CET468
Climate Change and Sustainability

Program Elective V (PEC)

Credit: 3, Slot D

S8

Academic Year: 2022-2023

Module 3

Urbanisation and Sustainable development

Urbanisation and Industrialization, Urbanisation, problems of urbanisation, Urban sprawl, Urban heat islands, causes, mitigation measures. Urban flooding, water conservation and ecological aspects.Urban Planning, Zoning of Land Use

Pillars of Sustainable development, Sustainability indicators, Life cycle analysis, Material flow analysis, Green energy, Waste management, 3R concepts, Sustainable cities, Sustainable Urbanisation

URBANISATION AND SUSTAINABLE DEVELOPMENT

MODULE 3

11 SUSTAINABLE CITIES AND COMMUNITIES

MAKE CITIES AND HUMAN SETTLEMENTS INCLUSIVE, SAFE, RESILIENT AND SUSTAINABLE

BEFORE COVID-19

SHARE OF URBAN POPULATION LIVING IN SLUMS ROSE TO 24% IN 2018

ONLY HALF

THE WORLD'S URBAN POPULATION HAS **CONVENIENT ACCESS** TO PUBLIC TRANSPORT (2019)

COVID-19 IMPLICATIONS

OVER 90% OF COVID-19 CASES ARE IN **URBAN AREAS**

AIR POLLUTION CAUSED 4.2 MILLION PREMATURE DEATHS IN 2016

47% OF POPULATION LIVE WITHIN 400 METRES WALKING DISTANCE TO OPEN PUBLIC SPACES

Introduction

— Fossil fuel is the mainstay of modern civilisations.

—Its consumption and availability will drive climate change.

—Population growth, energy efficiency, conservation measures, non-fossil fuel sources, industrial productivity, energy policy and availability of fossil fuel determines its utilisation rate.

—The impacts of climate change on human settlement patterns and infrastructure will differ regionally and could range from insignificant to catastrophic.

Urbanisation and Industrialisation

- Urbanisation and industrialisation have had a significant impact on climate change. Both of these processes have led to an increase in greenhouse gas emissions, which contribute to global warming and climate change.
- Urbanisation involves the growth of cities and the concentration of people in densely populated areas.
- This leads to an increase in energy consumption, as more people require heating, cooling, lighting, and transportation. The construction of buildings, roads, and other infrastructure also requires significant amounts of energy and resources, which can lead to increased emissions of greenhouse gases.

Urbanisation and Industrialisation

- Industrialisation involves the growth of industries and the mass production of goods.
- This also requires significant amounts of energy and resources, which can lead to increased emissions of greenhouse gases. Industrial processes such as burning fossil fuels for energy and manufacturing products that require the use of chemicals can also release pollutants into the atmosphere, contributing to air pollution and climate change.
- Overall, the combination of urbanisation and industrialisation has led to increased emissions of greenhouse gases. To mitigate these impacts, it is important to transition to more sustainable and low-carbon forms of urban and industrial development, such as renewable energy sources, green buildings, and sustainable manufacturing processes

Urbanisation

- More people and key assets are exposed to climate-induced impacts, and loss and damage in cities, settlements and key infrastructure.
- Many risks will not be felt evenly across cities and settlements or within cities. Communities in informal settlements will have higher exposure and lower capacity to adapt.
- The most rapid growth in urban vulnerability and exposure has been in cities and settlements where adaptive capacity is limited, including informal settlements in low- and middle-income communities and in smaller and medium-sized urban communities.
- Sea level rise, heatwaves, droughts, changes in runoff, floods, wildfires and permafrost thaw cause disruptions of key infrastructure and services such as energy supply and transmission, communications, food and water supply and transport systems in and between urban and peri-urban areas.
- Higher risks from temperature and precipitation extremes are projected for almost all Asian cities, impacting freshwater availability, regional food security, human health and industrial outputs.

Urbanisation

- An additional 2.5 billion people are projected to live in urban areas by 2050, with up to 90% of this increase concentrated in the regions of Asia and Africa.
- Growth is most pronounced in smaller and medium sized urban settlements of up to one million people.
- Asian and African urban areas are considered high-risk locations from projected climate, extreme events, unplanned urbanisation and rapid land use change.
- These could amplify pre-existing stresses related to poverty, informality, exclusion and governance, such as in African cities. Climate change increases heat stress risks in cities and amplifies the urban heat island across Asian cities at 1.5°C and 2°C warming levels, both substantially larger than under present climates.
- Urban land in flood zones and drylands exposed to high-frequency floods is expected to increase by as much as 2600% and 627% respectively across East, West and Central Africa by 2030.

Urbanisation

- Risks to critical physical infrastructure in cities can be severe and pervasive under higher warming levels, potentially resulting in compound and cascading risks, and can disrupt livelihoods both within and across cities.
- Projected changes in both the hydrological cycle and the cryosphere will threaten urban water infrastructure and resource management in most regions.
- By 2050, permafrost thaw in the pan-Arctic is projected to impact 69% of infrastructure, more than 1200 settlements, 36,000 buildings, and 4 million people in Europe.
- South and Southeast Asian coastal cities can experience significant increases in average annual economic losses between 2005 and 2050 due to flooding.
- In small islands, degraded terrestrial ecosystems decrease resource provision (e.g., potable water) and amplify the vulnerability of island inhabitants.
- Projections suggest that 350 million (± 158.8 million) more people in urban areas will be exposed to water scarcity from severe droughts at 1.5°C warming.

Urbanisation

- Cities and settlements (particularly unplanned and informal settlements and in coastal and mountain regions) have continued to grow at rapid rates and remain crucial both as concentrated sites of increased exposure to risk and increasing vulnerability and as sites of action on climate change.
- As cities expand into coastal and mountain regions prone to flooding or landslides that disrupt transportation networks, or where water and energy resources are inadequate to meet the needs of growing settlements.
- Climate change increases risks for a larger number of growing cities and settlements across wider areas, especially in coastal and mountain regions.
- In coastal cities and settlements, risks to people and infrastructure will get progressively worse in a changing climate, sea level rise and with ongoing coastal development.
- Climate change risks, including sea level rise, interact in intricate ways with non-climatic drivers of coastal change, such as land subsidence, continued infrastructure development in coastal floodplains, the rise of asset values and landward development adversely impacting coastal ecosystems, to shape future risk in coastal settlements.

Problems of urbanisation

- Overcrowding and lack of affordable housing: Rapid urbanisation can lead to a shortage of housing, which can drive up prices and make it difficult for lower-income residents to find affordable housing. This can also lead to overcrowding, which can negatively impact public health and well-being.
- Increased traffic congestion and air pollution: More people living and working in urban areas can lead to increased traffic congestion and air pollution, which can have negative impacts on public health, the environment, and the economy.
- Urban sprawl and loss of natural habitats: As urban areas expand, they can encroach on natural habitats, leading to a loss of biodiversity and the fragmentation of ecosystems.
- Unequal distribution of resources and services: Urbanisation can lead to unequal distribution of resources and services, with some areas having better access to jobs, education, healthcare, and other amenities than others.
- Social isolation and mental health issues: Urbanisation can lead to social isolation and mental health issues, as people may feel disconnected from their communities and lack social support.

Mitigation measures

- Retrofitting, upgrading and redesigning existing urban places and infrastructure combined with planning and design for new urban infrastructure can utilise existing knowledge on social policy, nature-based solutions and grey/physical infrastructure to build inclusive processes of adaptation into everyday urban planning and development.
- Social safety nets, inclusive approaches to disaster risk reduction and the integration of climate adaptation into education.
- Nature-based solutions include green and blue infrastructure in and around cities, including hinterlands, that increase water access and reduce hazards for cities and settlements, e.g.: reforestation of hill-slope and coastal areas.

Urban Sprawl

- Urban sprawl refers to the unplanned and uncontrolled spread of urban development into rural areas and open spaces.
- This is often characterized by low-density, automobile-dependent development, with homes and businesses located far apart from one another and connected primarily by roads.
- It is also characterized by low-density residential housing, single-use zoning, and car-dependent development.
- Urban sprawl typically involves the development of low-density, single-family housing subdivisions, large shopping centers and commercial developments, and extensive road networks designed to accommodate automobile traffic.
- This type of development is often characterized by large setbacks, wide streets, and lack of connectivity, which can make it difficult or unsafe to walk, bike, or use public transit.

Urban Sprawl

- Urban sprawl is typically driven by a number of factors, including population growth, demand for housing, and the expansion of commercial and industrial activities.
- As cities and towns expand outward, they often consume farmland and natural habitats, contributing to the loss of biodiversity and fragmentation of ecosystems.
- In addition, urban sprawl can lead to increased traffic congestion, air pollution, and energy consumption, as people are forced to travel further distances for work, shopping, and other activities.
- Urban sprawl can also contribute to social isolation, as people may feel disconnected from their communities and lack access to services and amenities.
- This can exacerbate issues such as poverty, crime, and health disparities, as certain groups may be excluded from the benefits of urban development.
- In India, much of this growth has occurred in sprawl like manner with low density and large spatial footprints.

Urban Sprawl-Characteristics

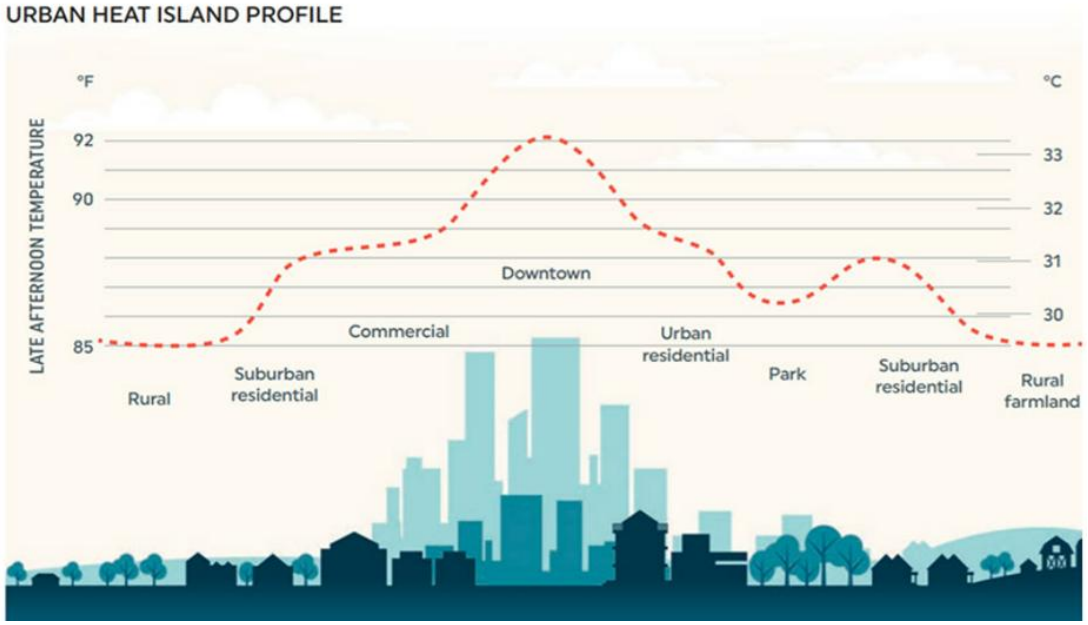
- **Low-density, single family dwellings:** The most frequently cited feature of sprawl is the abundance of large-lot (usually 1-5 acres depending on the development context), residential housing developments that consume large amounts of previously vacant or productive land. Density, in this sense, can be represented by median lot size, the number of dwelling units per neighborhood, or median floor space of single-family units.
- **Automobile dependency even for short trips:** Because sprawling development patterns create large distances between dwelling units and segregate different land uses, residents are forced to rely on automobiles at the expense of alternative forms of transportation. Also, the cul-de-sac dominated street patterns within these neighborhoods foster a lack of connectivity and serve as an obstacle for walking and biking to nearby destinations. Reliance on the automobile also encourages the development of homogeneous neighborhoods that lack a mixture of land uses.
- **Spiraling growth outward from existing urban center:** Sprawl is also conceptualized as low-density development rapidly expanding away from more compact urban cores. Approximately 80 percent of the acreage used for recently constructed housing in the U.S. is land outside urban areas; almost all of this land (94%) is in lots of 1 acre or larger.

