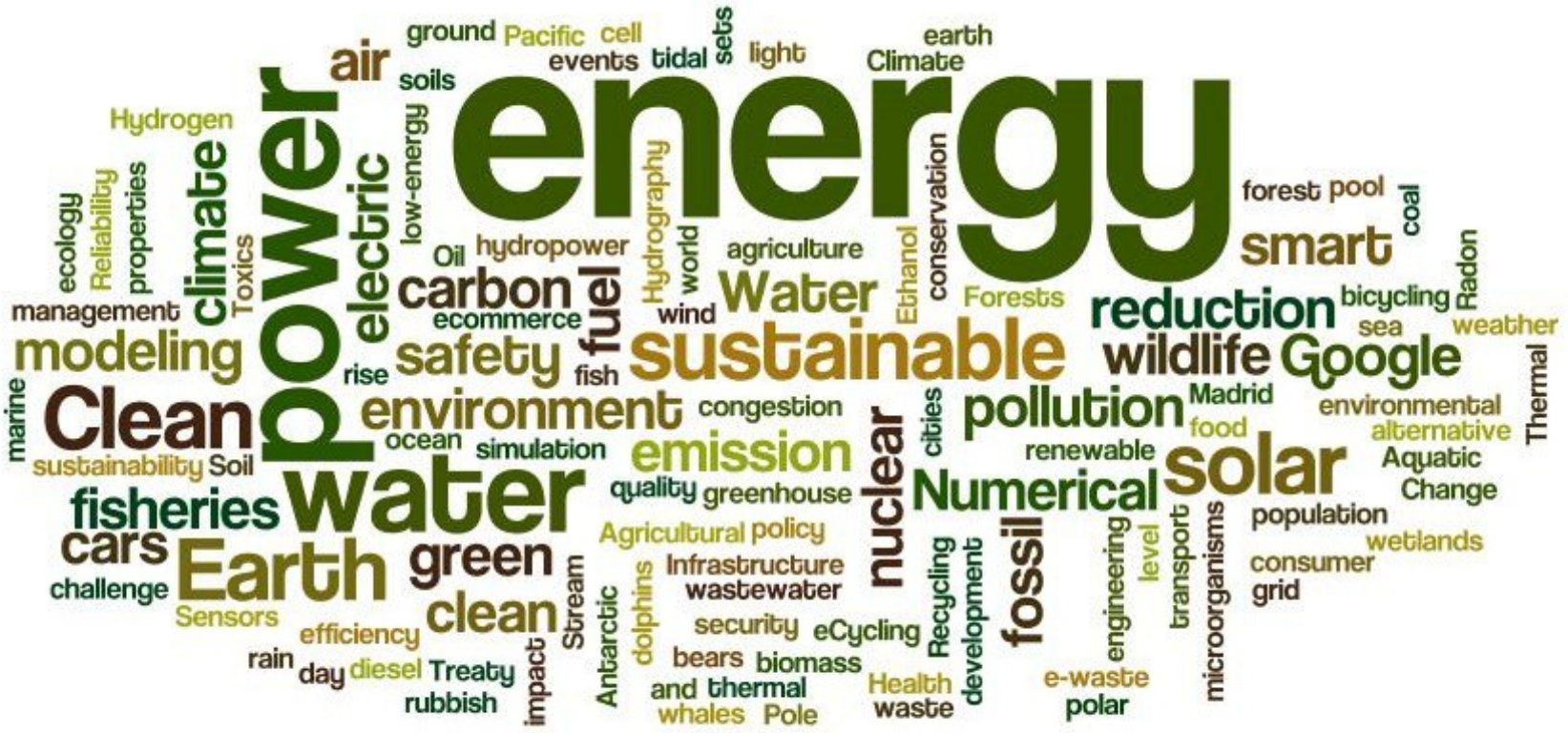
What is sustainability?



Sustainable Development

"*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*." Bruntland Report for the World Commission on Environment and Development (1992)

"*A process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations.*" The World Commission on Environment and Development

"*Sustainable development is a dynamic process which enables people to realise their potential and improve their quality of life in ways which simultaneously protect and enhance the earth's life support systems*." (Forum for the Future)

"*A sustainable future is one in which a healthy environment, economic prosperity and social justice are pursued simultaneously to ensure the well-being and quality of life of present and future generations. Education is crucial to attaining that future*." (Learning for a Sustainable Future - Teacher Centre)

