To evaluate the environmental sustainability of this program you need to think about the positive factors that show current and future needs are being met against the negative factors.
- To evaluate the economic sustainability of this program you need to think about the positive factors that show current and future needs are being met against the negative factors.
- To evaluate the social sustainability of this program you need to think about the positive factors that show current and future needs are being met against the negative factors.

# UNIT 4

## Overview of places and their challenges

### Urbanisation general definition:

A population shift from rural to urban areas and the ways in which each society adapts to the environmental, social and economic change

### The level of Urbanisation definition :

Refers to the proportion or percentage of people living in urban areas or settlement at a point in time. It can be used at a local, national or global scale

### The process of Urbanisation definition:

Refers to the reasons for the increase in the number of people living in either rural or urban areas.

- Urbanists define urban areas by their high population density. They maintain that this characteristic makes cities physically and sociologically distinct from rural areas.
- However urban areas are defined differently in each country
- Census organisations of different countries classify their population into rural and urban population on the basis of the definition of an urban area which takes into account the local conditions
- Therefore, no standard global definitions of an urban area. However
  - **India** defines an urban centre as **5,000** inhabitants, with adult males employed primarily in nonagricultural work
  - The **USA** Census Bureau defines a city as a densely populated area of **2,500** people or more
  - **South Africa** counts a city any settlement of **500** or more people
  - **Japan**: Minimum settlement size **30,000 population**
  - **Australia** has two definitions - Urban is over **1,000** people where a major urban is over **100,000**

### World Patterns

Highly industrialised countries have higher rates of urbanised population than do less developed countries - higher level of urbanisation

Developing countries are rapidly urbanising - higher process of urbanisation

	Europe	South America	North America	Oceania	Africa	Asia
Level of urbanisation	74%	79%	81%	90%	40%	50%

### Urbanisation implications on world population growth and human well being

- Globally, more people live in urban areas than in rural areas, with **54%** of the world's population residing in **urban areas**
- Continuing population growth and urbanisation are projected to add **2.5 billion** people in the world's urban population by **2050**, with nearly **90%** of the increase concentrated in **Asia** and **Africa**
- During rapid urbanisation the population of a country is still growing rapidly, however with better access to education and healthcare in the cities population growth slows as urbanisation increases
- In the developed world population growth has already stopped and in most of the developing it is already slowing
- 'Full' global urbanisation should lead to world population hovering at about the 11/12 billion mark

### Human well-being definition:

The quality of life of a population including both objective and subjective factors

Positive of urbanisation on well being	Negatives of urbanisation on well-being
Greater accessibility	Rapid sprawl
Lower fertility	Pollution, and environmental degradation

Positive of urbanisation on well being	Negatives of urbanisation on well-being
Longer life expectancy	Unsustainable production and consumption patterns
Higher levels of literacy and education	
Better health services	

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## Overview of the challenges facing rural and remote Australia

### Population Loss

1. Rural Australia has low population. Depopulation has resulted from the increasing mechanisation of farms during the 20th Century and the amalgamation of farms combined with environmental degradation (salinity) and climate
2. These factors have resulted in rural to urban shift in the search of better employment and tertiary educational opportunities

### Land use conflicts

- Occurs when there are conflicting views on land use policies, such as the conflict between a mining company and conservation groups and Aboriginal land rights
- For example after years of campaigning, the community of Broome, local Indigenous groups, and environmental groups stopped **Woodside** Petroleum from its **proposed gas hub project for James Price Point in the Kimberley**
- The issue of rural urban conflict can arise when there is no separation between incompatible uses, let alone the misunderstanding which may exist about the purpose and character of a district. Land use conflicts may arise in such situations through noise, odour, farm chemicals, light, visual amenity, dogs, stock damage and weed infestation, lack of understanding and lack of communication to name just a few.

### Isolation and remoteness

- Australia is a large nation, with a population of approximately **24m** people distributed across an area of **7.7Mkm<sup>2</sup>**. Whilst many Australian cities, particularly state capitals, are more densely populated. Australia's average population density is low by national standards at **3.0 people/km<sup>2</sup>**
- The accessibility remoteness Index for Australia demonstrates that more than 50% of Australia is classified as "Remote" or very remote. Approx 2% of Australia's population lives in these areas, facing a range of social and economic challenges
- Due to their isolation, these areas tend to be remote from important social services such as healthcare and education, and poorly connected to communication technologies such as internet and mobile phone coverage. The physical distance between remote places and larger centres of business causes delays in the delivery of services such as basic health services
- The royal flying doctor service provides emergency and primary health care services for those living in rural, remote and regional areas of Australia. It is a not for profit organisation which provides health care to people who cannot access a hospital or general practice due to the vast distances of the Outback.

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The process that have contributed to the characteristics and functions of urban and rural places in Australia

### Urban sprawl definition:

Urban sprawl refers to the uncontrolled growth of a metropolitan area into its surrounding hinterland. Sprawl can significantly change patterns of land use as urban patterns of land use as urban functions replace agricultural or conservation functions within the Rural Urban Fringe. E.g Perth sprawls 150Km from two rocks in the north to Mandurah in the south

## **Invasion and Succession**

Invasion: The process by which one function moves into an area occupied by a different type of land use. Evident in the IMZ (inner-mixed zone) and RUF (rural urban fringe). E.g Residential and industrial functions invading RUF. As Perth is growing by approx. **30,000/yr** the demand for housing is growing - Butler, Ellenbrook, Jindalee

Succession: Is said to have occurred when the process of invasion is complete and all evidence of the original function has completely disappeared. Evident in the IMZ and RUF. e.g East Perth at one time was industrial. Today it is predominantly residential mixed with other uses.

## **Renewal**

Urban renewal involves the upgrading and redevelopment of blighted areas. Old buildings are demolished and new ones built. Renewal occurs largely as a result of the need for space as functions develop and expand. E.g East Perth Redevelopment (began 1992) transformed run down inner city suburb of poor quality housing, light industry, warehousing, derelict buildings into a vibrant, sought after area consisting of medium to high-density housing, parks, restaurants, cafe.

E.g Subicentro- Subiaco another example on a smaller scale. Also takes place in the RUF - upgrading and intensification of rural land use

## **Planning**

Urban planning authorities will make a deliberate attempt to zone like functions together and establish buffer zones around incompatible ones. Industrial areas may be separated by transport or green belt buffer zones E.g Perth's Corridor Plan (1970)

## **Land use competition**

Accessibility is the dominant force behind this process, as it influences land values. The most desirable sites are located close to the CBD as all major transport links converge on this point. As land is limited in the CBD and highly desirable the land values are extremely high

e.g only businesses able to produce a large profit can afford to be situated in the CBD - Central offices of banks, insurance companies (AMP, AXA), mining companies (Woodside)

### Economic Rent Mechanism

Applies to the CBD. As you move away from the CBD the intensity of land use decreases (becomes space extensive) and the economic rent (profit) decreases.

E.g Ribbon development of retail and commercial functions along Albany Highway - Victoria Park

## **Inertia**

Occurs when established functions resist changing their location until it becomes too expensive and/or difficult to maintain its use where it is

E.g Royal Perth Hospital - was built in a spacious residential site in East Perth in the 1950's. Due to the invasion and succession of CBD functions, today it is almost within the CBD. The building is so costly to related so new development/additions to the building is made upwards (i.e multi-storey)

E.g WACA Ground - East Perth

E.g Perth zoo - South Perth

## **Agglomeration**

Is the grouping together of different or related land use functions that benefit from each other's operations or in the use of shared infrastructure

E.g Industrial areas tend to congregate in one area so they reduce the costs of power, water supplies, take advantage of common infrastructure (road, rail transport network) or use the products/services of related businesses. Many transport companies and companies that supply component parts are located in the heavy industrial zone of Kwinana so they service neighbouring manufacturing industry

E.g Agglomeration of offices is evident along St Georges Terrace to take advantage of the prestigious address and allows for close contact between providers and consumers. Stock exchange, banks, stockbrokers, accountants

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## The changing demographics in urban and rural places in Australia

### **Demographics meaning**

- Statistical data relating to the population and particular groups within it. Generally split into age and gender, socio-economic and cultural

### General Australian Demographics

- Australia has a population of 25 million. Population is growing strongly at 2% per year. (approx 1 million people every 3 years) due to:
  - **Recent baby boom** - the total fertility rate in Australia is 1.9 babies/woman
  - **Longevity** - life expectancy has been steadily increasing. Currently men (79.9 years) and women (84.3 years)
  - **Migration growth** - Australia is still attracting migrants from overseas.
    - Australia's strong population growth is projected to continue into the future, with the ABS's medium projection estimating that Australia will grow to just over 30 million by 2031
    - Majority of Australians live in capital cities (15% live outside coastal and urban areas)
    - Populations in rural areas have drifted towards cities in past decades.