Urban Sprawl-Characteristics

- **Leapfrogging patterns of development:** Another well-known characteristic of sprawl is dispersed development, which favors the development of parcels situated further out in the countryside over the vacant lands adjacent to existing development. Leapfrogging creates a haphazard development pattern that consumes large amounts of land.
- **Strip Development:** "Ribbon" development, in which residences or commercial properties line roads extending outward from urban centers is another prominent characteristic of sprawl. Homes arranged along rural highways present hazards related to traffic safety; commercial strips comprised of fast food chains and large retail stores cater to automobile access and are often fronted by expansive parking lots.
- **Undefined edge between urban and rural areas:** Sprawling residential development extending outward from urban centers tends to blur the division between urban and rural domains. This development pattern is often associated with the encroachment of open space and agricultural lands.

Urban Heat Island(UHI)

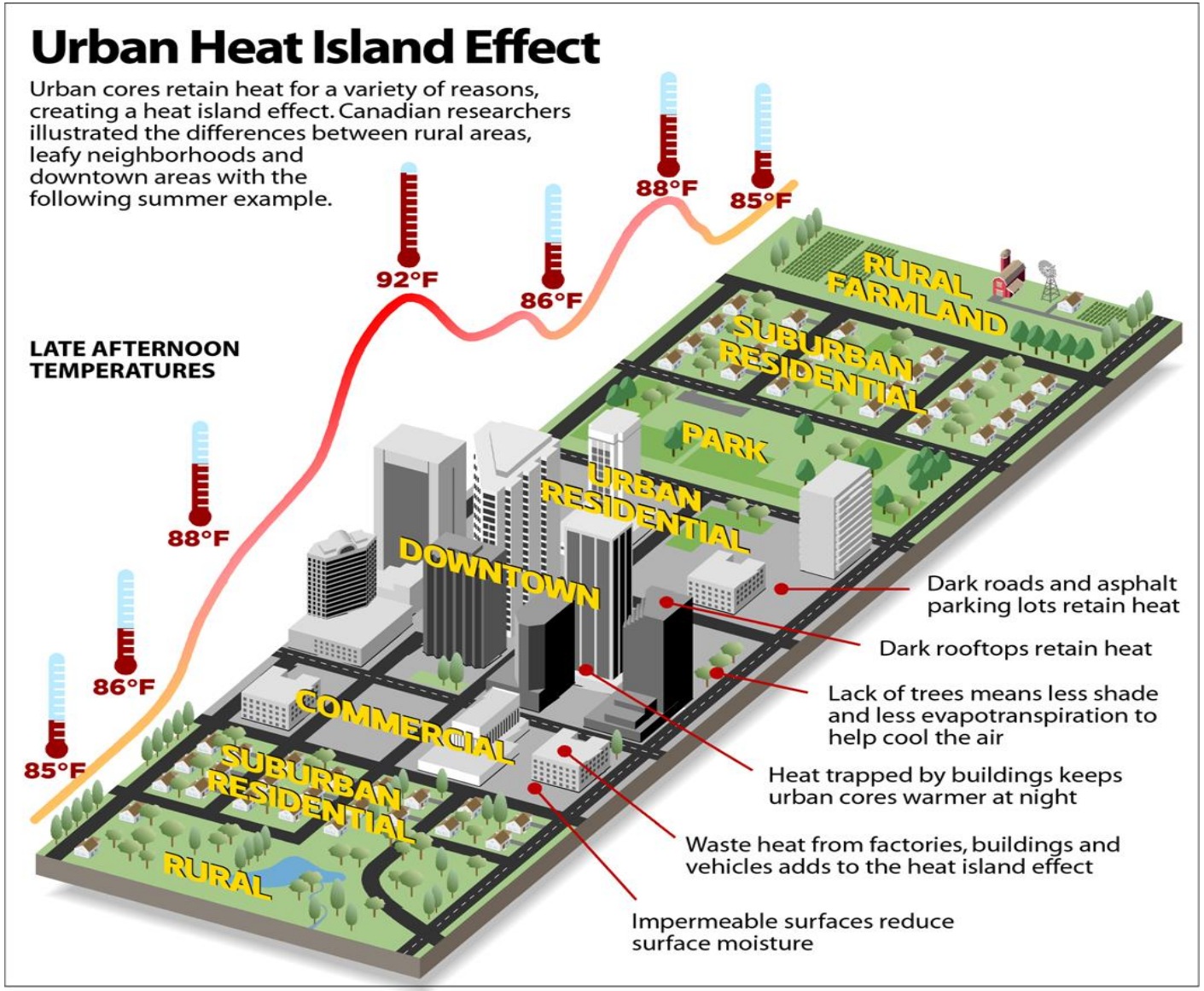
- Urban heat islands occur when cities replace natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat.
- This effect increases energy costs (e.g., for air conditioning), air pollution levels, and heat-related illness and mortality.



Urban Heat Island(UHI)

- Urban heat island (UHI) refers to the phenomenon where urban areas experience higher temperatures compared to surrounding rural areas. This is primarily due to the built environment and human activities in cities, which can significantly alter the local microclimate.
- The main factors contributing to the formation of urban heat islands include:
  - Modification of land surfaces: Urban areas are characterized by large areas of impervious surfaces, such as roads, buildings, and pavements, which absorb and retain heat from the sun. This can result in higher surface temperatures and reduce the cooling effect of natural vegetation, soil, and water bodies.
  - Heat generated from human activities: Urban areas have a higher density of human activities, such as energy consumption, transportation, and industrial processes, which release waste heat into the atmosphere. This can contribute to increased air temperatures in cities.
  - Reduced green spaces and vegetation: Urban areas often have less green spaces, such as parks and trees, compared to rural areas. Green spaces provide shade and evaporative cooling, which can help lower temperatures and reduce the heat island effect.
  - Limited air flow and ventilation: The layout and design of urban areas, with buildings and infrastructure closely packed together, can restrict air flow and reduce natural ventilation. This can trap heat and pollutants, leading to higher temperatures in cities.

Urban Heat Island(UHI)



SOURCE: D.S. Lemmen and F.J. Warren, Climate Change Impacts and Adaptation

PAUL HORN / InsideClimate News

Urban Heat Island - Causes

- Reduced Vegetation and Greenery – Plants and trees provide shade and cool the air through evapotranspiration.
- Reduced water spaces – Water helps in cooling environment by evaporation.
- Air conditioning – Air conditioners keep a building cool inside but absorb heat from inside, releasing it to the atmosphere. As a result, the outside environment is warmed, leading to increasing atmospheric temperature.
- Urban canopy – In urban areas, there are multilayer buildings. The heat reflected by a building is trapped by the nearby taller buildings, which is known as the urban canopy.
- Paved surfaces – They can absorb solar radiation as heat. Also they are impermeable, which means higher water runoff than being absorbed by plants or water bodies that help cool the area through evapotranspiration and evaporation.
- Wind blocking – Due to the presence of densely situated buildings, the velocity of wind is reduced, and it lessens the cooling effect by convection. So, the trapped heat intensifies the effect.

Urban Heat Island - Causes

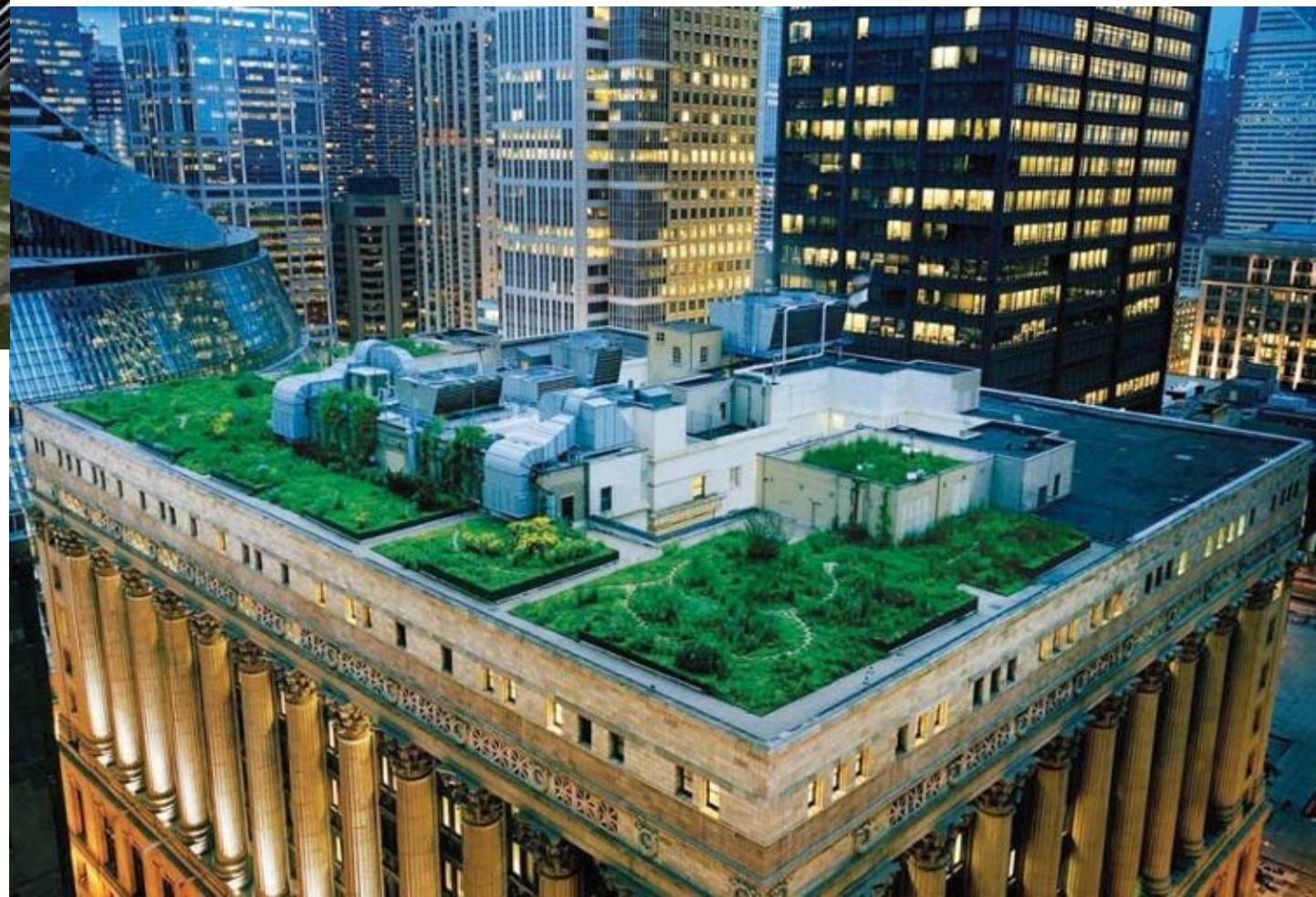
- Air pollution – Exhaust gases from vehicles, industrial pollutants released in the atmosphere, trap solar radiation, causing an increase in temperature.
- Population density and lifestyle – CO2 emissions by large density of people and their indirect contributions via lifestyle choices causes higher emissions leading to increase in temperature.
- Low Albedo Materials – Albedo is the ratio of the reflected solar energy to the incident solar energy. It depends on the arrangement of surfaces, materials, pavements, coatings, etc. Albedo has a direct impact on the formation of the microclimate. If the albedo of the urban surface is low, it will store more solar energy, and the effect will be an increase of urban temperature.
- Building heat – Buildings contain a lot of thermal mass, which means they store a lot of heat during the day and are slow to release the heat overnight.