Vision 2021 - UAE

SUSTAINABLE ENVIRONMENT AND INFRASTRUCTURE

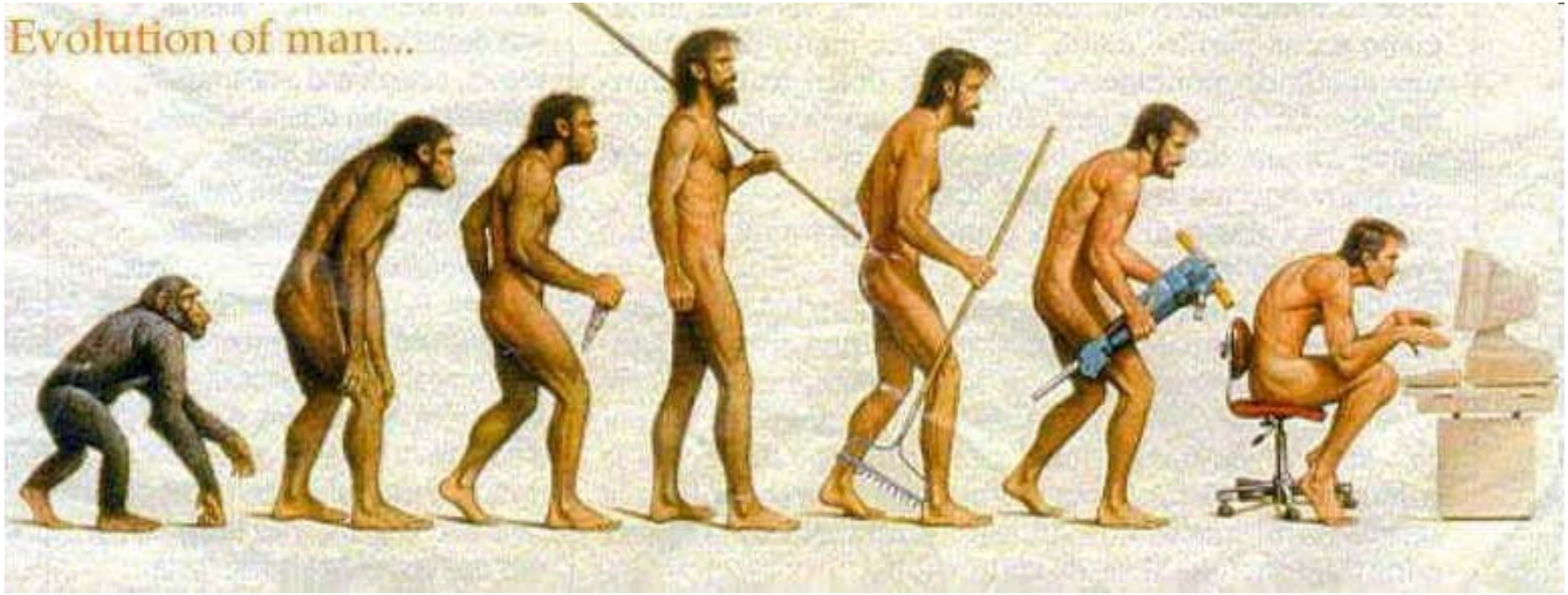
The UAE Government wants to ensure sustainable development while preserving the environment, and to achieve a perfect balance between economic and social development

To do that, the UAE Vision 2021 National Agenda focuses on improving the quality of air, preserving water resources, increasing the contribution of clean energy and implementing green growth plans.

Also, the National Agenda highlights the importance of infrastructure and aims for the UAE to be among the best in the world in the quality of airports, ports, road infrastructure, and electricity. And leading telecommunications infrastructure will allow the UAE to become a forerunner in the provision of Smart services.

Finally, seeking to further improve the quality of life of its citizens, the Agenda has set a target to provide suitable housing for eligible UAE nationals within a record timeframe.