### **Age and Gender**

Australia's population is dominated by middle aged, middle income earners. Overall we have an Ageing population

Proportion of people aged 65+ years has been increasing and is predicted to grow substantially

Percentage of people less than 15 years old is set to decline at a similarly rapid pace. Main reason is people are having fewer children later in life and life expectancy is increasing

Median age: past generation= 29, current generation= 37, next generation =40 years

This presents challenges for transport and infrastructure across the country as well as health and aged care spending

### **Socio-economic**

24% of Australian have university degrees

For people aged 25-64 years, 56% were working full time in 2009. Among young people aged 15-19 years, 74% were participating in full-time study

Population in rural and regional Australia has lower incomes, reduced access to services, declining employment opportunities and disadvantages of distance and isolation

Mining activities attract people to rural and isolated places

### **Cultural**

The growth of Australia's population is the result of natural increase and net migration

High immigration rates - 1 in 4 (25%) Australians are foreign born

Cultural diverse - 34% of households have parents who have both been born overseas

55% of Australian population growth is from immigration (mostly from England, India and China) and 45% from natural growth

Religion : Christianity dominates at 60%. Increase in non-Christian religions including Buddhism, Islam and Hinduism

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## Economic and environmental interdependence of urban and rural places

### **Urban and rural interdependence**

Urban places interact economically and environmentally. There are flows of goods and services, energy, minerals, information and people along transport routes between rural and urban places.

E.g

### **Economic interdependence**

1. Food: Is produced in rural places and transported to urban places for further processing and distribution. In Australia **40%** of all farm produce is consumed domestically and **60%** exported overseas. Investment and research on food occurs in urban areas, e.g Food and Fibre research, support for education. The 'Royalties for Regions' program in WA has been the state government set aside millions of \$ to develop rural based infrastructure and facilities
2. Often agricultural raw materials are processed in large urban places and then redistributed as packaged food products to other urban and rural places
3. State and Federal governments in Australia encouraged agricultural activities by supporting land clearance and settlement schemes in rural areas. The creation of Rural banks, the basetting of towns and the establishment of road and rail networks facilitated the expansion of agricultural activities into a new rural area.
4. Mining operations provide a significant link between rural and urban places. Job creation, both in the rural area where the mines are found and in the major urban places where head offices and relevant government departments are located, is significant. **25-40%** of all office space in the Perth CBD is linked to the mining and exploration industries. More than 30 international oil and gas companies and more than 40 oil and gas service companies with offices in Perth.
5. Energy production for urban places is predominantly carried out in rural areas. The location non-renewable energy sources such as coal, oil and gas has typically been in rural areas and therefore many of the power generation facilities have also been found in these locations. Urban places have subsequently been established in these areas. The LaTrobe Valley in Victoria, the Hunter Valley in NSW and the town of Collie in WA are examples of centres of coal based energy production. Whilst these areas are under threat from dwindling supplies and/or concerns over the long term effects of fossil fuel based energy production, most renewable sources of energy production, which may replace fossil fuels - such as solar, wind, wave and geothermal will also be based in rural areas.

### **Environmental Interdependence**

1. Urban places rely on rural places to manage the environment effectively to ensure the needs of the growing urban population are met. Clean air and water, food and drought mitigation, soils and soil fertility etc. These are all largely dependent on how well rural areas are managed, often develop plans to manage and implement strategies to mitigate environmental issues in rural areas, such as agroforestry in the WA Wheatbelt
2. Rural areas increasingly hold some attraction to urban dwellers in terms of short term lifestyle experiences. The desire to experience opportunities for an escape, reflection, recreation and reconnection with nature in pristine areas of wilderness, beside the ocean off in wide open spaces is common. Alternatively an 'adventure' experience may be desired involving some degree of risk taking in 'wild' remote rural places. In the longer term urban dwellers may seek to relocate to rural places due to perceived or real benefits in terms of lifestyle, affordability, space and safety. Increasingly referred to as a sea change or a tree change, if this continues to occur on a large scale the very rural-ness of these favoured locations may be lost as they begin to reflect the characteristics of urban places. Urban areas of Mandurah and Busselton in WA have largely suffered this fate
3. Vastness and remoteness of rural areas often results in the flow of wastes from urban to rural places. Worldwide, rural places are often viewed as suitable dumping grounds for urban wastes and undesirable functions. Air pollution and acid rain from large industrial areas in North America and Europe threaten both cultural and physical environments. The dumping of toxic and even nuclear wastes typically takes place in rural and remote areas. The Australian outback has often been the focus of government debates as to whether it provides suitable location for such wastes from urban places worldwide. Practices in agriculture, mining and fisheries, aimed primarily at meeting the needs of urban places, have the potential to impact farmland, coastal, marine and forest ecosystems in rural areas
4. Urban places rely on rural places to manage the environment effectively to ensure the needs of growing urban populations are met. There are many ecosystem services provided by nature, primarily in rural regions, that are essential to human survival and wellbeing in both urban and rural places. Clean air and water, flood and drought mitigation, soils and soil fertility, pollution mitigation, pest control, seed dispersal, biodiversity and climate stabilisation are all largely dependent on how well rural areas are managed. A greater responsibility is expected of rural places in providing ongoing stewardship and management of these areas. However, both urban and rural places require healthy environments (soil,



water, atmosphere, biotic organisms) in order for both places to function effectively. If one place negatively impacts on the environment, then this will also affect the other.

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## The historical, cultural, economic and environmental factors that have contributed to the spatial distribution of urban and rural places in Australia

Factors contributing to the Spatial Distribution of Urban and Rural places in Australia

### **Historical**

- European colonial settlements have become the large urban capital cities in Australia today. Original settlement frontiers based on original colonial capitals of Sydney, Melbourne, Adelaide, Brisbane and Perth from where development expanded
- Historically, the coastal areas were first areas to be settled by Europeans - the state capitals have acted as a focus of further development

### **Cultural - Gold Rush**

- Isolated, irregularly dispersed rural settlements corresponding with the location of natural resources, such as mineral deposits, contribute to the decentralisation of population in Australia
- Immigrants, bringing with them their traditions, values and beliefs, have influenced the spatial distribution and characteristics of rural and urban places
- E.g Kalgoorlie

### **Economic**

- In Australia, smaller towns tend to be associated with fewer functions while larger cities are associated with more
- This then increases employment opportunities have also impacted on population distribution - most of the population has been attracted to major towns and cities due to the presence of secondary and tertiary industries

### **Environmental - climate**

- Areas with adequate rainfall and moderate temperatures provide good agricultural possibilities and living conditions
  - Australia's arid and semi arid areas have low population densities
  - Coastal areas have high population densities
- 

## An overview of the challenges facing urban areas in Australia as a result of urbanisation

### **Congestion**

- become an issue when transport infrastructure of a city does not keep up with the demand of its population and economy
- Economically, congestion costs a lot for cities e.g congestion costs Australia \$15B per year
- It also results in a loss of productivity and other issues, like the cost of fuel and vehicle maintenance
- In mega cities, like Beijing, congestion is a major issue, which has resulted in restrictions being placed on the number of cars that can be registered
- Restrictions have also been placed on which days people can drive their car

### **Urban Sprawl**

- Occurs when land is converted to urban development quicker than population increases
- Due to the cultural value people place on lifestyle associated with living in low density suburbia
- Significant cost to the government in the development of these suburbs

- Create further demand on energy supply, water and sewerage infrastructure, transportation and damage to natural vegetation
- 'Australian Dream' can result in low population density but many Asian cities have much higher density living

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## Investigation of Perth City

### **Site**

Refers to the physical features of the landscape (height, slope, aspect, landforms, drainage, vegetation) on which a settlement is built

### **Situation**

Refers to the location of a place described by referring to its absolute location, its distance and direction to other places and its links to other places.

### **Site of Perth**

- sited on swan coastal plain between 0-60m asl
- Sited on the confluence of 2 main rivers (swan/canning) with generally sand and well draining soils

### **Situation of Perth**

- Situated around many main HWY e.g Kwinana FWY
- Situation on the Southwest coast of WA Lat/Long 31°57 S 115°52 E
- Situated 150KM North of Bunbury

### **What is city morphology**

- City Morphology is the study of the form of human settlements and the process of their formation and transformation. The study seeks to understand the spatial structure and character of the metropolitan area, city, town or village by examining the patterns of its component parts and the process of its development

### **External Morphology Definition / of Perth**

- Refers to the outside shape of the built up area of a settlement. Take many shapes but most common are : Linear, Rectangular, Star/satellite Shape
- Perth has a semi-stellate/star shape that is becoming increasingly rectangular
- It has a compact core along Swan River and 5 corridors extending outwards from the city with rural land uses and bushland found between resulting in semi-stellate pattern
- It extends from Yanchep (north) to Mandurah (south) and from the coast to Mundaring (east). Perth Metropolitan covers a total area of 1600km<sup>2</sup>. Several satellite settlements e.g Ellenbrook

### **What factors have influences Perth's External Morphology**

Why is it half a star shape - SHEEP

**Social** - desire to live close to the coast, our cultural prefers open space, large housing blocks and detached homes

**Historical** - Needed to be close to the coast as ships were only means of connection to the outside world : all early roads converged on centre of plain where Perth was established in 1892

**Economic** - Flatter coastal plains - cheap to build, increased accessibility along transport routes is desirable for businesses and this has resulted in linear development

**Environment** - (site factors) coastal plain; flat land; Darling Scarp/Ranges, coastline (natural barrier to westward development) Swan-Canning river system

**Political** - planning - 1970's corridor plan: 1990 Metroplan, Network city 2004, Directions 2031

### **Internal Morphology - Definition / info**

- Refers to the layout of land uses and urban functions within a city, it is an examination of the internal structures within an urban area.
- This includes an examination at
  - The arrangement of functional zones within the area
  - Transport patterns
  - Building characteristics including size, shape and architecture IV, land values
- Functional zones are areas within an urban settlement that are dominated by the provision of particular sets of urban functions, e.g an industrial area
- Urban Function is the purpose or role of an urban area - the economic and social activities carried out by city dwellers in that area
- Perth's internal morphology contains a large number of urban functions aimed at meeting the requirements of the residents as well as the population. A city can't perform all its economic functions at one single point
- Various processes have been at work within Perth over a period of time which have given rise to today's differential pattern of land use, this is known as the internal morphology
- Perth's Internal morphology most closely aligns with the Multiple Nuclei model. The urban area is most concentrated around a compact urban core, the CBD, yet Perth relies on OBD such as Rockingham and Joondalup. The internal morphology is influenced by the external morphology such as the river and the scarp. The cultural values of the Australian dream and desire for coastal living has led to the sprawling nature and the location of its functional zones
- Site factors can account for the arrangement of land use zones within Perth. Site refers to the physical features of the landscape and can work to either attract or repel urban development. For example, heavy industrial sites such as Kwinana require larger areas of flat and stable land in close proximity to the coast.
- Perth's internal morphology has been influenced by the presence of the Swan-Canning River system and the proximity to the coast.