Urban Heat Island - Mitigation

- Build **Green Infrastructure** improvements into regular street upgrades and capital improvement projects to ensure continued investment in heat-reducing practices.
- Green infrastructure or blue-green infrastructure refers to a network that provides the ingredients for solving urban and climatic challenges by building with nature.
- The main components of this approach include stormwater management, climate adaptation, the reduction of heat stress, increasing biodiversity, food production, better air quality, sustainable energy production, clean water, and healthy soils, as well as more anthropocentric functions, such as increased quality of life through recreation and the provision of shade and shelter in and around towns and cities.
- **Build green roofs:** Green roofs are an ideal heat island reduction strategy, providing both direct and ambient cooling effects. In addition, green roofs improve air quality by reducing the heat island effect and absorbing pollutants. Many communities offer tax credits for installing green roofs.

Chicago City Hall 2001:

The project was one of three national pilot projects sponsored by the U.S. Environmental Protection Agency. The design includes over 150 species of native cultivated and non-native plants, and utilizes both intensive and extensive systems. Water use is mitigated through collection of stormwater that is recycled for irrigation.



Green Roofs at Nanyang Technological University's School of Art, Design, and Media 2016 :

The roofs insulate the building, harvest rainwater and cool the surrounding air. The roofs define the building yet help to marry it with its surroundings through planted grasses intermixed with native greenery.

Urban Heat Island - Mitigation

- **Urban Forestry; Plant trees and other vegetation**: Planting trees around the city can be another way of increasing albedo and decreasing the urban heat island effect. Space in urban areas might be limited; integrate small green infrastructure practices into grassy or barren areas, vacant lots, and street rights-of-way.
- Use of city trees (canopy) to address urban heat, stormwater management, and other concerns.
- Planting native, drought-tolerant shade trees and smaller plants such as shrubs, grasses, and groundcover wherever possible.
- Make traditional water quality practices serve double duty by adding trees in or around roadside planters and other green infiltration-based practices to boost roadside cooling and shading.
- **Passive daytime radiative cooling** – A passive daytime radiative cooling roof application can double the energy savings of a white roof, attributed to high solar reflectance and thermal emittance.
- **White roofs and light-coloured concrete** – In cities, there are many dark colored surfaces that absorb the heat of the sun in turn lowering the albedo of the city. White rooftops allow high solar reflectance and high solar emittance, increasing the albedo of the city or area the effect is occurring.

Urban Flooding

- Urban flooding refers to the inundation of urban areas with water, typically caused by heavy rainfall, storm surges, or other weather-related events.
- Urban areas are particularly susceptible to flooding due to the large amount of impervious surfaces, such as roads, buildings, and pavements, which prevent rainwater from infiltrating into the ground.
- In addition to natural weather events, urban flooding can also be caused by human activities, such as poorly designed drainage systems, improper waste management, and land-use changes that alter the natural hydrology of an area.
- Urban flooding occurs when city landscapes cannot absorb excess water after prolonged periods of intense rainfall, river overtopping, or storm surge.
- Consequently, flooding occurs very quickly due to faster flow times (in a matter of minutes).

Urban Flooding

- It is not only the event of flooding but the secondary effect of exposure to infection also has its toll in terms of human suffering, loss of livelihood and, in extreme cases, loss of life.
- Urban flooding can cause a range of negative impacts, including property damage, disruptions to transportation and essential services, public health risks from contaminated water and mold growth, and loss of life.
- Low-income and marginalized communities are often disproportionately affected by urban flooding, as they may lack access to resources and infrastructure that can help mitigate the impacts of flooding.
- Urban areas are also centers of economic activities with vital infrastructure which needs to be protected 24x7.
- In most of the cities, damage to vital infrastructure has a bearing not only for the state and the country but it could even have global implications.
- Major cities in India have witnessed loss of life and property, disruption in transport and power and incidence of epidemics.

Urban Flooding – Mitigation

- Improved urban planning and design to ensure proper drainage and reduce the amount of impervious surfaces.
- Gray infrastructure- including dams and seawalls, traditionally constructed of concrete or other impervious materials and designed to prevent the flow of water.
- Green Inrastructure- Implementation of green infrastructure, such as rain gardens, green roofs, and permeable pavements, to capture and treat stormwater before it enters waterways.
- Drainage systems- Upgraded drainage systems that can handle larger volumes of water and prevent overflows.
- Land use - understanding and altering land use and the proportion of land allocated to different purposes/use types is important in flood management planning.
- Community education and awareness campaigns to promote responsible waste management and reduce littering.
- Emergency response plans and early warning systems to help communities prepare for and respond to flood events.
- Climate change adaptation strategies, such as sea-level rise projections and storm surge modeling, to help cities plan for future flood risks.

Water Conservation and Ecological aspects

- Water conservation is also an important aspect of sustainable urban development.
- Urbanization can lead to increased water demand, and in many areas, water resources are already limited.
- Therefore, urban planning and zoning of land use should include provisions for sustainable water management, such as rainwater harvesting, graywater reuse, and water-efficient landscaping.
- Ecological aspects of urban development are also important to consider. Urbanization can cause habitat destruction and fragmentation, which can negatively impact local biodiversity.
- Therefore, urban planning and zoning of land use should include provisions for the protection and restoration of green spaces, wildlife corridors, and other important natural habitats.

Urban Planning

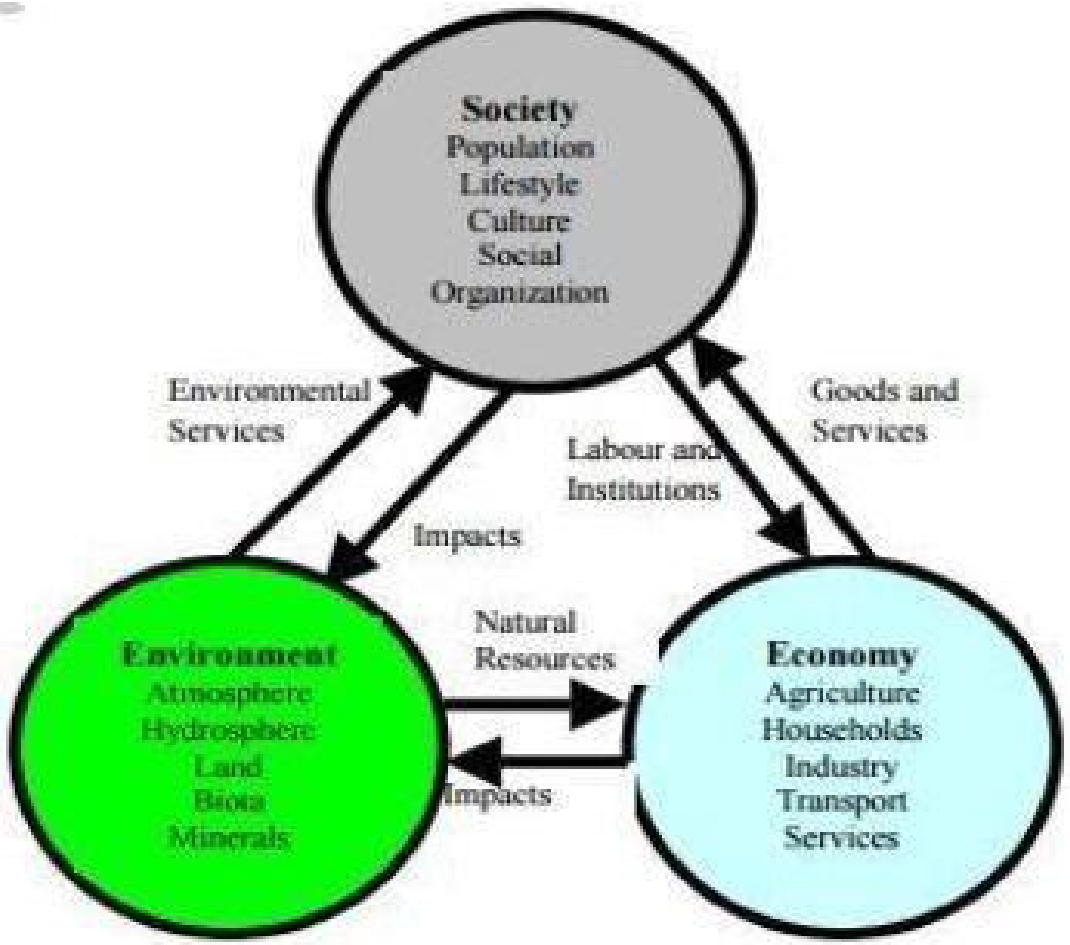
- Urban planning and zoning of land use can help mitigate the impact of urban flooding by ensuring that urban development is done in a way that promotes sustainable drainage systems, green infrastructure, and permeable surfaces.

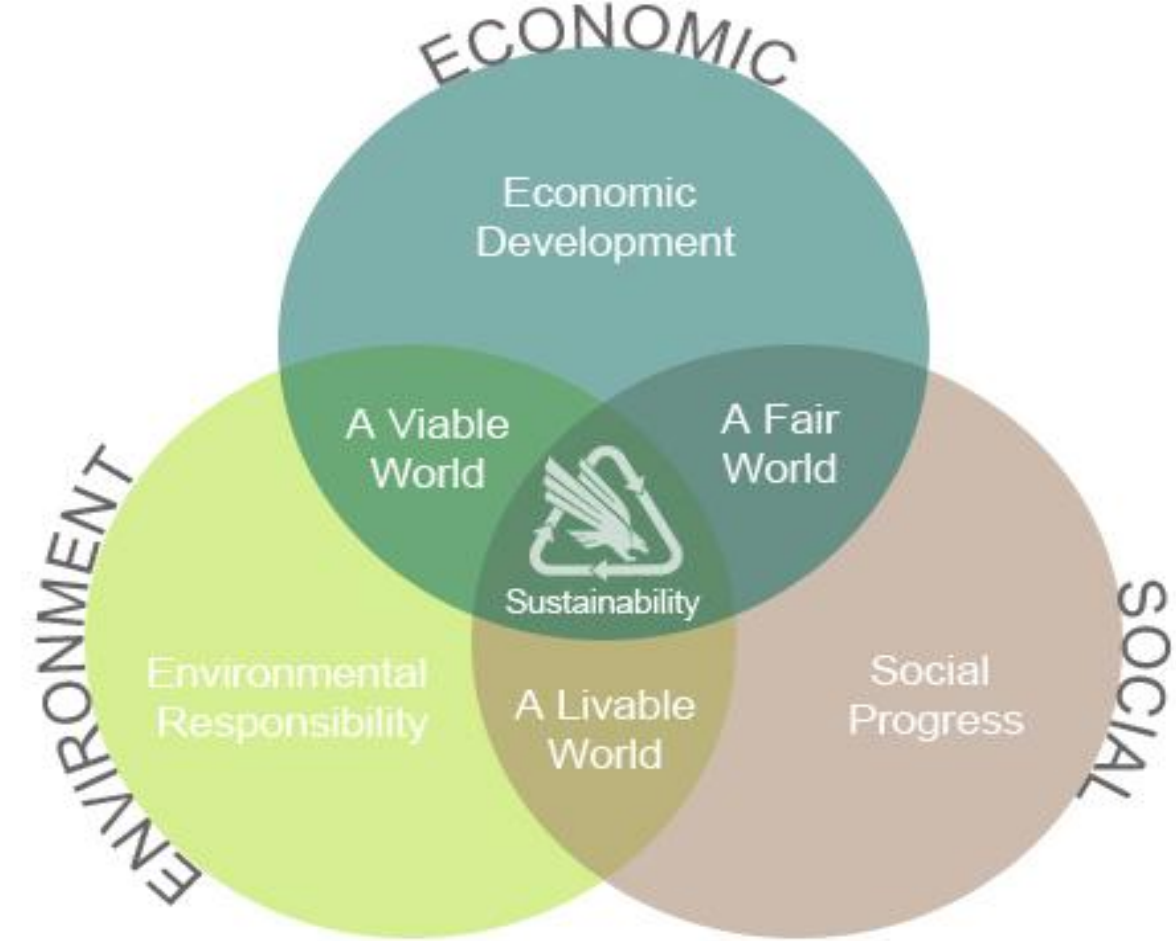
Zoning of Land Use

- Zoning of land use is the process of dividing a municipality or jurisdiction into different zones or districts, each with its own set of permitted land uses and development regulations.
- Some common zoning categories include residential, commercial, industrial, and open space or conservation districts.
- The process of zoning typically involves a comprehensive planning process that engages the community, identifies existing land uses, and establishes future land use goals and objectives. Based on this process, a zoning map is developed that identifies the various zoning districts and the regulations that apply to each district.
- Zoning regulations can include a wide range of provisions, such as building height and setback requirements, minimum lot size requirements, and restrictions on the type and intensity of land uses allowed within a district.
- Zoning can also be used to encourage specific types of development or land uses, such as affordable housing, mixed-use development, or conservation areas.