The Human Ecosystem



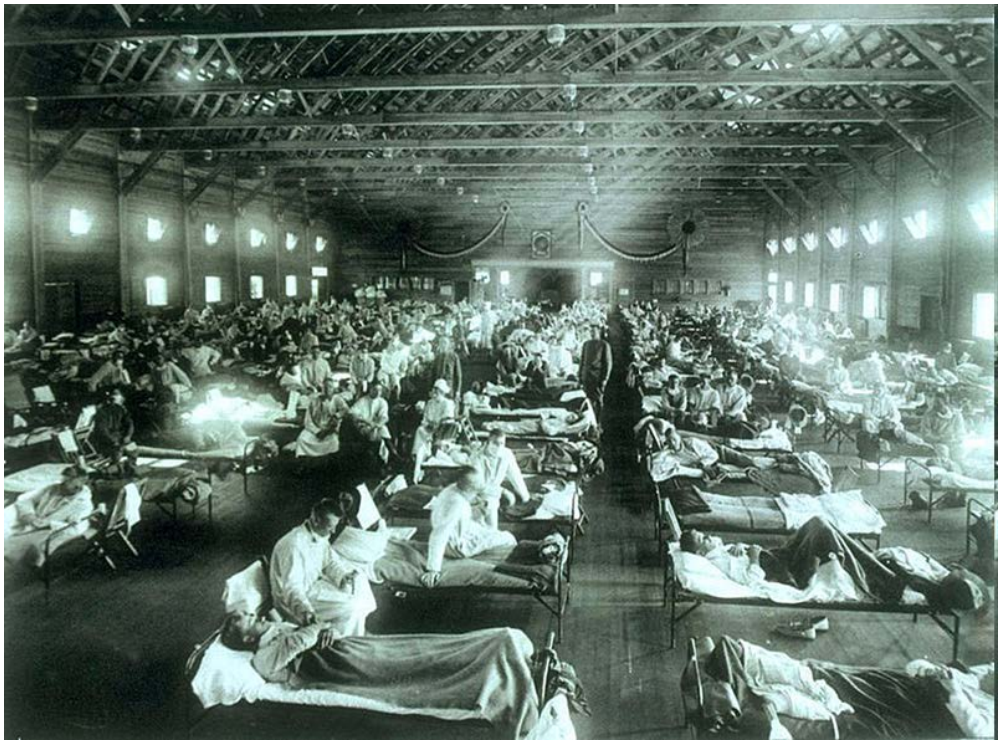
Although sophisticated social creatures, human beings are nonetheless animals who inhabit a finite space (i.e. the world). Like all other animals, they inhabit an ecosystem, which is influenced by the same rules that govern all ecosystems.

The Black Death (1347 – 1350)

- In the 14th century, the bacterium, *Yersinia pestis,* caused the bubonic plague (the Black Death). Bubonic plague entered Europe and Africa through infected rodents and fleas.
- The plague epidemic spread through Europe, Africa, and the Middle East, killing about 20 million people in Europe alone. Plague is spread to humans through the bites of fleas, which pick up the bacteria while sucking blood from rodents, especially rats.
- In the United States, health care providers report cases of plague even today, most of which are found in the Southwest.

Source: U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

1918 Spanish Flu



- From 1918 to 1919, the influenza virus ravaged worldwide populations. Estimates of the number of people killed during the so-called “Spanish flu” pandemic range from 20 million to 40 million.
- It has been estimated that about 3% of the world's population, died of the disease and that about a third became infected.

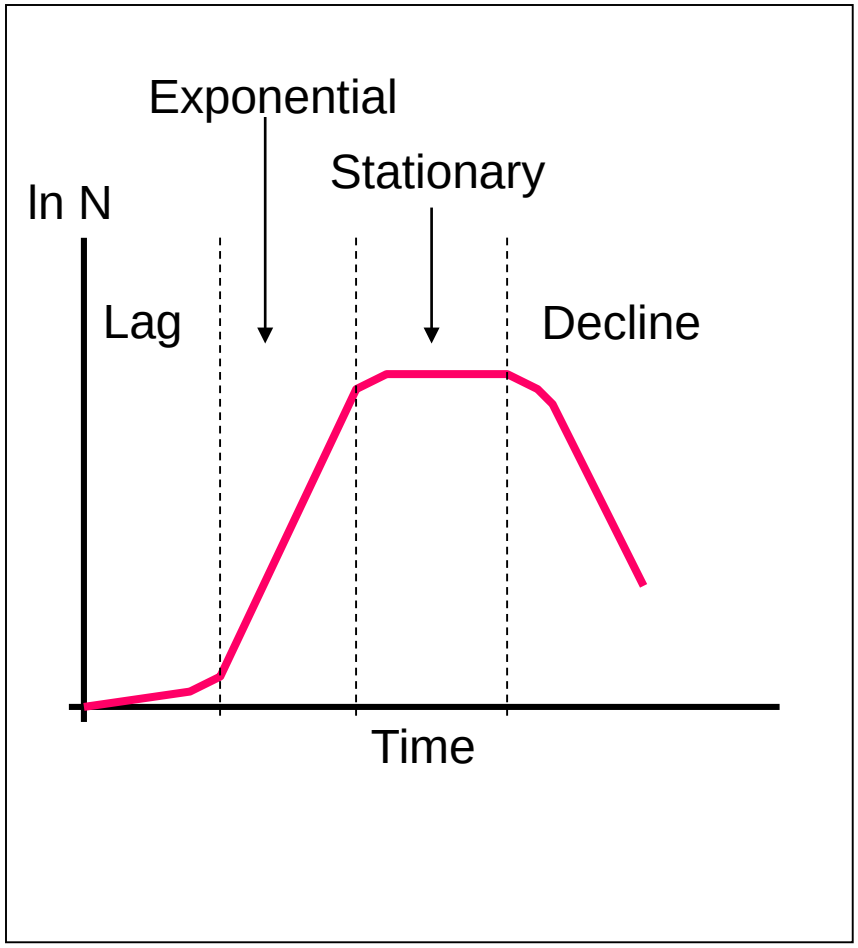
Source: U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