## **FUNCTIONS IN PERTH**

### **Central Business District (CBD)**

- This is the core of the metropolitan area and is recognisable by its grid like street patterns and its high density buildings seen by the high rise buildings on the skyline. It is located on the north bank of the swan river and contains the most intensive land use zone of the metropolitan area
- Most of the CBD is commercial and admin, with government buildings and limited residential. However new apartments and higher density living are becoming popular with younger professionals
- The area has a high daytime population and a lower night time population
- Due to the large commuting workforce, the CBD is a central transport node. All train services converge in the CBD, this is linked to the rest of the city through bus and road networks such as the Mitchell and Kwinana freeway.

### **Inner mixed zone (IMZ)**

- This is a transitional zone located just beyond the boundaries of the CBD and include suburbs such as NorthBridge, West Perth and East Perth
- It has the largest level of mixed use functions which includes residential, commercial, recreation and entertainment, light industry, transport and admin. High accessibility combined with lower cost means the IMZ is an attractive alternative to the CBD

### **Established residential zone (ERZ)**

- Is the largest functional zone within the metropolitan area and this obviously dominated by housing. This zone contains the oldest suburbs of Perth. Mount Lawley, Claremont, Victoria Park and Subiaco
- Houses here tend to be older with house prices varying depending on the attractiveness of the suburb, for example Claremont has an annual median house price of 1.4 million compared to Morely of 560,000

### **Newer growth zone (NGZ)**

- This is the new growth zone of residential development and tends to be located on the outer boundary of the established residential area, often joining the rural fringe. It includes suburbs Ellenbrook, Landsdale

and Alkimos. These areas are often lack full services and have to wait to get them such as the Ellenbrook train line. The land value in these areas is lower and often attracts young families

### **Industrial zones (IZ)**

- Light industrial zones are scattered throughout Perth such as Osborne Park and Welshpool. Heavy industrial areas are located further from the CBD such as the Kwinana industrial estate located 40KM south of the CBD

### **Rural urban fringe (RUF)**

- Perth Rural Urban Fringe is located on the outer edge of the metropolitan area. This is when Urban and Rural converge such as the Upper Swan and Mundaring. The Rural Urban Fringe is often characterised by a mix of land use with viticulture, recreation and rural industry to name a few.

### **Outer Business District**

- The zones within Perth are dispersed throughout the metropolitan area, often accessible locations amongst residential zones such as Joondalup and Rockingham. The main purpose of these areas is to decentralise jobs and provide services to people away from the CBD

### **Special Purpose Zones**

- Generally scattered and unevenly distributed throughout the metropolitan area. Their functions are not easily categorised and space extensive such as Perth Airport, parks and reserves e.g Kings Park and the Showgrounds

### **Demographic definition**

- Statistical data relating to the population and particular groups within it. Generally split into age and gender, socio-economic and cultural.

### **Age and Gender general characteristics in Perth**

- there is a higher % of 0-14 year olds in the outer suburbs such as Ellenbrook and Wannero
- As a % 15-64 tends to dominate central Perth and Freo
- Inner city areas such as Claremont, vic park and city beach have the highest proportion of 65 years and older
- The outer suburbs have the lowest proportion of 65 and over
- Overall there is more males in Perth than females. Males tend to dominate the inner suburbs and CBD
- Females dominate in Claremont, Peppermint Grove and Mosman park

### **Cultural diversity**

- Approximately 35% of Perth's population is born overseas
- Indigenous groups scattered around Perth but tend to be located in low socio-economic areas
- 'Pockets' of people born overseas are found within the metro area as newer arrivals tend to associate with people from a similar cultural background. High New Zealand population in Kalamunda, Vietnam in Mirrabooka and India in Girraween
- High proportions of overseas around uni and colleges
- White Australians tend to dominate high socio economic areas

### **Socio-Economic general characteristics in Perth**

- The highest stressed socio-economic areas are within the inner city and the outer suburbs
- The lowest stressed suburbs are generally the established residential zones of Nedlands, City Beach, Cottesloe, Peppermint Grove

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## Challenges of waste management

### Nature of waste management

Waste management is the collection, transportation, treatment, recycling and/or disposal of solid and liquid waste

### Waste management is regarded as a challenge when

- the amount of waste produced by an urban area is greater than the areas capacity to treat, recycle or dispose of the waste

### Waste is generally placed into two categories

- 1. solid waster - waste that is solid in form I.e general household rubbish
- 2. Liquid waste - includes sewage and waste water from industries, agriculture and houses i.e from toilets, showers, baths, sinks and washing machines

### The scope of the challenge

What is the scope (extent) of waste management in Perth ?

- the PMA doesn't have the required infrastructure for adequate waste treatment, recycling and disposal of the waste that is being produced within Perth making this a city wide challenge
- Perth produces over 6.9 million tones of waste per year with only 34% being recycled. Meaning that 2/3 of waste is sent straight to landfill
- However, the number and amount of space available in landfill sites (30 in total) is also decreasing I.e Tamala park set to close by 2028 with no further landfill sites planned to open in Perth

### Causes of the challenge

- The main causes of Perth's waste management challenges are
  - Population growth
  - Consumer society
  - Lack of waste management facilities

### Population growth

- With an ever increasing population within the PMA, this is only going to increase the amount of waste that is produced and needed to be transported, treated, processed, recycled or disposed
- It has been estimated that each day a person creates **3 kg** of waste (solid and liquid)
- And on average each WA person will produce **1.4 tonnes** of solid waste each year and a combined total of **2.5 tonnes** of waste each year
- With a current population of 2.2 million and expected increases
- Extra **500,000 by 2030, 3.5 million by 2050**
- Household waste generation in Perth will grow - rising from the current **6 million** to about **9.7 million tonnes a year by 2050**

### Consumer society

- this is a society in which people often buy new goods, especially goods that they do not need
- And throw away the old, as people tend to place a higher value on owning the latest and newest products / technologies
- This has also come about due to better living standards, including personal / household income
- e.g Growth in waste generation in Perth is positively related to growth in household income, with Perth residents having an average personal income of **\$728 / week** which has assisted in Perth having the highest per capita waste generation (2.56 tonnes) Consumer society
- This has seen an increase in the ownership of more durable goods per person (ie. electronics) and an increase in the consumption of nondurable goods which have higher packaging to product ratios than other goods)
- This creates the production of "e-waste" (electronic waste) with over 140,000 tonnes produced in Australia each year, with very minimal of these electronics being ... recycled (10%)
- In Australia, each person produces an average of 73kg of e-waste each year

- And Perth's wasteful society is also occurring regarding the food is wasted with 1/4 to 1/5 of all food purchased thrown away, which also impacts on the waste of resources that it took to produce that food

### Lack of waste management facilities

- Perth is one of the most sprawled and isolated cities on Earth, where transporting and processing waste for the ability of it to be disposed or recycled is an issue within the PMA due to a lack of facilities
- As Perth has a small population compared to other cities, the amount of waste generated (even though it's still quite a lot) doesn't make it viable (economically) for recycling processing infrastructure to be built in PMA
- Recyclable material and waste, once processed has to be transported long distances to landfill sites or recycling markets (mostly overseas - such as Vietnam, China and overseas) Glass is the only commodity recycled in Perth facilities, reused as road base - but glass isn't actually recycled as glass in WA
- The current handful sites, such as Tamala Park, Red Hill and Armadale landfill are filling up
- For example Tamala park is expected to be full by 2028, with no further viable landfill sites available within the PMA

### Implications of waste management

Social	Economic	Environmental
Increase in household costs due to an increase in the cost of the 'landfill levy' - the tax per tonne that is paid to the government for waste put in landfill (from \$75 in 2015 to \$212 in 2019)	Cost to find alternative solutions for waste are expensive - i.e RRF (\$82 million)	Creation and release of GHG through decomposition and burning of landfill (methane)
Loss of amenity and liveability within suburbs (odours, litter and illegal dumping)	Increase in transport costs of waste and recycling from urban sprawl to new facilities / close of filled sites	Rubbish that ends up as litter has huge environmental consequences on both the land and animal species, including birds, marine species, turtles, penguins and dolphins
	Cost to landfill currently costs \$212 / tonne compared to \$30/ tonne for processing and recycling material in yellow bins	Possible leakage (leachate) into the environment of toxic chemicals and materials from landfill sites .