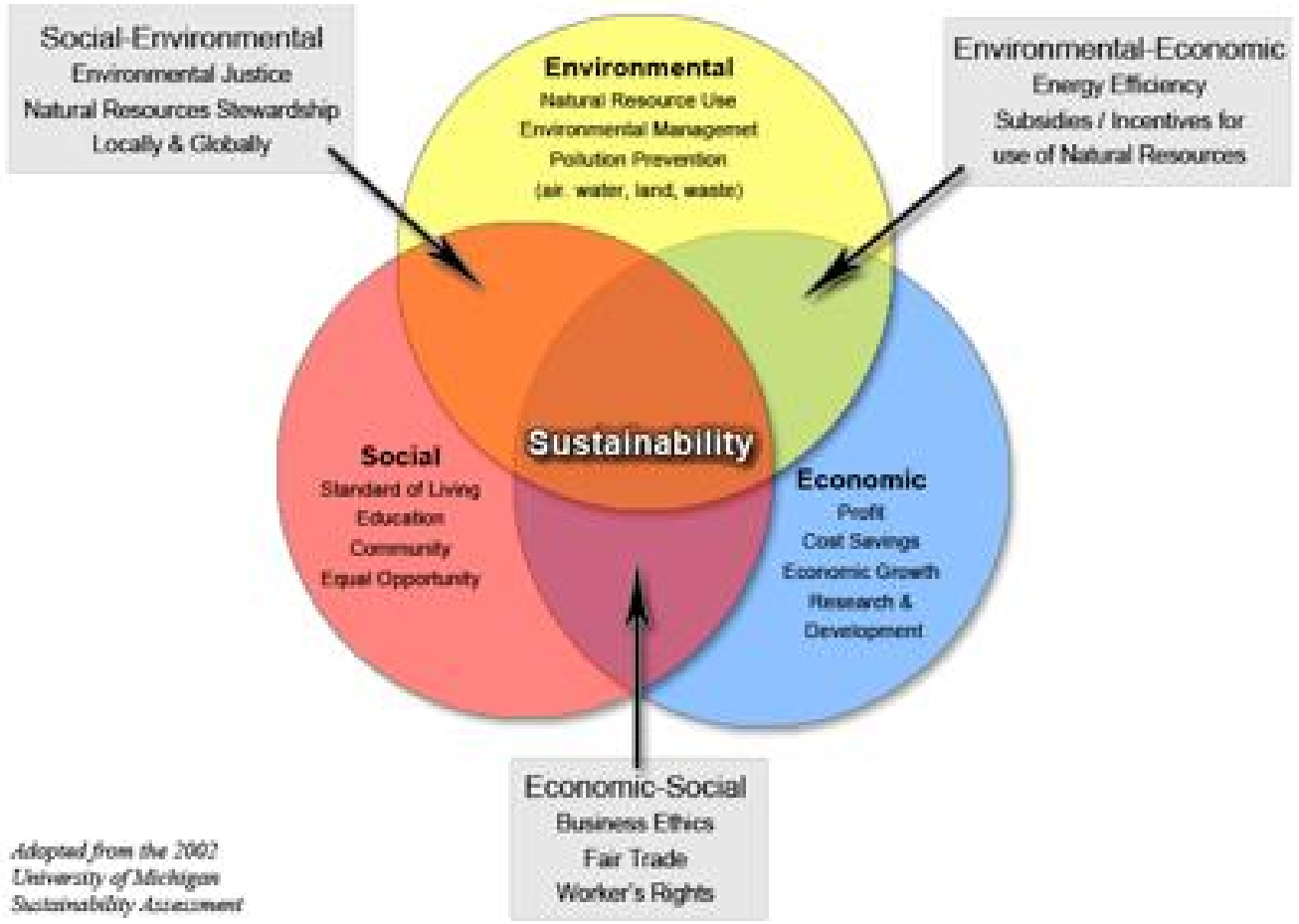
Pillars of Sustainable development

- Mainly 3 components (3 pillars)
  - Society
  - Environment
  - Economy
- Environment gives resources, raw materials to the Economy for production activities.
- Economy creates products and sells it to society for use.
- Production by Economy and Consumption by Society leads to the many environmental impacts such as Exhaustion of Resources, Loss of Biodiversity, Deforestation, Ozone Depletion, Global Warming, Acid Deposition, Desertification, Eutrophication etc.




ECONOMIC
Economic Development
A Viable World
A Fair World
Sustainability
ENVIRONMENT
Environmental Responsibility
A Livable World
Social Progress
SOCIAL

The Three Spheres of Sustainability



SOCIAL SUSTAINABILITY

- Six principles
  - Maintain residents‟ quality of life
  - Enhance local economic vitality
  - Promote social and intergenerational equity
  - Maintain the quality of the environment
  - Incorporate disaster resilience and mitigation into its decisions and actions
  - Use a consensus-building, participatory process when making decisions

ENVIRONMENTAL SUSTAINABILITY

- Environmental sustainability requires:
  - Maintenance of biodiversity (genes, species and ecosystems)
  - Protection of natural capital (air, water, soils etc)
  - Maintenance of the energy and material cycles of the planet
  - Health and resilience of all life support systems

ECONOMIC SUSTAINABILITY

- The economic sustainability ensures that making profit without creating much damage to environment
- Economic growth is expressed in terms of Gross Domestic Product (GDP)
- GDP = Total amount of production produced within a nation, within one year
- Economic growth has to be sustainable, if it improves quality of human life
- Thus, population factor must be included to ensure fair resource consumption.

Quality of Life Concerns	Economic Issue		Social Issue		Environmental Issue	
	Unsustainable	Sustainable	Unsustainable	Sustainable	Unsustainable	Sustainable
Water	High cost of drinking water	Drinking water availability at low cost	Access to drinking water denied to weaker section	Adequate water supply to all sections	High-level of pollution in lakes and rivers	Conservation of existing fresh water bodies
Food	High cost of food and use of fertilizers and pesticides in farming	Good food available at low cost	Access to good food denied to weaker section	Adequate access to good food to all sections	Overuse of fertilizers and pesticides pollute the environment. Deforestation - conversion of forestland to farms	Food is of nutritious quality and related diseases are lowered.
Energy	High cost and intermittent power supply	Electricity available at low cost	Overuse of energy by the rich society and inadequate energy distribution	Adequate energy available to all sections	Use of fossil fuels and pollution	Use of renewable resources.(solar, wind, biomass)

Sustainability indicators

- Sustainability indicators are used to measure progress towards sustainable development goals and to track the performance of various systems and sectors over time.
- These indicators are typically based on quantitative data and can be used to assess progress across the three pillars of sustainable development.
- Some examples of sustainability indicators include:
  - Economic sustainability indicators: GDP growth rate, income inequality, unemployment rate, poverty rate, and economic diversity.
  - Social sustainability indicators: Education and literacy rates, healthcare access and outcomes, social inequality, gender equality, and community participation.
  - Environmental sustainability indicators: Air and water quality, land use and conservation, biodiversity, greenhouse gas emissions, and energy consumption.

Life Cycle Analysis (LCA)

- Process to assess the environmental impacts associated with all the stages of a product, process or activity from cradle to grave by identifying the materials used and waste generated.
- For eg: in the case of a manufactured product, environmental impacts are assessed from raw material extraction and processing (cradle), through the product's manufacture, distribution and use, to the recycling or final disposal of the materials composing it (grave).
- LCA can be a very involved and lengthy process
- https://youtu.be/6RNnzfUHwY8
- https://youtu.be/BiSYoeqb_VY
- https://youtu.be/Uo5BC7wKzrk

Basic Steps in LCA

1. Goal and scope
2. Inventory
3. Impact assessment
4. Improvement assessment

1. Goal and scope

- Every LCA has boundaries. This is also the point where you ask what data do you need, what are your data quality requirements, what methods will you use to assess impact, to interpret, and how you will report it.

2. Inventory

- This is the data that you are collecting. The inventory includes things like emissions, energy requirements and material flows for each process involved. These are the flows into and out of the system you are studying. The data of these are adjusted depending on the functional unit you're looking at. This is known as a Life Cycle Inventory (LCI)
- This can be extremely complex because it can involve dozens of separate processes, as well as hundreds of tracked substances. This is where most of the complexity of an LCA is involved

3. Impact assessment

- The Life Cycle Impact Assessment (LCIA) is where the impacts on the environment are calculated. The categories of impacts are chosen and the impacts on them based on the flow of emissions, energy and material from the inventory, are assessed.
- There are lots of different types of impacts (depletion of abiotic resources, global warming, ozone layer depletion, acidification, etc) so this stage accounts for all the different impacts that have been chosen.

4. Improvement assessment

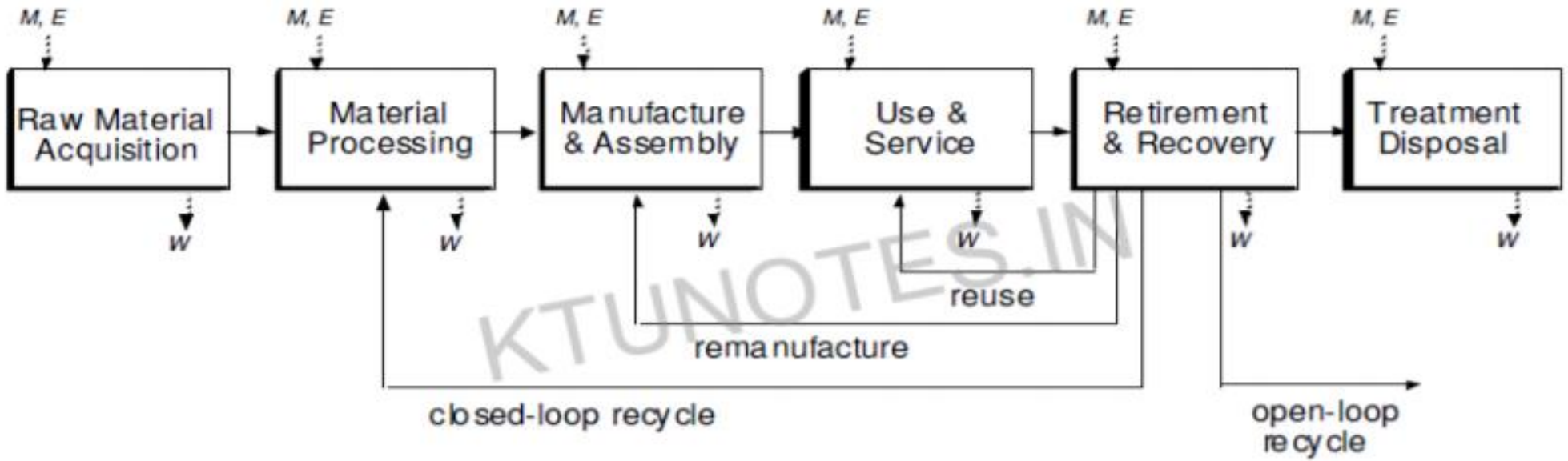
- Finally, the results are analysed in the context of the goal and scope of the study set out at the beginning. What have we learned about the system from this LCA? This is where recommendations are typically included.