Slide from June 2019

False Security on diseases

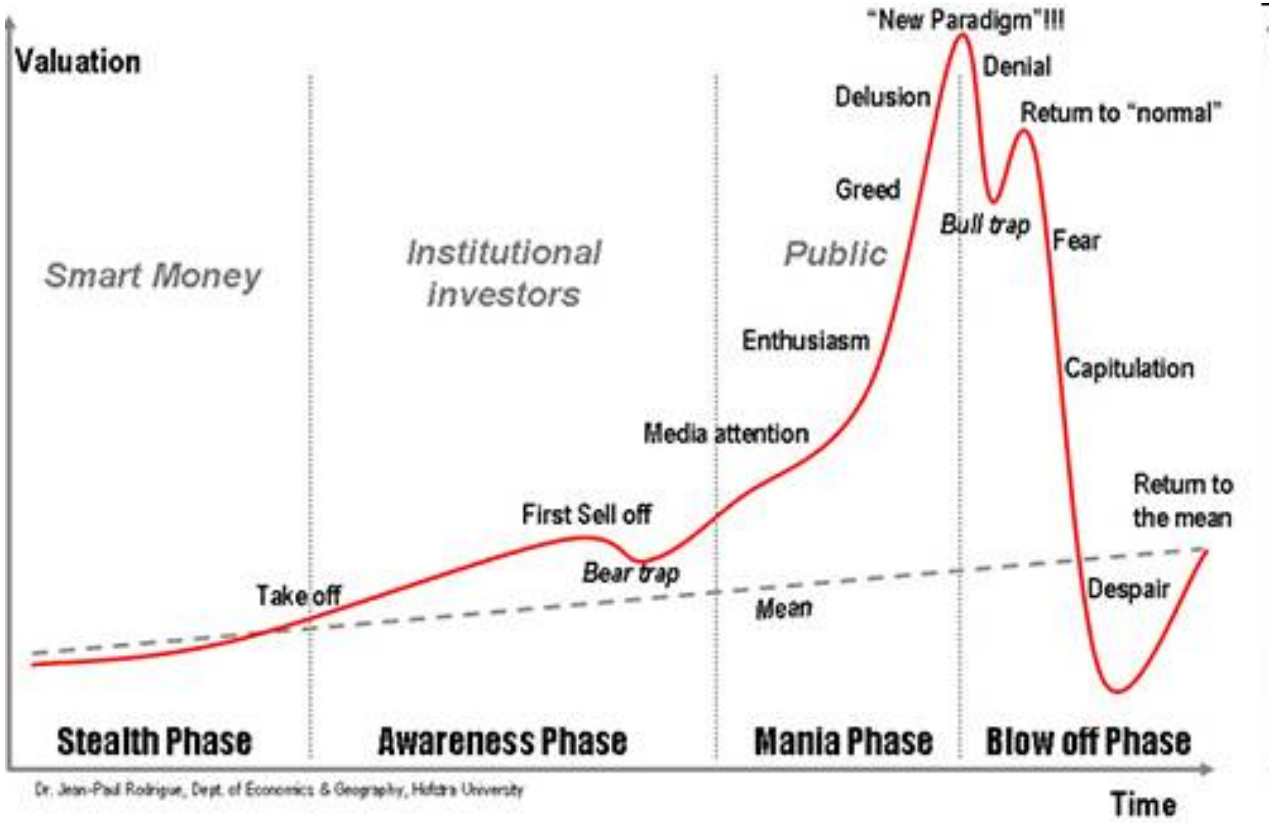
- Because we are technologically advanced it is tempting to believe such plagues are a thing of the past.
- We live in an antibiotic age in which many infectious diseases can be controlled.
- The massive death toll associated with infectious diseases (experienced by previous generations) is a distant memory.
- Surely, we have conquered infectious disease?
- Many microbes have developed resistance to our antibiotic drugs.
- If our antibiotic drugs fail, then infection will once again claim millions of lives.
- It is a constant battle which requires mankind to invest huge amounts of money and energy in pharmaceuticals in order to prevent millions of deaths.

Bacterial Growth Curve



- This classic curve applies to all bacterial populations suspended in a broth in a flask.
- Initially growth is slow as bacteria adapt to the new environment.
- Bacterial growth is then exponential, until nutrients become depleted or waste toxins inhibit growth.
- Growth then becomes stationary.
- Eventually the environment becomes depleted of nutrients and toxins increase so that the cells die.