### Waste Management stakeholders

The definition of a stakeholder is a person or group who has an interest in or investment in something and who is impacted by and cares about how it turns out.

1. Indigenous population - They do care - The landfill sites are on their land which holds cultural importance to them. - 2019 100 indigenous people went to parliament house to protest what's happening to the environment
2. General population - They do not care - they don't see the effects of waste management - out of sight out of mind - 2/3 of recycling is not recycled in WA

### Planning Strategies

- WA state government and the WA Waste Authority have outlined their strategies to address the challenge of waste management in the following planning documents:
  - WA Waste Strategy - Creating the Right Environment
  - Water Forever Plan
- Within these documents, the range of strategies that are adopted to address waste management include:
  - Resource Recovery Facilities (compost)
  - Material Recovery Facilities (recycling)

- Waste education
- Better Bin system (3 bin system)
- Waste water treatment plants
- Incineration of Waste (Waste to electricity)
- In general the WA Waste strategy plan aims to increase recycling rate to 65% by 30 June 2020. Currently about 30% is diverted from landfill

### **Resource Recovery Facilities (compost)**

- The RRF is a composting facility designed to take organic waste and turn it into compost. It has been running for 10 years and takes 100,000 tonnes of waste per year, turning 30,000 tonnes into compost
- Food scraps and all other general organic waste are transferred into compost in less than a month at a processing plant in Neerabup
- The facility takes the mixed solid waste (MSW) from Mandurah Regional Council (MRC), WA's largest waste management authority, managing the collection, disposal and treatment of waste by some 500,000 residents living in its locality. The MRC is composed of 7 member Councils: City of Wanneroo, Stirling, Perth, Joondalup, Cambridge, Vincent and Vic Park
- Organic waste is sorted through a sieve and magnet system and then turned into compost. The sorting process also allows for recyclable material to be then sent to recycling plants in the Eastern States and Overseas. 50,000 tonnes of recyclable material is recycled at the site leaving only 20,000 Tonnes of the 100,000 to be sent to landfill.

### **Waste Education**

- Free programs are run by the various City's in partnership with recycling companies with an aim to educate students about waste minimisation and management through implementing avoid, reduce, reuse and recycle principles. These programs have been designed to integrate with school curriculums, making it easy for teachers to use the sessions efficiently and as a part of the school year, rather than an additional topic to cover
- Children are recognised as great agents of change, encouraged to take what they learn from the program and utilise the principles within their school, at home and within the community. They will learn concepts and approaches for sustainable practices that should be carried forward into adult life.

### **Strategies comparison**

- These planning strategies can be compared and / or have been informed by strategies implemented in a number of other places both inside and outside Australia for example
  - Education and behaviour programs similar to that of Tokyo
  - RRF composting similar to that of NSW and Canada (but they are doing it so much better than us)
  - 3 bin system similar to that of over East (e.g Lismore City Council)
  - Waste energy inspired from Sweden, Norway

**Resource Recovery Facilities (compost)  
Informed from NSW and Canada**

NSW		CANADA - TORONTO	
SIMILARITIES	DIFFERENCES	SIMILARITIES	DIFFERENCES
The Kemps Creek Facility is currently licenced to process up to 134,000 tonnes of waste per annum, with approximately 55% of incoming material diverted from landfill. The process is exactly the same to turn waste into compost.	NSW has 4 RRF plants. NSW are looking to expand the facility to process up to 220,000 tonnes per annum and the recovery and recycling of plastics on site	The process is exactly the same to turn waste into compost.	Much more efficient – Due to the large amount of deciduous trees and therefore organic matter from the leaves, the Toronto plant is far more efficient and produces higher quality compost. Residents are better and sorting waste so no glass in soil.

**INFLUENCED BY / ENHANCED SUSTAINABILITY**

	POSITIVES	NEG
SOCIAL	<ul style="list-style-type: none"> <li>• 250 employees including drivers.</li> <li>• Smell from composting all kept in one place</li> <li>• Tours available and promotion to increase behaviour / awareness</li> </ul>	<ul style="list-style-type: none"> <li>• Bad habits can return to individuals as all waste can technically go into one bin.</li> </ul>
ECONOMIC	<ul style="list-style-type: none"> <li>• Minimise the impact of increasing landfill cost and the landfill levy.</li> <li>• All water and electricity used come from grey water from roof and solar panels</li> </ul>	<ul style="list-style-type: none"> <li>• Costs \$82 mill to build plus ongoing costs</li> <li>• The company is struggling to sell all the compost because of glass contamination</li> </ul>
ENVIRONMENTAL	<ul style="list-style-type: none"> <li>• Decreases waste to landfill sites</li> <li>• Re-use of a product – compost</li> <li>• Reduces methane emissions</li> </ul>	<ul style="list-style-type: none"> <li>• High amounts of electricity required</li> <li>• Only 2/3 diversion from landfill</li> <li>• Not strictly classed as compost</li> </ul>

**LIVEABILITY**

- Refers to the quality of the natural and built environment that adds to an areas / community’s quality of life

**Factors of liveability include**

- The amount of natural environmental
- Economic prosperity
- Social stability and equity



- Housing safety
- Access to services and transport
- Educational and employment opportunities
- Cultural, entertainment and recreation possibilities

### Enhancing Liveability

Education and employment	Economic Prosperity
<p>Jobs creation through the RRF, 115 construction jobs to build the facility, then employee over 250 employees to run the Facility</p> <p>Education opportunities at the RRF also further the liveability benefits of the facility. \$4.5 million dollars spend on waste education throughout Australia.</p> <p>Allows for the community to have an understanding about waste management and what they can do to help. This then improves waste reduction behaviours throughout the PMA and allows for livability to increase.</p> <p>The facilities allow education programs for schools, community groups and businesses as well as tours to the RRF</p>	<p>\$82 million spent of RRF in PMA from government</p> <p>Due to the facilities producing sustainable compost, this compost is then able to be sold, increasing revenue</p> <p>By limiting the amount of waste entering disposal sites each year, it minimizes the impact of increasing the cost of the landfill levy, allowing for a more livable community.</p>

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## Urban Sprawl

### Urban sprawl

- the uncontrolled growth of a metropolitan area into its surrounding hinterland. Sprawl can significantly change patterns of land use as urban functions replace agricultural or conservation functions within the Rural-Urban Fringe
- Urban Sprawl is regarded as a challenge in Perth because - Perth has maintained a very low density approach to development since the 1950's as it's population has grown over 400%
- As a result, it is one of the most sprawling cities on Earth, with over 3/4 of it being built in the last 50 years
- Perth's housing density is only 10 dwellings per hectare, less than half that of Adelaide, Melbourne and Sydney

### Scope of challenge

- Perth now stretches 150 km from Two Rocks in the North to Mandurah in the south covering more than 100,000 hectares or 6,000 km<sup>2</sup>
- Greater Perth will extend far beyond that area in the year's to come unless something is done to address urban sprawl.
- Perth is more than double the size of Tokyo and three times the size of LA! Despite our much smaller population.
- In 2014, the population of greater-Perth metropolitan area hit 2 million.
- With a current population of **2.2 million** and expected increases...
- Extra 500,000 by 2030, 3.5 million by 2050
- The ABS is predicting that Perth's population will more than double over the next 40 years to reach 5m by 2055.

## **The Causes of Urban Sprawl**

- The main **causes** of Perth's urban sprawl challenge are...
- Population Growth – Either from urbanisation, interstate migration or overseas migration
- Transport
- Centrifugal forces/Australian dream
- Government policies

## **Population Growth**

- Perth is a low density city with a population of over two million. By 2030 Perth will need to find the space for an estimated additional 500,000 people.
- Suburbs such as Ellenbrook have been built with a rapid population growth. These suburbs provide cheaper housing on bigger building blocks – The Australian Dream!
- Population growth has occurred in already established zones such as North Perth and City Beach
- To the north of Butler there are many new subdivisions, especially by the coast.
- Development of Ellenbrook commenced in 1992 and since then has been one of the fastest growing residential developments in Western Australia.
- Ellenbrook now has a population of approximately 40,000 residents who live in 'villages' clustered around the town centre.
- New housing estates are being built every year between Butler and Yanchep. Urban sprawl at a rapid rate

## **2. Transport**

- Perth evolved from a small, walking settlement to a large transit-orientated city by the 1900's. Eventually it has become the sprawling low-density car dependent place of today
- High motor vehicle ownership and road transport networks have reshaped Perth's morphology. The factors combined have contributed to a reduction in functional distance, that is, people are able to travel further in a shorter amount of time. Perth's car focused society impacts the way the city grows
- Using the new extended freeway it is now possible to travel from Yanchep to Perth city in 45 minutes without traffic
- Eg. Mitchell freeway, extended 30 km north to Burns Beach, encourages Perth's expansion north. Planned extensions further North extend to Yanchep beach road and will link up the outer suburbs of two rocks (approx 65km from the CBD). New developments of Alkimos, Yanchep and two rocks illustrate the leapfrogging of urban growth north
- Increased road access to the NorthEast of Perth through road development such as the Ride and Tonkin highway have increased access to places such as Wanneroo and Ellenbrook