Process of How LCA is done

- At the Life Cycle Inventory (LCI) stage is where you're breaking product system and getting data on all the elements.

Processes	Impacts
Raw material extraction	Global warming potential
Manufacture	Air, water and soil pollution
Distribution and transport	Ecotoxicity
Use and maintenance	Resource depletion
Disposal and recycling	

Product Life Cycle



M, E = Material and Energy inputs to process and distribution
W = Waste (gas, liquid, or solid) output from product, process, or distribution

Material flow of product component

EXHIBIT 1: INPUTS AND OUTPUTS OF A SYSTEM

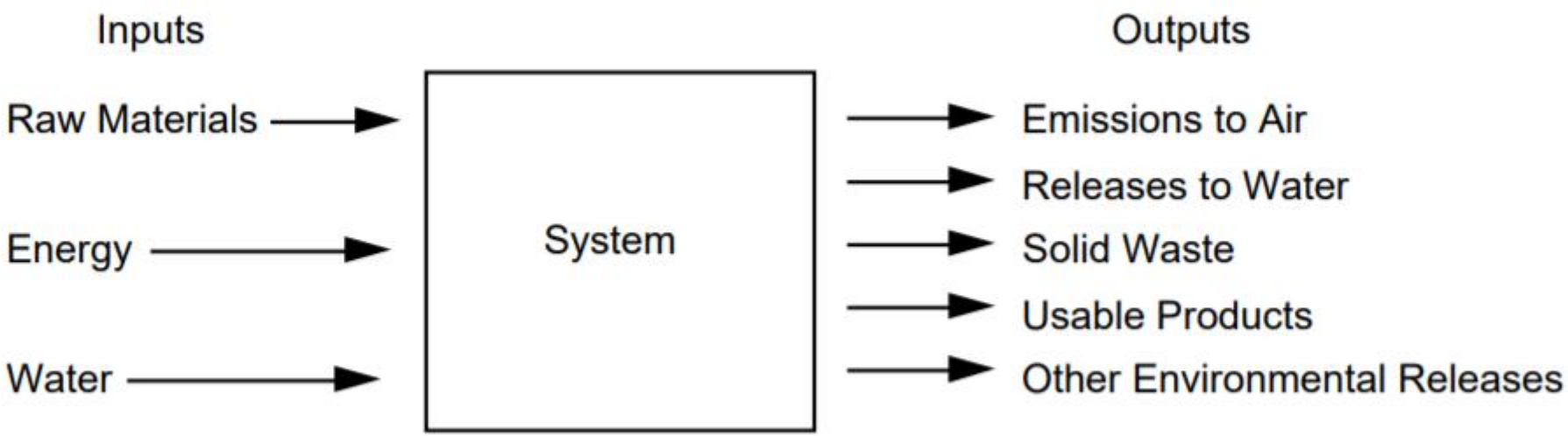
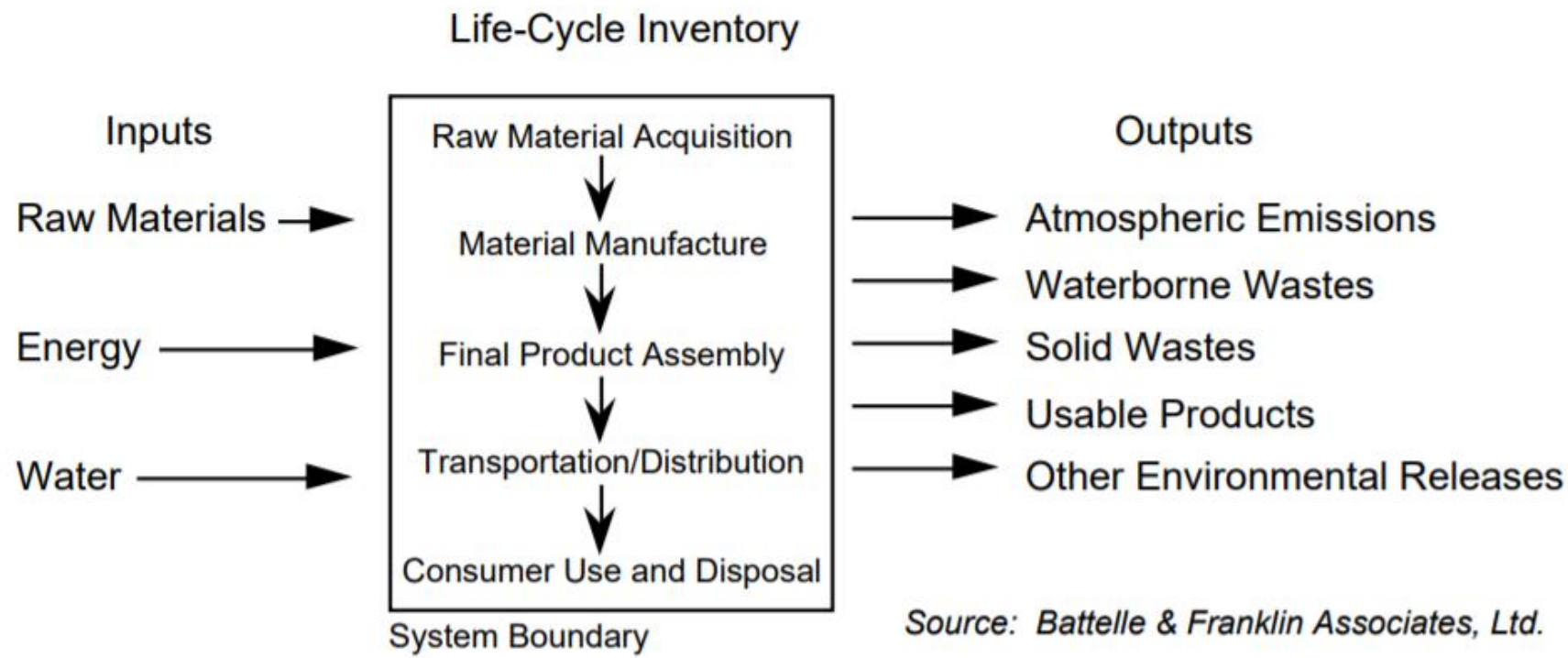


EXHIBIT 2: DEFINING SYSTEM BOUNDARIES



Source: Battelle & Franklin Associates, Ltd.