Classic Market Bubble



- Initially growth is very slow as the market adjusts to the new demand.
- Then the market takes off and everyone wants a piece of the action.
- The price of the commodity rises steeply until a point at which it cannot be sustained.
- The product is overpriced and the market collapses.

Throttling Effect

- Economies behave in a very similar manner to ecosystems.
- As demand rises and resources become scarce, so competition increases and the price rises.
- As the price rises, so only the strongest/richest can afford the commodity and the others suffer.
- In economics, when the price becomes too high, it is unsustainable and it falls back to a level that is affordable.
- However, if a resource is essential and very scarce (e.g. food), the price may remain high and those who cannot afford it will simply die off (as in the Irish potato famine of 1847).
- In ecosystems when this happens, the population simply falls to a point where the available resources can once against support the survivors.
- Given that economies behave like ecosystems, this suggests that mankind is no cleverer than other animals!
- Left to his own devises man appears to consume resources at an unsustainable rate until nothing is left – just like bacteria!

Lesson from Easter Island

Easter Island, a small and remote rocky outcrop in the Pacific Ocean. Faced with dwindling timber resources it is thought that the ancient tribal groups on the island fought each other for control of supply and ultimately consumed all the timber on the island, with disastrous consequences.

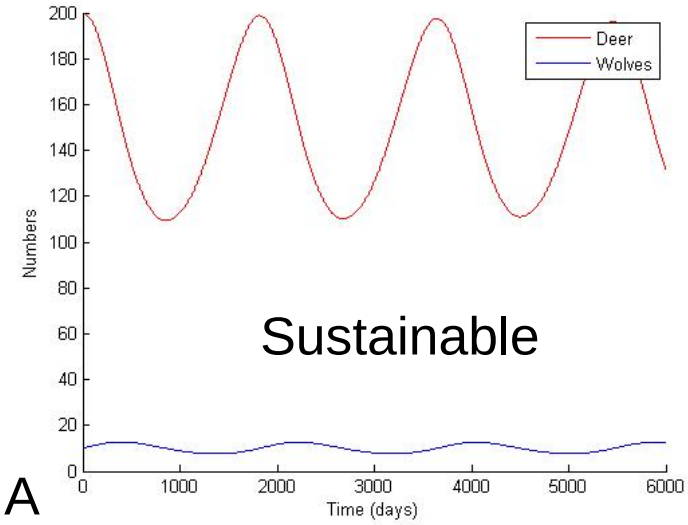
"*The Easter Islanders, aware that they were almost completely isolated from the rest of the world, must surely have realized that their very existence depended on the limited resources of a small island. After all, it was small enough for them to walk round the entire island in a day or so and see for themselves what was happening to the forests. Yet they were unable to devise a system that allowed them to find the right balance with their environment."*

C Ponting, 1993

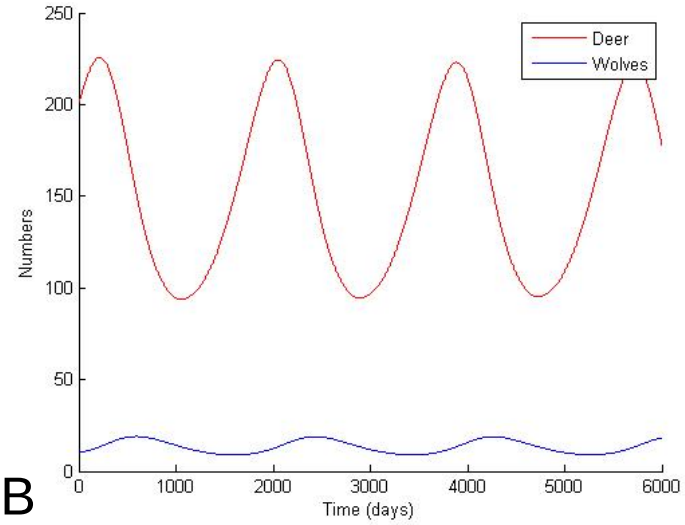
Sustainable Ecosystems

- An ecosystem is a distinct ecological unit that consists of both the living and non-living elements. Although change will continually occur within such an ecosystem, if it is to be sustainable it must have mechanisms which can cope with change.
- To be sustainable an ecosystem must use resources efficiently. Photosynthesis uses energy from the sun to promote plant growth. The solar energy ‘trapped’ in the plants is then transferred to animals when they feed on the plants. When plants and animals die, they decompose and the resultant organic material makes nutrients available for the ecosystem's organisms (e.g. plants, fungi, etc.). In this way the resources in the ecosystem are efficiently recycled.
- However, in order to stay healthy the ecosystem needs a continuous supply of energy from the sun. Without this, it will die.
- To be sustainable the ecosystem’s resources must not be depleted too quickly – there must be a balance between replacement of resources and demand. Predator-prey relationships illustrate this concept. Prey species such as deer feed on plants and grass. Left unchecked, populations increase, consuming all the available resources, to the point where some members starve. Predators however eat the deer and keep the herd numbers in check. As a result the grass and plant resources are not depleted and the ecosystem remains sustainable.