## **3. Centrifugal forces**

- Centrifugal forces (e.g inner city traffic congestion, noise, pollution and crime) push people and functions away from the centre of Perth; while, the attraction of cheaper land, large blocks, new homes and open spaces pull people and functions towards the newer outer suburb areas
- Locations on the suburb of Perth offer large (half 10 acre) properties. Many suburbs offer a semi-rural lifestyle within commuting distance to Perth. These include Parkerville and the upper Swan
- This combined with the availability of cheaper, larger block of land (the Australian dream) push and pull people to outer suburbs

## **4. Government policy**

- The plan provided the early basis for the city's current spatial form, characterised by urban corridors separated by green wedges of non urban land uses.
- The corridor plan for Perth was adopted by government in 1970, and was developed in response to rapidly increasing car ownership and lower than expected residential densities
- The facilitation of job creation and employment growth in a new pattern of centres throughout the middle suburbs, high levels of accessibility via both public and private transport and a new system of metropolitan parks
- The growth of Perth has been strongly controlled by the Corridor plan. Since its creation, growth has occurred outwards along major transport corridors towards decentralised business centres. The rapid population growth experienced by Perth in recent years put pressure on the government to release land

quickly for residential development. New housing developments on the urban fringe were quickly developed

- First home owner grant. Currently today a first home owner will receive a grant of \$10,000 if they buy a new home compared to \$3,000 for an existing home. In the past (2000) a new home owner would receive \$7,000 for any house they purchased and a further \$7,000 if this was a new build property

### **Urban Sprawl Stakeholders**

- A person or group who has an interest in or investment in something and who is impacted by and cares about how it turns out
- Potential stakeholders interested in the issue of urban sprawl could be :
  - Government parties
  - Environmentalists
  - Individuals who previously lived on the fringes
  - Individuals who want cheap housing

### Planning strategies

- WA state government have outlined their strategies to address the challenge of urban sprawl in the following planning document
- **DIRECTIONS 2031 AND BEYOND**
- Within this document, a range of strategies are adopted to address urban sprawl and include
  - High density living including TOD's
  - Redevelopment and infill
- Directions 2031 replaces all previous metropolitan strategic plans for the metropolitan Perth and Peel region and supersedes the draft Network city policy. It provides directions on
  1. How we provide for a growing population whilst ensuring that we live within available land, water and energy resources
  2. Where development should be focused and what patterns of land use and transport will best support this development pattern
  3. What areas we need to protect so that we retain high quality natural environments and resources
  4. What infrastructure we need to support our growth
- These directions are aimed at addressing economic, environmental and social concerns within Perth. Urban Sprawl causes all of these problems and is addressed

### **High Density living. - including TOD's**

- Reduction of lot sizes (from 608m<sup>2</sup> in 2003 to 450m<sup>2</sup> in 2013)
- Increasing high density housing complexes focusing specifically on inner city e.g East Perth and TODS e.g Cockburn Central
- Urban infilling in central areas of the city should provide a further 121,000 dwellings, with a further 33,550 to be scattered across outer areas
- In 2015, the WA government announced plans to address the challenge of Urban sprawl in Perth. Trends indicate that an estimated 800,000 homes will be needed to be built in Perth in the next 35 years
- Over the past 10 years Perth has already seen a reduction in lot sizes from 608 square meters in 2003 to 450 square meters in 2013. Because of this there has been an increase in demand of apartments in the inner city, especially East Perth

### **Redevelopment and infilling**

- Before 2031 the infill rate of suburbs was 35% with a new target of 50%. Often for infilling to occur new rezoning need to occur by implementing R-Codes
- R-Codes indicate how many dwellings can go on 10,000 square meters (1 hectare) of land. For example r20 means 20 dwellings on 1 hectare at a 450 meter square average. This is low density. Therefore the higher the rating then the higher the density.
- 25 and below = low

- 30-60 = average
- 80 and above = high

### **Strategies comparison**

- There planning strategies can be compared and / or have been informed by strategies implemented in a number of other places both inside and outside of Australia for example Sydney - TODS and urban infilling. NYC- TOf's, via Verde

### **Sydney - Urban infilling**

#### **Polycentric Cities**

- all modern cities are trying to learn from the past by creating poly centric cities. Activity centres are mixed up 'mini cities' set up across the city. Sydney's past planning strategies such as 'City of Cities' and the '20 minute city' are based around the concept of the poly centred city

#### **Concepts from taken inside Australia**

- Perth looked to Sydney and Adelaide for solutions to Urban sprawl such as subdividing and infill targets. However Perth target is well below most Australian cities Sydneys target at 70% meaning only 30% of new houses are built on the outer suburbs. Those blocks built on the outer suburbs are much smaller again creating higher density and less sprawl. Local councils have generally be more willing to increase housing density and encourage subdividing and infill compared to Perth
- Perth has looked at the rezoning of suburban town centres using public transport nodes to increase densities and mixed use developments. The success of these in Sydney encourage the use of TOD's such as Subiaco and Cockburn

#### **Sydney**

- A standard Sydney property has gone from 312sq m in 2010 to 285sqm - a loss of 27sq m or roughly the areas of a small city bus - and forecast suggests properties will continue to get smaller. Population growth estimates show Sydney will need between 20,000 and 35,000 new homes built each year until 2050, but small properties will form the bulk of this construction activity if builders continue to favour high rise apartment developments over detached housing
- Councils have also made it easier for builders to construct smaller dwellings and this is particularly evident in areas such as Campbelltown, where the minimum lot size permitted by council has gone from 700sq m in 1992 to the current requirement of just over 200sq m

#### **New York - Via Verde**

- Via Verde, the subsidised housing development now rising on a long, narrow slice of formerly contaminated city property in what used to be one of the worst stretches of the South Bronx
- The low and moderate income residents spiral around what will be leafy, semi-enclosed court
- Single family own houses are taking shape alongside a 20 story apartment tower overlooking the sea of housing complexes that have transformed the neighbourhood
- Conclusions based on how successful this strategy has been in addressing Urban sprawl is varied
- Since the target was set in 2010, this has increased and lot sizes have decreased. For example in 2014 size was 393m squared compared to 457 m squared in 2009. There has also been a 40% reduction on development rate of underdeveloped Bushland
- Of the 32 local councils in Perth that set targets to subdivide and infill only 50% have reached their target residents and community groups are against Urban sprawl they are also against the medium to high density developments close to their homes

#### **Liveability**

- refers to the quality of the natural and built environment that adds to an areas / communities quality of life

#### **Factors of liveability include**

- the amount of natural environmental
- Economic prosperity

- Social stability and equity
- Housing safety
- Access to services and transport
- Educational and employment opportunities
- Cultural, entertainment and recreation possibilities

Economic Prosperity	Social Stability and Equity	Access to Services and Transport
<p>- Cockburn is centred upon a main Square with transport opportunities to connect with City jobs. To enhance private job opportunities the government has invested heavily in government related jobs such as health care, police and Environmental Protection which should improve confidence in the area enhanced private businesses. By providing jobs where people live this enhances liveability as commuter times are reduced along with the cost of transport. This allows people to socially spend more time with their family and economically have a greater disposable income.</p>	<ul style="list-style-type: none"> <li>- An important aspect of liveability is to create a cohesive, connected and safe community. In terms of safety houses and Apartments overlook public open spaces and Streets are well lit for security. This improves surveillance and reduces crime in the area.</li> <li>- A key aspect of liveability is to create communities that by a wide range of Housing services that are affordable. The suburb of Cockburn is achieving this with the current median house price of 400000 well below the Perth median of 530000. Apartments provide a mix of private and public housing options with more affordable apartments on the lower floors and more expensive apartments on the higher levels.</li> </ul>	<p>A major Target of liveable neighbourhoods is to have at least 60% of the population live within a 400 metre walk of services and facilities. For example the square and public transport options. Cockburn easily reaches is Target which encourages engagement between residents and access to essential services.</p>

Tods sustainability	
<b>Social</b>	<p>TOD's are socially sustainable as urban sprawl has promoted the lower income families to be pushed onto the outskirts of the metropolitan area and become isolated. Apartments such Cockburn Living are not only affordable at around 300,000 but located around employment opportunities to enhance social well-being of Cockburn residents. Community areas such as the central square promote social behaviors and interaction within the area.</p>
<b>Environmental</b>	<p>Cockburn is designed to fit a suburb of residents within 12 hectares of land. R60 codes throughout the area mean high density living which reduced the environmental impact of sprawl elsewhere. The apartments in Cockburn have also been designed with consideration for the environment. Apartments use passive solar energy as well as grey water from the roof-tops and solar panels for energy.</p>

Tods sustainability	
<b>Economic</b>	All the apartments in Cockburn have been designed so the bottom floor can be used for businesses. This promotes economic growth has employment opportunities are increased. The proximity of the trainline within 800m for all residents also provides easy access to the City for employment. Government building are also based in Cockburn such as Cockburn police station and DFES.