EXHIBIT 3: RAW MATERIAL ACQUISITION SUBSYSTEM

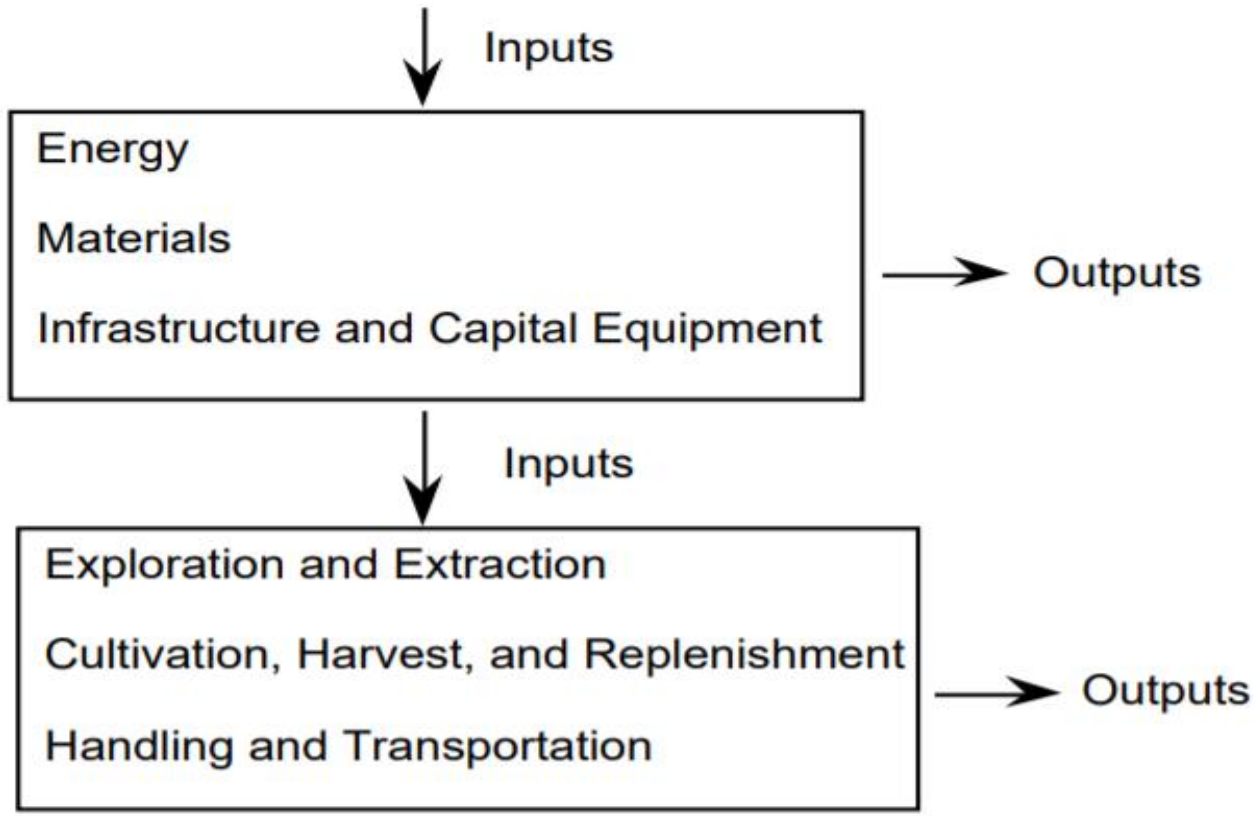


EXHIBIT 4: MANUFACTURING AND FABRICATION SYSTEM

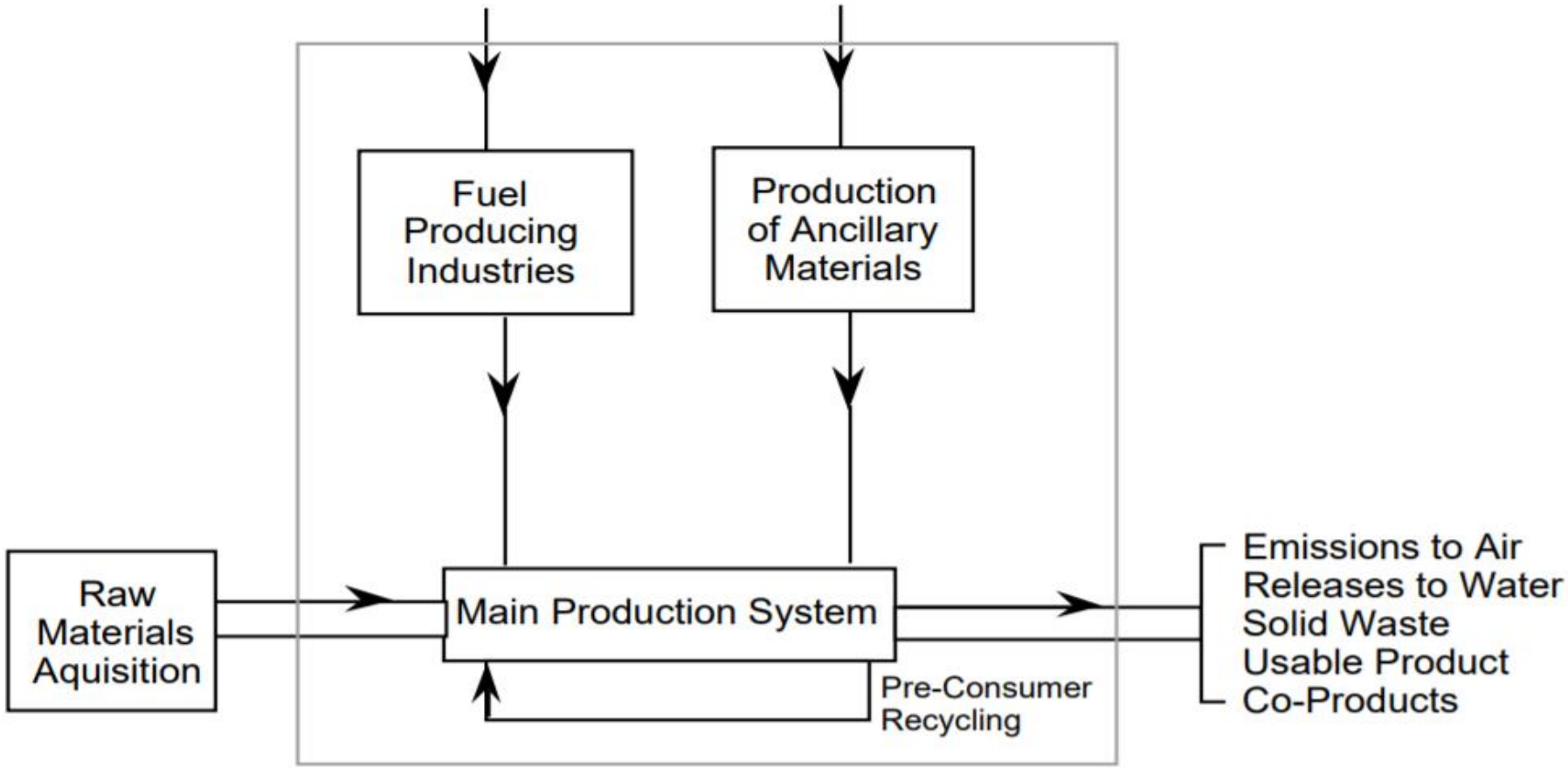


EXHIBIT 5: TRANSPORTATION/DISTRIBUTION SYSTEM

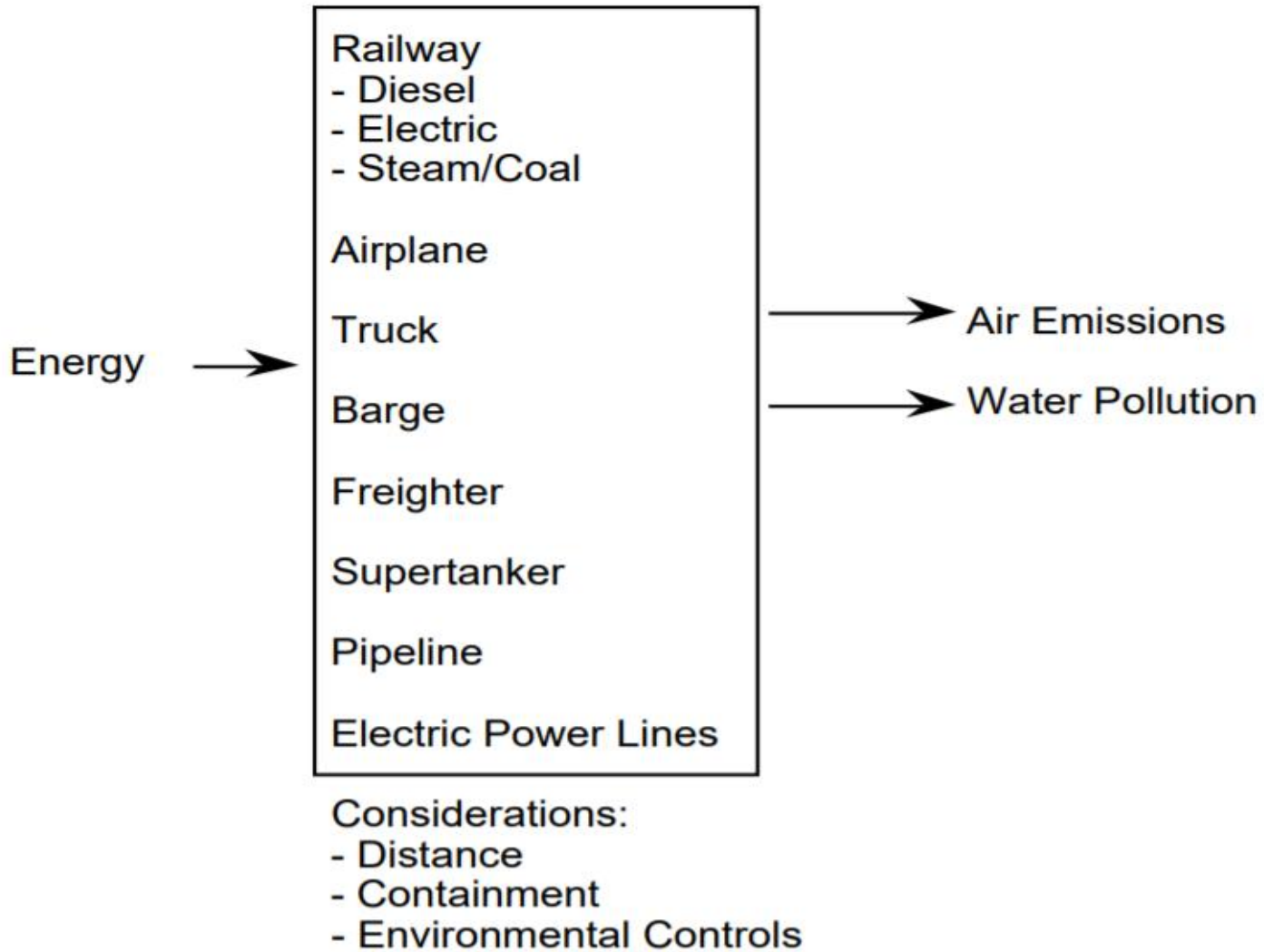


EXHIBIT 6: CONSUMER USE/DISPOSAL SYSTEM

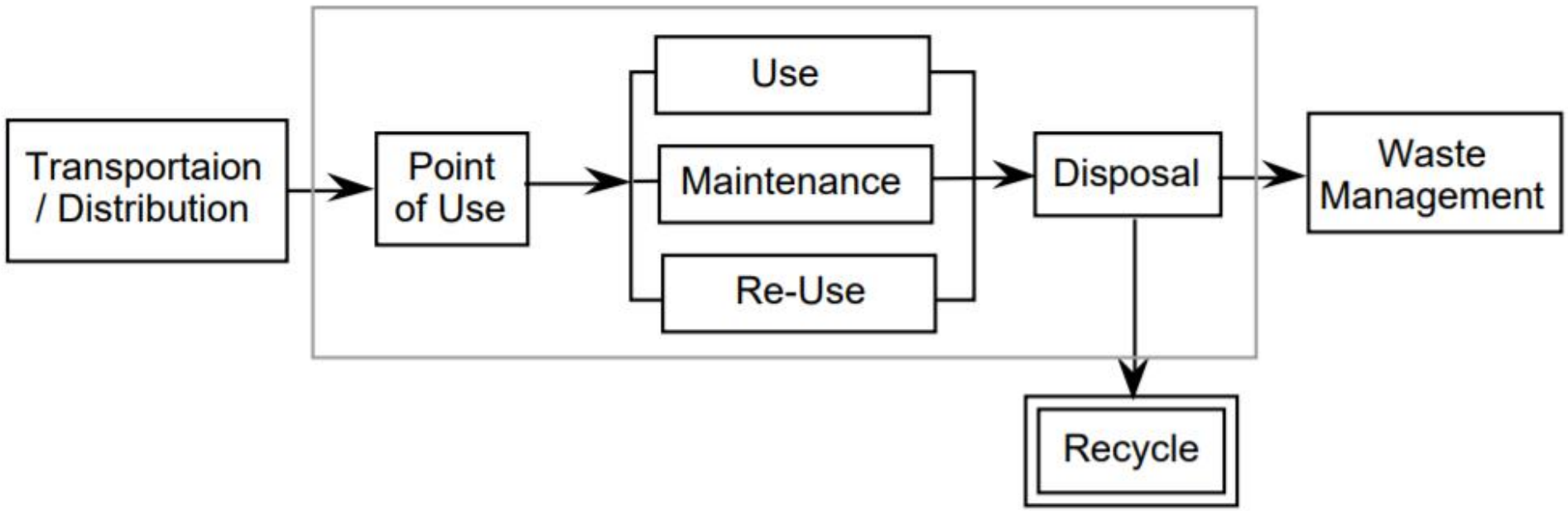
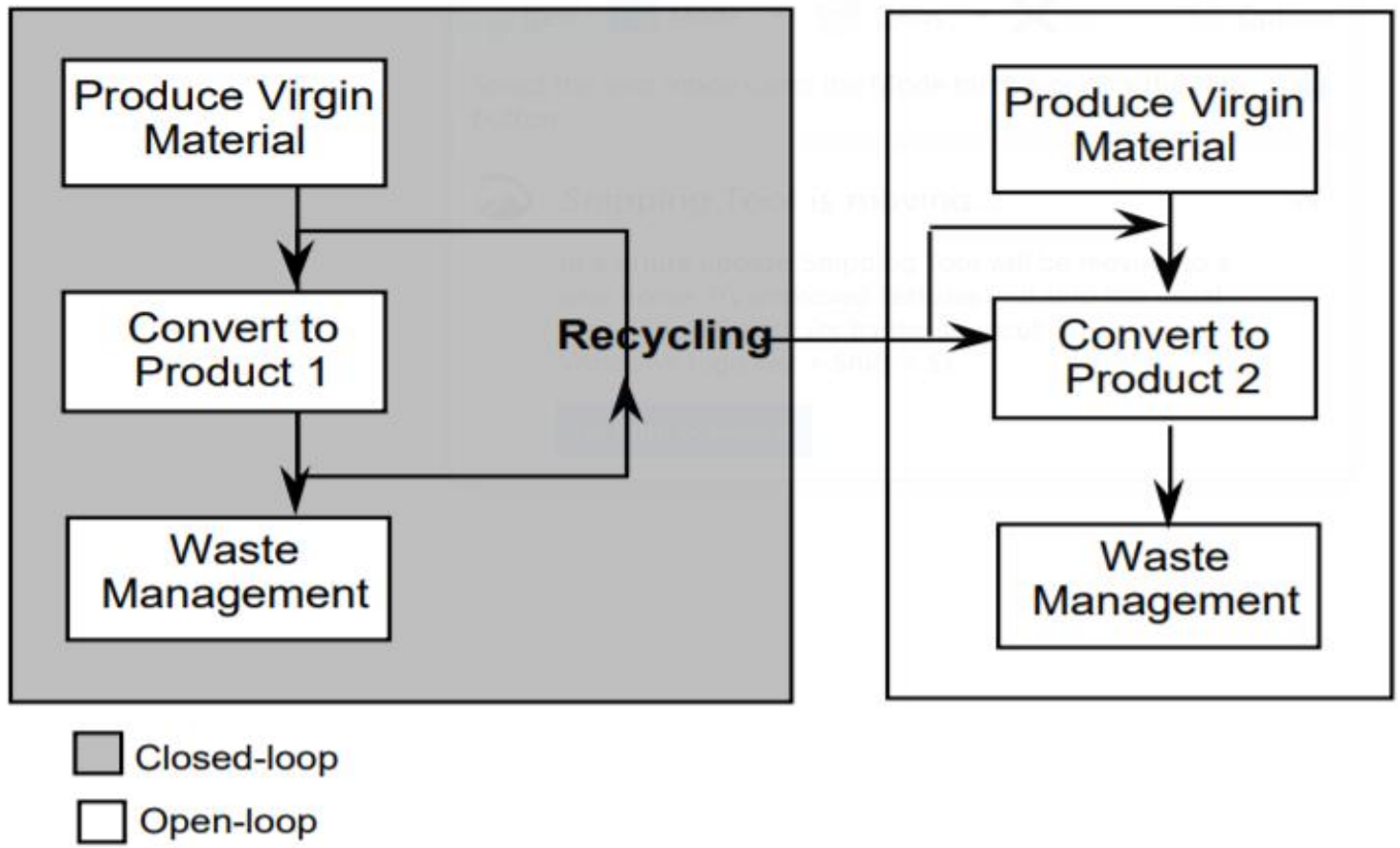


EXHIBIT 7: RECYCLING SUBSYSTEM



Limitations of LCA

- Studies relate to normal operations, rather than where incidents occur, which must be understood through separate risk assessments
- The quality of the available data: obviously this is what determines the validity of the whole LCA
- Reliability of the environmental scores is dependent on the skill of the LCA practitioners employed
- Investment decisions are delayed as a consequence of how long LCAs take

Example of LCA

https://youtu.be/6RNnzfUHwY8

Material Flow Analysis

- MFA, on the other hand, is a tool used to track the flow of materials and resources through a system or economy, from extraction to final disposal.
- It helps to quantify the amount of materials used and generated at each stage, and to identify areas where waste and inefficiencies can be reduced.
- MFA can be used to assess the environmental impacts associated with material use, and to guide decisions about waste management, recycling, and resource conservation.