Lotka-Volterra Model of Deer & Wolves



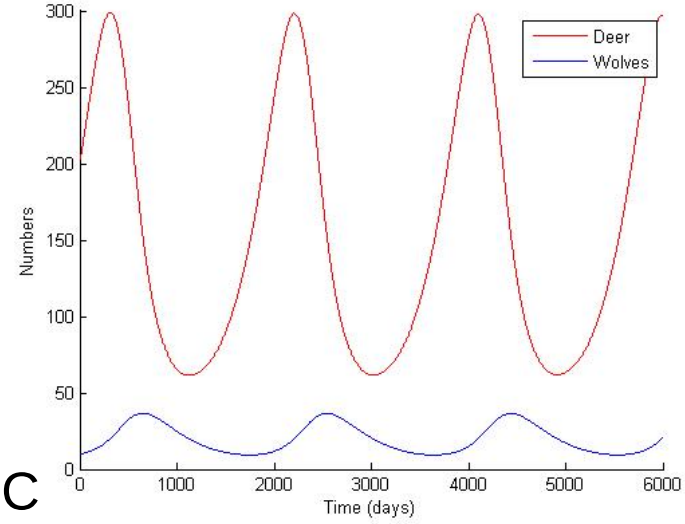
A



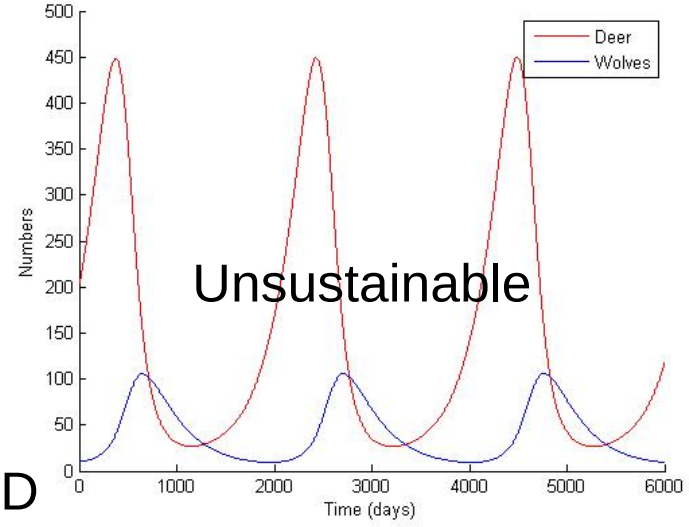
B

Predation Rates

A: 0.0004
B: 0.0003
C: 0.0002
D: 0.0001



C



D

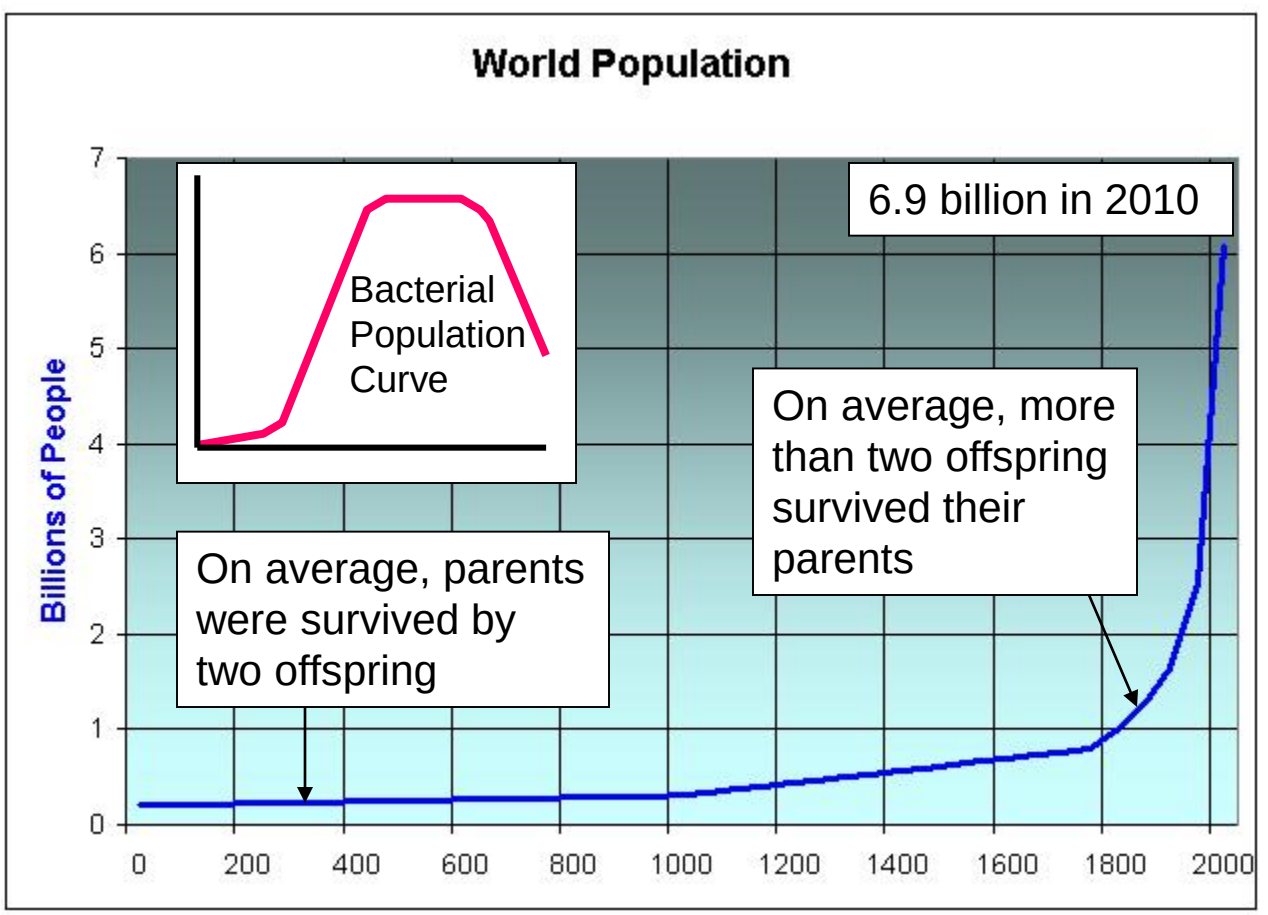
Key Sustainability Characteristics

In sustainable ecosystems:

- Predation occurs and animals die.
- Cyclical fluctuations occur in population numbers, these result in periodic population booms and crashes.
- Resources are not depleted at a rate faster than they can be replenished.
- There is a natural throttling process, in which animals die or leave, if resources become too scarce.
- Waste products are bio-degradable and efficiently recycled.
- There is a continuous input of energy from the sun. Without this the ecosystem will die.
- Ecosystems are finely balanced and even small changes in the behaviour of one species can result in big changes in the ecosystem.

Why is sustainability important NOWADAYS?

Population of the Earth (AD 0 - 2010)



In the nineteenth century with improvements in hygiene and medicine, the threat of infection decreased and the population of the Earth started to increase rapidly. Now the world's population is increasing exponentially, just as in the classic bacterial population curve.

Unprecedented Challenges

Increasing Water Scarcity

Threat of Waterborne Illness

Growth of Developing Nations

Rising Cost of Energy

New Stringent Regulations

Massive Infrastructure Needs

Everyone Can't Be Rich or can they?

Developed world

- Highly ordered society
- Good infrastructure
- High per capita energy consumption
- High per capita GDP
- High standard of living

As one goes up the other must come down.

Developing world

- More chaotic society
- Poor infrastructure
- Low per capita energy consumption
- Low per capita GDP
- Low standard of living

Ethical Dilemma

Throughout history the population of the Earth has been controlled by the presence of disease, particularly infectious diseases. In effect, microorganisms are man's major predator. For example, before it was eradicated in 1977, smallpox killed many millions of people over thousands of years. In 1918-19, the "Spanish flu" pandemic killed in the region 20-40 million people.

This presents us with a major ethical dilemma. We develop medicines to fight disease because we want to save lives and yet in doing so we create another problem, over-population, which ultimately threatens the human ecosystem.