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## NEW YORK

### Site

- on a natural harbour e.g Hudson River leading to Atlantic
- On an undulating coastal plain e.g average elevation NYC 10m asl
- Built above solid / stable bedrock e.g Browstone

### Situation

- Relatively close to Boston e.g NYC lies 350km SW. Of Boston
- Situated in NE United States e.g Located at 40 42 N 74 00 W
- Positioned on coastal trade route e.g Access to Europe and Africa

### City morphology

- City Morphology is the study of the form of human settlements and the process of their formation and transformation. The study seeks to understand the spatial structure and character of the metropolitan area, city, town or village by examining the patterns of its component parts and the process of its development

### External morphology

- Refers to the outside shape of the built up area of a settlement. Take many shapes but most common are: Linear, rectangular, star
- Manhattan has a linear morphology along the 21.6 km length of the island
- However the metro area of NY itself is multicellular with the Hudson River and east rivers dissecting New York City
- The external morphology expanded once bridges and tunnels could expand NY across the physical barriers
- Examples include Manhattan bridge and the Lincoln tunnel
- Today the Atlantic coastline restricts the city as does the mountain ranges scubas the Catskills.

### Internal Morphology

- Refers to the layout of land uses and urban functions within a city, it is an examination of the internal structures within an urban area.
- The location of NY functional zones form a complex spatial pattern
- Within metro NY there are the original cities of the 5 boroughs and all their business, commercial, industrial and residential areas
- Transport routes are largely responsible for the shape and layout of NY
- In 1811 the 'commissioners plan' was established to solve the problem of uncontrolled planning in NY. The area of Manhattan was becoming cramped leading to serious health problems
- The plan established a grid system in NY. 12 North to South street and 155 East to west streets.

### Functions

## **1. Central Business District**

- Manhattan is accepted as NY central Business and financial district with the other cities forming large outer business districts. Manhattan is made up of districts and neighbourhoods all with their distinctive characteristics .
- Characterised by high rise office towers, major financial institutions and high prices
- High day time traffic with 300,000 professionals working in the area
- Most commute via ferry, subway or rapid transit railway

## **2. Inner mixed zone**

- TriBeCa, SoHo and Chelsea are all imp
- Were once manufacturing and distribution hubs but was abandoned due to push factors by the mid 1900's
- They fell into despair and were occupied by low socio economic
- By the 2000's the area was converted into luxury loft apartments which became popular with high income groups
- It now has upmarket boutiques, restaurants and bars as well as prestigious schools such as the Stuyvesant High School
- They have been turned into a trendy inner city residential areas with a mix of high value mixed land uses, with heritage facades.
- Lower East Side and East Village - in the mid 1900's were established with apartment buildings to house the thousands of immigrants entering NY
- Today young people occupy the many and crowded apartments
- A dynamic social scene of restaurants. Clubs and festivals exist in these areas

## **3. Residential zone**

- As the population grew and land values increased people sought out cheaper areas to live
- The suburbs had cheaper land, less congestion and larger block sizes
- The extensive transport system allowed people to commute to Manhattan for work
- Residential areas include : Brooklyn Heights, Crown Heights, Williamsburg, Riverdale, Long Island City

## **4. Rural Urban Fringe**

- Urban Sprawl is the result of little planning controls on urban development
- Fringe land has been developed due to non farm growth in rural and semi-urban areas
- Population has decentralised seeking larger cheaper blocks and less congestion
- Greenfield sites are being developed as urban estates
- Transport links allow residents to commute quickly and easily to the city
- Jobs have also been decentralised through the NY Metro Area making it a quicker commute
- The enlargement of approx. 2500km<sup>2</sup> reflects this expansion of employment interchange between the central counties and counties outside the metro area
- Hunterdon County is located on the edge of the NY Metro Area. However it is situated in New Jersey showing the sprawl through transport routes into other states

## **5. Industrial zones**

- Industrial functions have agglomerated throughout NYC
- 2006 NYC created 16 industrial Business Zones (IBZ) across the city
- Aimed at protecting current manufacturing districts and encouraging industrial growth city wide
- IBZ's established in various neighbourhoods e.g Hunts Point
- Those that service Manhattan are located nearby to reduce delivery time and congestion
- IBZ's also established along the waterfronts such as the Port Authority of NYC and New Jersey terminals
- Hunts point is a neighbourhood located on the peninsula in the South Bronx of NYC, it is the location of one of the largest food distribution facilities in the world

## **6. Special Purpose**

- Functions include universities, airports, hospitals, cemeteries, sporting venues and parks
- NYC has 3 major airports - JFK International is 20km SE of lower Manhattan on Long Island
- NYC has many public parks and open spaces, approx 14% is covered in green spaces (29,000 acres)  
Central Park was the public Landscaped Park in the USA it covers 843 acres and includes a zoo, a lake for boat rides, a water exhibition and restaurants
- Sporting Venues are spread throughout NY metro area, most large arenas are aligned with public transport and dispersed through Industrial and residential zones

## **Demographics**

### Age and Gender

- There are more females than Males in NYC overall
- Most populated area in NYC is Brooklyn
- The lowest male to female ratio is in Bronx with 89.2 males per 100 females
- Children are mostly located in Bronx and Queens, and a majority of young adults (20-24) in Bronx
- Young adults (24-29) and adults (30's) are mostly located in Manhattan, middle age (40-50) are mainly located in Brooklyn, Staten Island and Queens, and elderly people (over 85) are located in Manhattan

## **Cultural diversity**

- African Americans predominantly make up the area of Bronx and Harlem and a large portion of eastern side of Queens
- The whites take up Staten Island and the South of Manhattan
- The Hispanic takes up the South of Bronx and the North West of Queens
- Queens and Brooklyn are multicultural
- Manhattan contains small communities such as China town, Little Italy
- The Northern Manhattan suburb of Washington Heights has a high concentration hispanics, also in Jackson Heights in Queens

## **Socio economic**

1. Staten Island - \$70,295
2. Manhattan - \$66,739 (highest - upper east side, lowest - lower east side)
3. Queens - \$54,373
4. Bronx - \$45,321 (lowest - hunts point)
5. Brooklyn - \$44,850

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## **Congestion -NYC**

- Is when the flow or movement of vehicles travelling along road networks is slowed. Congestion can be either random or recurring

Congestion is regarded as a **challenge** when the effects of congestion have significant social, economic, and environmental impacts

### **Scope**

- Traffic congestion plagues NYC as roads across the city become clogged with traffic. About 3.7 million people work within NYC on a weekday with almost a million still driving their cars
- Manhattan's population swells by 1.5 million during the day. The average commute time in NYC is not estimated at 39 minutes
- The public transport system is well developed with 50% of commuters using the rail and bus networks. However of the remaining commuters 10% walk or ride leaving 40% using cars mainly as single drivers

## **Causes of congestion**

### **roads used for freights**

- Many of the goods that are used and built in NYC are transported on the same roads as car users. The old high line which was a train service throughout the heart of NY dedicated to manufacturing has closed. It has little chance of re-opening as it is now a tourist attraction as an award winning redevelopment program
- This means that all freight trucks are on the same roads at similar times to commuters increasing congestion throughout NYC

## **Ride Hailing Services**



- There are over 13,000 taxis combined with an increase in Uber, Lyft and Ola services that place over 50,000 vehicles in some of the most congested parts of NYC. The area that most people are travelling to is South-Manhattan and the nature of Ride Hailing means car stopping and picking up passengers which heightens congestion, especially at peak times.

**Manhattan Island**

- NY being a series of interconnected island means that vehicles have to cross bridges to access different islands, especially Manhattan. There simply aren't enough bridges and tunnels connecting Manhattan to accommodate the amount of vehicles. Bridges cause natural bottle necks as drivers have to merge to cross over one of the few options
- The problem is enhanced by the fact that 4 of the bridges over the east river are free e.g Manhattan Bridge and Brooklyn Bridge. Commuters are driving the 'long way round' through the busiest part of Manhattan to avoid paying the \$16 round trip toll on the Queens and Brooklyn tunnels.

**Implications**

Social	Environmental	Economic
Over half of Manhattan's and large parts of Brooklyn and Queens have average travel speeds of below 20kph during the peak morning and evening period. This means that commuters have to leave earlier and arrive home later significantly reducing the amount of family time they have	More cars on the roads means more pollution, reduced air quality, greenhouse emissions and therefore global warming. Vehicles caught in traffic congestion consume more fuel due to excessive braking, idling and acceleration. This contributes further to air pollution through increased carbon dioxide emissions. The average car emits 6 tonnes of carbon per year which increases the impacts of the enhanced greenhouse effect	It has been estimated that the loss of productivity has led to the loss of over 50,000 jobs in NY metro area alone and reduced productivity, increased shipping times and pollution related health problems cost the NY region more than \$13 billion a year.