Green Energy

- Green energy refers to energy sources that are renewable and have a low impact on the environment, such as solar, wind, hydropower, and geothermal energy.
- These sources of energy are typically considered more sustainable than fossil fuels, which have significant environmental impacts such as air and water pollution and greenhouse gas emissions.
- Investing in green energy infrastructure and technologies is a key strategy for mitigating climate change and promoting sustainable development.

Waste management

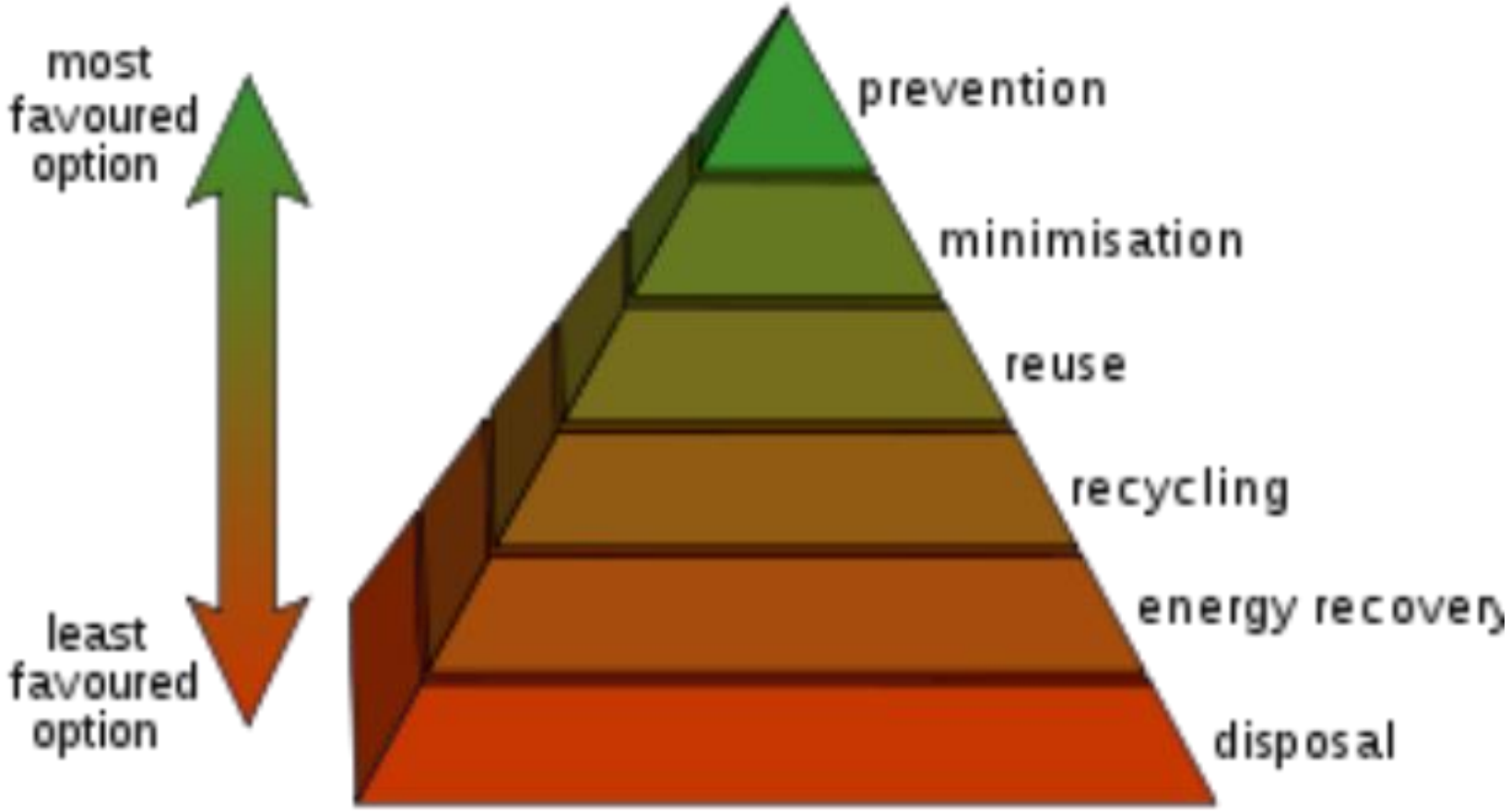
- Waste management refers to the collection, transport, processing, disposal, and monitoring of waste materials in a way that minimizes their impact on human health and the environment.
- Effective waste management strategies include reducing waste at the source, recycling and reusing materials where possible, and disposing of waste in ways that minimize its impact on the environment, such as through incineration or landfilling.
- Proper waste management is crucial for protecting public health, reducing pollution, and conserving natural resources.

Waste management

- Minimizing solid waste
- Minimizing packaging
- Recyclable-
  - Paper, plastics, metals, glass, wood
- Reusable-
  - Textiles, leather, rubber, metals, wood
- Compostable-
  - Yard trimmings, food scraps (vegetable)

Waste hierarchy

Waste hierarchy refers to 3 Rs
Reduce, Reuse, Recycle



3R Concepts

- **Reduce, Reuse ,Recycle**
- Reduce the amount of the Earth's resources that we use.
- Reuse Don't just bin it, could someone else make use of it?
- Recycle Can the materials be made into something new?

3R Concept of Waste Management

- The three R's – reduce, reuse and recycle – three essential components of environmentally-responsible consumer behavior.
- Helps to cut down on the amount of waste we throw away.
- They conserve natural resources, landfill space and energy.
- The three R's save land and money communities must use to dispose of waste in landfills.

Reduce

- Reduce: to make something smaller or use less, resulting in a smaller amount of waste.
- "Source reduction" is reducing waste before you purchase it, or by purchasing products that are not wasteful in their packaging or use.
- A key part of waste "reduction" is "conservation" - using natural resources wisely, and using less than usual in order avoid waste.

Reuse

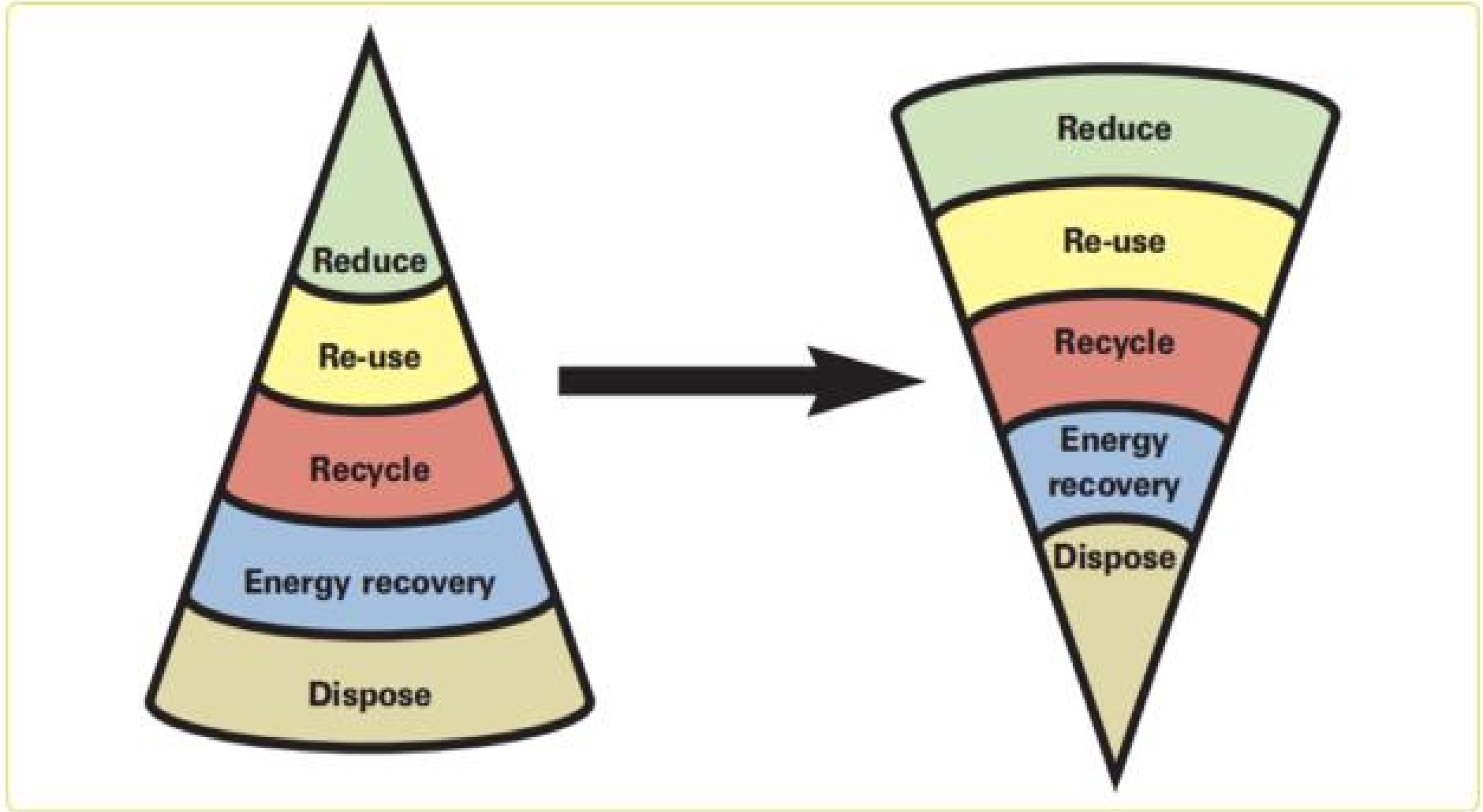
- Reuse: to use again or more than once
- Reuse materials and items so that they have longer life spans and don't get thrown away after the first use.
- Many items found around the home can be used for different purposes.
- So before you throw those items away, think about how they can be reused.

Recycle

- Recycle: to convert materials/waste into reusable material
- Landfills are full of items that could be recycled.
- Recycling puts objects through a process that allows them to be used again.

Advantages of 3R

1. Protects environment and natural resources.
2. Reduces energy consumption
3. Reduces pollution, global warming etc
4. Reduces waste generation
5. Creates jobs at recycling sites.


Reduce
Re-use
Recycle
Energy recovery
Dispose
Reduce
Re-use
Recycle
Energy recovery
Dispose

Sustainable Cities

- Sustainable cities, urban sustainability, or eco-city is a city designed with consideration for social, economic, environmental impact and resilient habitat for existing populations, without compromising the ability of future generations to experience the same.
- These cities are inhabited by people whom are dedicated towards minimization of required inputs of energy, water, food, waste, output of heat, air pollution - CO2, methane, and water pollution.
- A sustainable city can feed itself with minimal reliance on the surrounding countryside, and power itself with renewable sources of energy.
- The crux of this is to create the smallest possible ecological footprint, and to produce the lowest quantity of pollution possible, to efficiently use land; compost used materials, recycle it or convert waste-to-energy, and thus the city's overall contribution to climate change will be minimal, if such practices are adhered to.
- Promote the use of public transit, walkability and biking which would benefit citizens health wise but also be environmentally beneficial.

Sustainable Cities - Features

- Eco industrial parks
- Urban farming
- Waste recycling
- Walkable streets, public spaces.
- Parks & recreational areas- Access to green spaces, such as parks and gardens, that provide opportunities for recreation, relaxation, and biodiversity.
- Green buildings
- Sustainable transport- Efficient and sustainable transportation systems, such as public transit, cycling infrastructure, and pedestrian-friendly streets.
- Renewable energy- Sustainable energy systems, such as renewable energy sources and energy-efficient buildings, that reduce greenhouse gas emissions and promote energy security.
- Sustainable water management systems, such as rainwater harvesting and wastewater treatment, that conserve water resources and reduce pollution.
- Socially inclusive and equitable urban planning, that ensures access to essential services, affordable housing, and employment opportunities for all residents.

Copenhagen

- The city's airport, rail and suburbs are all connected to the centre by the metro system.
- In the city centre, a combination of measures has encouraged an increase in walking and cycling and a decrease in private car use.
- 90 % of all construction waste is recycled and 75 per cent of all household garbage used for heating.
- Many public squares and streets are pedestrianised.
- The city has a programme to gradually reduce the number of car parking spaces by 3 per cent per year and further develop cycle lanes and a free cycle hire scheme.

Copenhagen goals

- 90% of citizens will be no more than 15 minutes' walk from a park or one of Copenhagen harbour's two swimming facilities.
- Creation of green cycle routes with Government ministers leading by example. Currently 37km out of proposed 110 have been completed
  - **"Our main goal is to be the world's first carbon neutral city by 2025" Klaus Bondam – Mayor Of Copenhagen (March 2009)**

FREIBURG GREEN CITY

Approaches to Sustainability

Eco housing, car-free streets and socially conscious neighbours have made the German city of Freiburg a shining example of sustainability.
The Observer 23rd March 2008

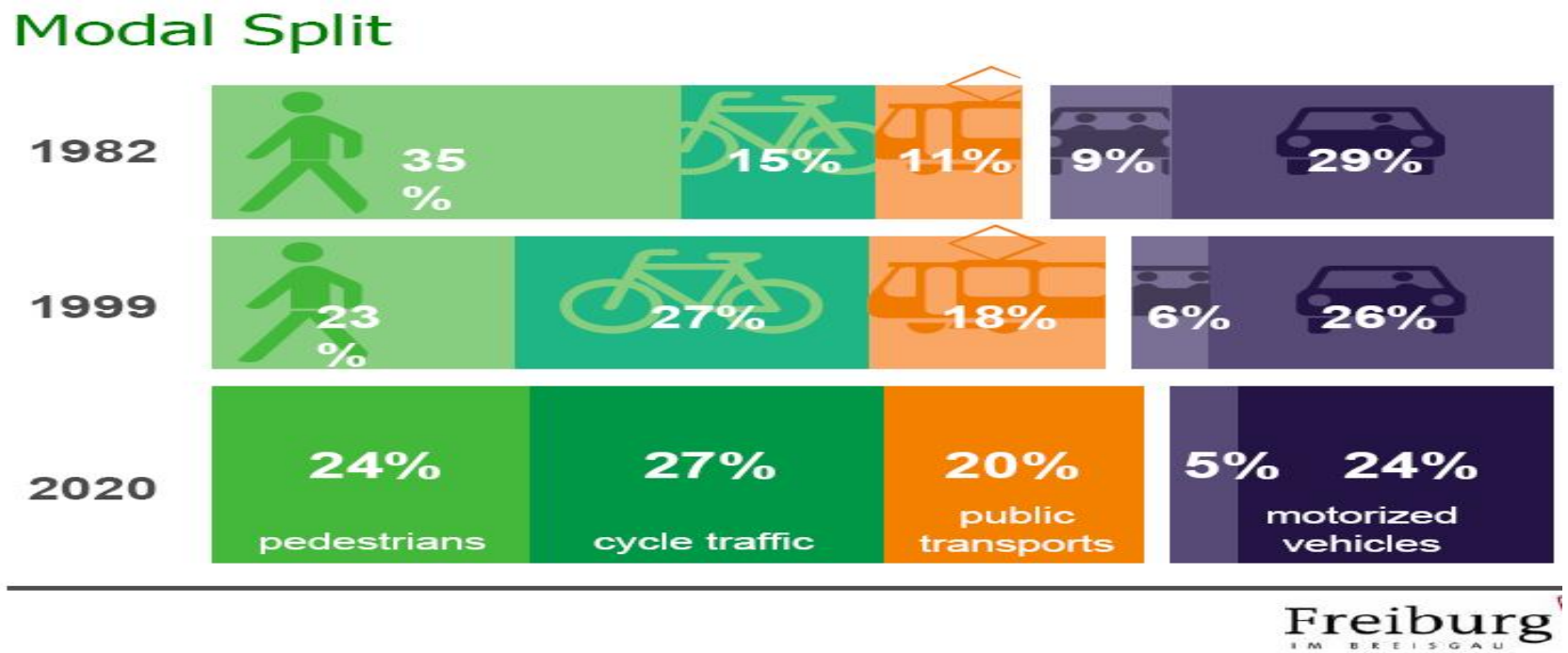
- After devastation of WW2, planners rebuilt the city for people not cars.
- Pedestrianised streets, bike lanes and excellent trams were at the heart of the city's development. Plus the unique Freiburg Bächle, small canals that run down each central street.

•http://www.youtube.com/watch?v=IMnB6V5yG1I&feature=player_embedded#

- **Climate protection** - In 1996, the municipal council decided to reduce CO2 emissions by 25 percent before the year of 2010. In the summer of 2007, the municipal council raised the benchmark even higher for the next phase: 40 percent less CO2 by 2030.

- **Solar Power** - With more than 1,800 hours of sunshine each year and an, Freiburg is one of the sunniest cities in Germany. Freiburg hosts the world's first energy selfsustaining solar building, the Heliotrope. Even the local football stadium has become an attraction as the first stadium worldwide to have its own solar plant.

Recycling - The city itself sets a good example by using paper, of which approximately 80 percent has been recycled. Since 2005, non-recyclable waste from the region is incinerated at a plant in the Industrial Park Breisgau, located 20km south of Freiburg. It supplies energy to 25,000 households.



Transport - In 1969, introduced a transport that sought to ensure a good level of mobility that did not encroach upon positive urban development, nature and the environment. Policy gives preference to environment-friendly modes of movement (pedestrian traffic, cycling, local public transport).

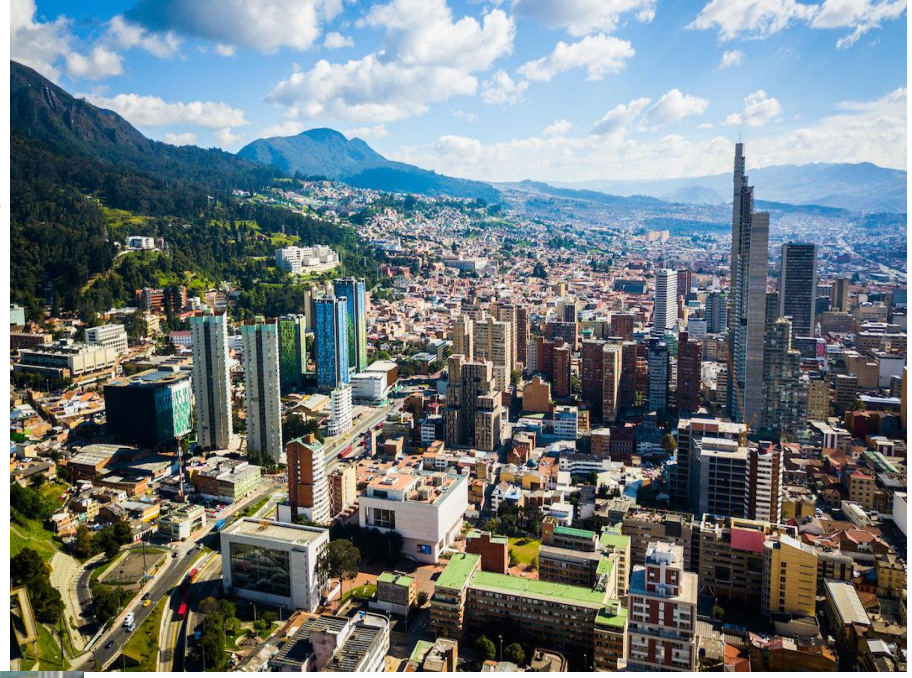
- Between 1982 and 1999, the contribution of cycling to the city's volume of traffic increased from 15 to 28 percent. At the same time, public transport increased from 11 to 18 percent, whereas the distances driven by motor vehicles decreased from 38 to 30 percent. Compared with other major cities in Germany today, Freiburg has the lowest motor vehicle density, with 423 motor vehicles per 1,000 people.

Frieburg, Germany

- Freiburg has an extensive pedestrian zone in the city centre where no motor cars are allowed.
- Freiburg also has an excellent public transport system, operated by the city-owned VAG Freiburg. The backbone of the system is the Freiburg tramway network, supplemented by feeder buses.
- Car share websites such as Mitfahrgelegenheit are commonly used among Freiburg residents, since they are considered relatively safe.

Bogota, Columbia

- Public transport- Transmilenio
- Bicycle paths
- Travel restrictions
- Pedestrian lanes, segregation



- India is working on Gujarat International Finance Tec-City or GIFT which is an under-construction world-class city in the Indian state of Gujarat. It will come up on 500 acres land. It will also be first of its kind fully Sustainable City.

Further Research

- **http://www.sustainablecities.org.uk/good_practice/**
- **Bogota – Colombia**
- **Greensburg – USA**
- **Malmo – Sweden**
- **Vancouver – Canada**
- **http://www.wwf.fi/wwf/www/uploads/pdf/sustainable_model_city_freiburg_in_germany.pdf**



Sustainable Urbanisation

- Urbanisation is the process in which the number of people living in cities increases compared with the number of people living in rural areas.
- A country is considered to be urbanised when over 50% of its population lives in urban places.
- Urbanisation is most rapid in Third World countries, where the world's largest cities occur.
- Mexico City, the world's largest city, has a population of more than 18 million, estimated to grow to over 125 million people by the year 2015.
- 2050- 2/3rd of the world population may live in urban areas.

Urbanisation

- The process of urbanization has occurred differently in much of the developing world.
- Historically many of these countries were former colonies.
- They have some of the highest rates of population growth and the largest urban areas.
- They are characterized as being poor having significantly less technology than the developed world.
- Very rapid transition from rural to urban societies.
- Population is placing pressure on urban areas
- No benefit of industrialization - the lack of employment opportunities for the mass of urban migrants
- Undermines the ability of cities to incorporate people.
- The consequences of this lack of employment opportunities are
  - growing urban areas a large percent of whose population is unemployed
  - poverty
  - life in unsanitary squatter settlements

Urbanisation

Push factors- Leave their area(negative reasons)

- No alternative jobs
- Less income/money.
- Poor access to healthcare and education.
- Higher effects of natural disasters.
- Low quality of air, water etc.
- Civil wars, corruption

Pull factors- Attract people to new area(positive reasons)

- More jobs in many avenues.
- Better income
- Better facilities for education and healthcare.
- Less affected by natural disasters
- Better quality of air, water.
- Better governance, less corruption.

Sustainable Urbanisation

- Sustainable urbanization refers to the process of managing urban growth and development in a way that promotes sustainable development outcomes.
- This includes the adoption of sustainable urban planning and design principles, the promotion of sustainable transportation and energy systems, and the provision of essential services and infrastructure in a socially inclusive and equitable manner.
- Economic sustainability-Income generation and opportunities. Use of resources without degradation.
- Environmental- Resources, environment.
- Social- Inclusiveness, cultural heritage preservation.
- Political- Governance/planning growth/design of urban areas.

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- https://ndma.gov.in/Natural-Hazards/Urban-Floods

Sustainability

https://www.un.org/millenniumgoals/?