**Planning strategy**

- The NYC state government have outlined their strategies to address the challenge of congestion in the following planning document
  - ONENYC
- With in this documents, a range of strategies are adopted to address congestion and include
  - The development of Public Transport
  - Houses near work - including Tod's
  - Bike sharing scheme

**Bike sharing scheme - Citi Bike**

- Citi Bike is a privately owned public bicycle sharing system serving New York City as an effective solution to traffic congestion in NYC. Since 2006, commuting numbers have doubled to around 20,000 as some 360 km of new bike lanes were developed within the boroughs. While bicycling storage and security issues continue, alternatives have been sought in the form of bike sharing programs.
- In 2011, the Bloomberg administration introduced a bike sharing scheme, making 10,000 bikes available around the city. 500 bike stations are spread across 50 neighbourhoods, focusing on Manhattan, and also in Queens, Brooklyn and New Jersey which as of 2017 has expanded to 706 stations and 12,000 bikes. Using a phone app or the 'kiosk' at any bike station and credit card, a day pass (\$12) ,3 day pass (\$24) or yearly pass (\$14.95 per month) can be purchased.
- In Mayor de Blasio's OneNYC, the city will add another 320 km of bike lanes in the next 4 years and 10% of these will be protected. Protection comes in the form of three-lanes; a pedestrian footpath, a cycle lane followed by a lane of parked cars. The parked cars provide a safety barrier between the pedestrians and

cyclists. The plan aims to expand the Citi Bike program with more bikes and stations, but most importantly expand the bike network into the boroughs where it can attract more working commuters and target traffic congestion. OneNYC details the expansion and maintenance of the Citi Bike program which is a significant solution to traffic congestion as it gets people off the roads and out of cars and onto bikes to move about New York City. New York City's bike sharing program has been sponsored by Citibank and MasterCard and has been a success based on rider numbers, attracting both tourists and locals alike.

### Strategies comparison

Similarities	Differences
<ul style="list-style-type: none"> <li>- Same bikes – bank sponsorship</li> <li>- Similar cost to use, however NYC more expensive</li> <li>- No need for helmets</li> <li>- Bike stations around the city</li> <li>- Simple and easy use pick up and drop system</li> </ul>	<ul style="list-style-type: none"> <li>- Longer for free with the annual subscription</li> <li>- Angel app to deal with uneven bike distribution</li> <li>- Car parked, provide extra safety</li> <li>- Government funded in London, privately owned in NYC</li> <li>- Bike station set in the ground in London, however can be moved in NYC if there is a change in demand</li> </ul>

Bike Sharing Sustainability	
Social	<ul style="list-style-type: none"> <li>- Bicycling avoids traffic congestion and makes people less stressed. It also has significant health benefits, increasing fitness levels means cyclists are less likely to rely on the heavily subsidised health systems. Since the increase in cycling in NYC the risk of injury has declined considerably since 2000. Using the Angel app means people can get rewards from just their normal commute which increases social well-being</li> <li>- Gets people outside / meeting new people</li> <li>- Scenery is pleasing</li> <li>- Less health problems</li> <li>- Reduces time from 38 min commute to less</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>- A cyclist takes up far less road space than a car, consequently other urban land uses and functions can be accommodated for, including open spaces and housing. Moreover, less on-street parking is recruited and the activity does not contribute to climate change through vehicle emissions. Many New Yorkers live within 5km of their work place so faster moving traffic has a positive effect on the environment.</li> <li>- Bikes easier to recycle</li> <li>- Less oil demand</li> </ul>
Economic	<ul style="list-style-type: none"> <li>- The public cost of bicycling infrastructure is minimal when compared to other forms of transportation. New York City's bus and subway systems are heavily subsidised. The cost of building a km of freeway can equate to hundreds of km of bike paths, which take far less time to construct. Citi bike generated \$36 million in its 1<sup>st</sup> year and created 170 new jobs</li> <li>- cheaper to make bike paths than roads</li> </ul>

- The planning strategies can be compared an / or gave been informed by strategies in a number of other megacities
- Bike sharing scheme - Paris and London
  - Introduced in 2010
  - 20,000 users a day in the 1st 6 months

- Currently 12,000 cycles and around 700 docking stations
- \$180 for a year and \$4 a day access fee
- Free to use under 30 minutes - \$4 after every 30 mins after
- The only issue is most users have come from other forms of public transport

Economic Prosperity	The Natural Environment	Access to Services and Transport	Social stability and Equity
<ul style="list-style-type: none"> <li>- Indirect economic benefits can be gained from reduced traffic congestion and green infrastructure can add to the appeal of areas, lifting real estate values. As well as, much of the money spent on cars goes offshore and is not circulated through the local economy.</li> <li>- Cheaper transport costs</li> <li>- Less money spent on health care</li> <li>- Rewards for riding</li> <li>- Sponsor by Citibank which provides free advertisement</li> <li>- No cost for servicing car/ bike</li> </ul>	<ul style="list-style-type: none"> <li>- Taking cars off the road eliminates smog and emissions which can improve the visibility of New York, making it a more liveable city as people can have less respiratory issues and it nicer to be outside and around. The most liveable cities in the world have removed most cars off roads which not only eliminates congestion but also a lot of CO2 emissions making the environment better for the Earth but also better to live in.</li> <li>- Better air quality</li> <li>- Preserve biodiversity</li> </ul>	<ul style="list-style-type: none"> <li>- Bicycling is accessible to all socio economic groups and unlike congestion charging it does not discriminate against the poor. It can also be considered a social time for people who can ride with people and experience the streets rather than being stuck inside a car. At \$155 per year is offers a method of transport to local services for everyone.</li> <li>- Quicker transport times</li> <li>- App - shows availability - makes it quicker</li> <li>- Go at your own speed</li> </ul>	<ul style="list-style-type: none"> <li>- increase fitness and well being</li> <li>- Increase time spent with family</li> <li>- Decrease stress due to depress congestion</li> <li>- Everyone can afford</li> <li>- Better aesthetics compared to train</li> <li>- Seasonal</li> </ul>

- **Liveability**

Liveability refers to the quality of the natural and built environment that adds to an areas / community's quality of life.

- Factors of liveability include
  - the amount of natural environment
  - economic prosperity
  - social stability and equity
  - housing safety
  - access to services and transport
  - educational and employment opportunities
  - cultural, entertainment and recreation possibilities.

## Waste management -NYC

### Nature

- Waste management is the collection, transportation, treatment, recycling and/or disposal of solid and liquid waste. The nature of the challenge of waste management in NYC is that the cities growing population and high density living is resulting in limited space to treat waste, that is, the amount of waste produced by an NYC is greater than the areas capacity to treat, recycle or dispose of the waste.

### Scope

- The scope of waste management is that NYC has a population of 8.7024 Million residents (2018), which generates above 14 million tones of waste and recyclables per year (City of New York, 2014), which is collected by two systems (NYC Department of Sanitation DSNY and private companies). The DSNY collects approximately collects 3.8 million tons of solid waste a year, with only 14% being recycled, 76% sent to landfills and 10% converted to energy. Waste sent to landfills can travel as far as 1200km's to landfill sites in Pennsylvania, Ohio, Virginia and South Carolina. NYC spends approximately \$1.5 billion (\$500 per household) annually to collect residential and public waste, with over 2000 garage trucks and 5900 sanitation employees.

### Causes

Urban sprawl	Consumer society	Population growth
<ul style="list-style-type: none"> <li>- NYC is famous for having a high density living, with a population density of 10,194/km<sup>2</sup></li> <li>- To accomodate this high population density, apartment buildings are tall and cramped with units, with the units being small</li> <li>- uncommon to find segregated waste in an NYC apartment- everything put in one bin.</li> <li>- apartment buildings have centralised waste rooms in the basement, citizens needing to travel up/down stairs to remove their waste, = poor recycling habits</li> <li>- With the population shifting to the outer suburbs rather than living in the inner city, waste is being transported longer distances to management facilities, = costly and expensive</li> <li>-</li> </ul>	<ul style="list-style-type: none"> <li>- buy new goods, and is able to purchase wants not only needs.</li> <li>- goods start to appear old, new models become available or they break, citizens simply throw it away and purchase a new one, with many citizens viewing popularity status on owning the higher value and latest products / technologies.</li> <li>- Products designed to break</li> <li>- prestige</li> <li>- 12.5% of e-waste being recycled each year</li> <li>- better living standards, with the average wage in NYC being \$652 per week. = increase in ownership of durable goods</li> <li>- increase in the consumption of nondurable goods which have higher packaging to product ratios than other goods.</li> </ul>	<ul style="list-style-type: none"> <li>- the amount of waste that is produced and needed to be transported, treated, processes, recycled or disposed will also increase</li> <li>- increase in food, packaging, construction materials (increase in population will increase the amount of new developments to accommodate this growing population), paper, plastics, glass, metals and many more types of wastes.</li> <li>- increase to 9 million persons by 2040, which is an increase of 783,000 (9.5%) since 2010</li> <li>- 2 kg of waste each day,</li> </ul>

## Implications

Social	Economic	Environmental
<ul style="list-style-type: none"> <li>- use of landfill sites and waste transfer stations attracts rodents and parasites = cause disease and bacteria which can both impact the community and the local environment.</li> <li>- type of waste placed in these sites can expose animals and humans to hazardous materials which scientists believe can increase the chance of human/animals developing cancer.</li> <li>- landfill and waste transfer sites (WTS) are located close to apartments and businesses. 26 of the 38 waste transfer stations are located in North Brooklyn, South Bronx and Southeast Queens. These areas are experiencing a loss of liveability as odours and litter</li> </ul>	<ul style="list-style-type: none"> <li>- process of waste management, from collection to recycle/disposal is extremely expensive.</li> <li>- paid for by councils of each borough and state government.</li> <li>- approximately \$1 billion annual budget for solid waste management and approximately \$300 million is spent to export the waste out of state.</li> <li>- Trucks are travelling further into the suburbs to collect solid waste and as a result are needing more fuel. This combined with rising fuel costs has put strain on the NYC budget for waste management.</li> <li>- increase of transportation vehicles needed to accommodate for the increase in waste. This increase in waste has led to an increase in landfills and waste transfer stations</li> <li>- Sanitation Department has opened 4 new waste transfer station</li> <li>- annual waste bill is expected to increase to \$421 million by 2021</li> <li>- two more WTS opening in Brooklyn and Upper East Side. The average cost per tonne has increased from \$63 to \$129 since 2007, with prices expected to increase.</li> </ul>	<p>releases Green House Gases (GHG), particularly methane and carbon dioxide, Toxic waste dumped in landfill can contaminate surface water, groundwater, soil and air</p> <p>Decomposing material can produce a toxic substance known as leachate which can pollute waters</p> <p>litter which has extreme environmental consequences on both the land and the organisms in this area.</p> <p>Around the world, an estimated one million birds and 100,000 marine mammals and sea turtles die each year as a direct result of litter finding its way into the ocean.</p>

## Planning strategies

1. One planning strategy that NYC uses to manage its waste is collection by two separate systems.
  - One is public and the other is private.
  - The public sector, run by the New York City Department of Sanitation (DSNY), provides for residential buildings, government agencies and non profit organisations.
  - Private commercial business so not receive free waste collection from the city government. Hence they must pay private companies to collect their solid waste.
  - Three quarters of NYC's waste is generated by commercial businesses, with most of it being debris from construction projects.

- The private waste collection system involved a group of 248 waste companies that are regulated by the Cities Business Integrity Commission. The
  - The commission licenses waste removal companies to remove commercial waste. The DSNY works with the Sims Multi Recycling Recovery Families, the Department of Parks and Recreation and GreenNYC to control the city's waste through reduction strategies in waste reduction, recycling and composting and organic waste diversion. Annually, the collection of residential and commercial solid waste is approximately \$2.3 billion of the city's \$75 billion budget.
2. A second strategy that NYC is using to address the issue of waste management is the development of the waste equity legislation which is sponsored by the NYC Council.
- This legislation limits the amount of waste that can be sent to high populated neighbourhoods.
  - These neighbourhoods house privately owned waste transfer stations. 26 of the 38 waste transfer stations are located in North Brooklyn, South Bronx and Southeast Queens. These stations store waste brought by truck until shipment to out of city landfills, recycling plants and composting facilities can occur.
  - These stations cause congestion of trucks, noise pollution and smell which disrupts the quality of life of the residents nearby.
  - The waste equity legislation lowers the permitted capacity of waste transfer stations by 50% for North Brooklyn and 33% in South Bronx and Southeast Queens. The legislation allows for growth for recycling and composting, and for waste to be transported by rail instead of truck, which allows the facilities to be more environmentally friendly.
  - The legislation is the beginning of a major improvement plan for the commercial waste handling operation in NYC. Environmental organisations are pushing for the creation of a zoned system to be incorporated into the city to replace the current illogical and unsustainable collection process of waste management.
3. A third planning strategy that NYC has incorporated into their waste management system is to move their waste to other areas outside of NYC. NYC has adopted a 20 year plan to export government managed waste to neighbouring states.
- The strategy relies on a truck based system and is a combination of local and land based transfer stations that take the city waste and dispose it in landfills and recycling facilities.
  - The DSNY approximately collects 3.8 million tons of solid waste a year, with only 14% being recycled, 76% sent to landfills and 10% converted to energy.
  - Waste sent to landfills can travel as far as 1200km's to landfill sites in Pennsylvania, Ohio, Virginia and South Carolina. NYC spends approximately \$1.5 billion (\$500 per household) annually to collect residential and public waste, with over 2000 garbage trucks and 5900 sanitation employees.
  - The citizens budget commission report states that on a per ton basis, waste collection cost the DSNY is more than double the cost of other public agencies.
  - It costs nearly \$100 per ton to ship waste to Pennsylvania, Virginia, Ohio and South Carolina is both economically and environmentally unsustainable.

**S u s t a i n a b i l i t y**

Social	Environmental	Economic
<ul style="list-style-type: none"> <li>- is that less citizens of NYC will have to deal with the smell and other implication of living near a waste transfer station.</li> <li>- As the legislation is decreasing the amount of waste permitted at certain facilities that have a high population density living around them and are seen as ‘overburdened’ in the neighbourhood, the smell and pollution in these areas should decrease as there is less waste being stored there.</li> <li>- This decrease in waste in certain neighbourhoods increases sustainability as the needs of more citizens both present and future, are being met.</li> <li>- With less waste being transported to these areas, the amount of traffic congestion caused by trucks and other waste transport vehicles will decrease.</li> <li>- This results in less noise pollution and disturbance to the citizens that live in this area.</li> </ul>	<ul style="list-style-type: none"> <li>- a decrease in trucks and other vehicles in these high populated areas will decrease the amount of pollution in these areas. Trucks produce CO2 as a by-product</li> <li>- decrease in pollution in these areas will positively effect the air quality in this area, benefitting both humans and nature.</li> <li>- By lowering the permitted capacity of waste transfer stations by 50% for North Brooklyn and 33% in South Bronx and Southeast Queens, these areas will produce less methane as a by-product of the decomposing waste.</li> <li>- further improve the air quality in these areas. Therefore this legislation enhances sustainability in NYC.</li> <li>-</li> </ul>	<ul style="list-style-type: none"> <li>- City Council has to spend less money on trying to contain and manage the smell that the waste produces.</li> <li>- This money can be spent on other areas of need in the Cities budget such as health care or education.</li> <li>- brings awareness of the issue of waste management to the populations attention.</li> <li>- Therefore they can begin to be more thoughtful about what they are doing with their waste, decreasing the amount of waste and increasing the amount of recycling</li> </ul>
<ul style="list-style-type: none"> <li>- does not solve the issue of the amount of waste being generated, but simply move the waste to another area, where it will impact other citizens.</li> <li>- Citizens that live in the areas that the waste is being diverted too, will now have to deal with the same implications that the original citizens needed to deal with. As urban sprawl increases, the areas that the waste is being diverted too will have a growing population. Therefore in the future the same issue is going to effect citizens, just in a different area. As this legislation does not target the cause of the waste, it is unsustainable as it will simply effect others at a later time.</li> </ul>	<ul style="list-style-type: none"> <li>- transport vehicles have to drive further distances to dispose of the waste. This increases the amount of CO2 and other GreenHouse Gasses being emitted into the atmosphere,</li> <li>- The legislation does not target the issue of waste in NYC, the waste is just moved around the city and its surrounding states.</li> </ul>	<ul style="list-style-type: none"> <li>- trucks and other transport vehicles have to drive further to dispose of the waste.</li> <li>- This increases the amount of fuel being used, increases the km’s on the vehicle which increases the likelihood of it needing parts replaced which is expensive and time consuming.</li> <li>- increases the amount of greenhouse gases being emitted, meaning the city will have to divert more money to decreasing the impact these gases has on the environment. original infrastructure will need to be upgraded to take in this diverted waste, and new infrastructure will be built.</li> </ul>

Liveability

Social stability and equity	Education.	Employment	Environmental benefits
<ul style="list-style-type: none"> <li>- citizens that live around these WTS's tend to have low incomes and live around these areas because the housing and apartments are cheaper, because there is a strong smell and pollution in this area, bringing the housing prices down</li> <li>- enhances the liveability of NYC as some of the waste is taken from these low socio-economic areas and moved to other locations. This results in these areas becoming a more pleasant place to live as the amount of pollution and smell will decrease in these areas.</li> <li>- better quality of life for those who live in low socio economic areas, as they are not further disadvantaged by living in a high pollution / smell area just</li> </ul>	<ul style="list-style-type: none"> <li>- media and the effects of living near a waste transfer station have effected the day to day living off the community, it has raised awareness for the issue of waste management in NYC. This awareness has led to the education of the citizens of NYC about what can go into the general waste bin and the recycling bin.</li> <li>- actions are affecting others has led to the education of many in regards to waste management.</li> </ul>	<ul style="list-style-type: none"> <li>- NYC employs 2000 garage trucks and 5900 sanitation employees. This legislation provides for growth in the waste management infrastructure. With a growth in infrastructure, more people will be employed, this provides more jobs to the community and has a positive economic affect. This legislation allows for an increase in recycling, which will lead to an increase in the need for workers at recycling plants, w</li> </ul>	<ul style="list-style-type: none"> <li>- promotes recycling, less waste is placed in landfill sites to decompose, hence less greenhouse gases are being emitted into the atmosphere.</li> <li>- Better air quality</li> <li>- decrease the chance of certain cancers in both the human population and the environment.</li> <li>- less pollution in one area. As there will be less trucks in certain areas, the amount of pollution in those areas will decrease. The average car emits 6 tonnes of carbon per year, and as these trucks are larger and travel further distances than the average car, this figure is expected to be much larger in relation to waste transport trucks.</li> </ul>