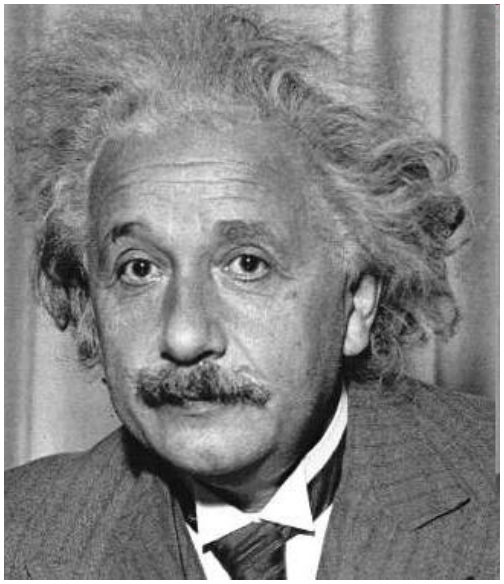
But Humans are not Animals

But we need to think differently about the way we do things

- https://www.youtube.com/watch?v=5lOSIHWOp2I

What things or practices today do you think are fundamentally unsustainable though they seem like a good thing today?

Second Law of Thermodynamics: Chaos will Increase



"A theory is the more impressive the greater the simplicity of its premises, the more varied the kinds of things that it relates and the more extended the area of its applicability. Therefore classical thermodynamics has made a deep impression on me. It is the only physical theory of universal content which I am convinced, within the areas of the applicability of its basic concepts, will never be overthrown."

Albert Einstein

The second law of thermodynamics deals with the natural direction of energy processes. For example, according to the second law of thermodynamics, heat will always flows only from a hot object to a colder object. In another context, it explains why iron always turns to rust, and rust never becomes pure iron. This is because all processes proceed in a direction which increases the amount of disorder, or chaos, in the universe. Iron is produced by smelting ore in a foundry, a process which involves the input of a large amount of heat energy. So, when iron rusts it is reverting back to a ‘low energy’ state.

Entropy & Chaos

The second law of thermodynamics tells us that if a system is left alone it will always decay and that the amount of disorder, or chaos, will increase. Although it is a difficult concept to grasp, disorder has been quantified and given the name ‘entropy’. Entropy can be used to quantify the amount of useful work that can be performed in a system. In simple terms, the more chaotic a system, the more difficult it is to perform useful work.

In order for a system to be highly ordered (i.e. low entropy), a great deal of ordered energy must be focused in the system. For example, in order to keep a steam railway locomotive running, the engine, track and rolling stock must be constantly maintained, and coal must be mined and regularly transported to the locomotive. If the system in not constantly maintained, then it will fall into disrepair and there may even be an explosion or train crash – something that will definitely increase entropy (i.e. chaos).

Second Law of Thermodynamics

Entropy Increases

Coal burnt in power station to produce electricity

Electricity used to produce car

Car eventually crashes and rusts

- The second law of thermodynamics offers some profound insights into global energy usage. It tells us that when energy is expended in a system, the system will become more chaotic.
- When we burn coal or oil, we are essentially burning ‘concentrated sunlight’, which took millions of years to form.
- This is solar energy stored in a highly ordered way. When it is burnt the second law of thermodynamics states that the amount of disorder will increase (i.e. entropy increases).
- The more we burnt, the more disorder is created. This ultimately explains why we have pollution problems.

Low & High Entropy Societies

- If the second law of thermodynamics applies to railways, then it can also be applied to societies as a whole.
- for a advanced nations, such as the UK or USA, to maintain infrastructure, healthcare system, education system, and its manufacturing etc large amounts of focused energy must be expended every day else decay.
- Advanced hi-tech nations can therefore be considered to be low entropy societies.
- Developing nations which do not have access to large amounts of focused energy, tend to be less organised and more chaotic, and therefore can be considered as higher entropy societies.
- If however, energy is expended which is not focused, say as in a war, then entropy and chaos will tend to increase – something which is clearly evident in many parts of the world.

The World is a Small Place

- The world is a small interconnected space, with finite resources.
- Energy is traded across national boundaries.
- Advanced ‘low entropy’ nations need to import vast amounts of fossil fuel from other countries in order to ensure that GDP is maintained.
- Emerging economies such as China, Brazil & India, need vast amounts of fossil fuel in order to increase their GDP.
- Pollution does not respect national boundaries.

This is the era of sustainability!

The Three Elements of Sustainability

- **SOCIAL**
  - Social variable dealing with community, education, equity, social resources, health, well-being and quality of life.
- **ECONOMIC**
  - Economic variables dealing with the bottom line and cash flow.
- **ENVIRONMENTAL**
  - Environmental variables relating to natural resources, water & air quality, energy conservation and land use.

Sustainable Development is at the CORE

Element Interactions

- **EQUITABLE**
  - Business ethics
  - Social investment
  - Fair trade
  - Worker's rights

- **BEARABLE**
  - Environmental regulation
  - Natural resource stewardship
  - Education to encourage environmental sustainability

- **VIABLE**
  - Resource efficiency
  - Life-cycle management
  - Subsidies & incentives

Element Interactions

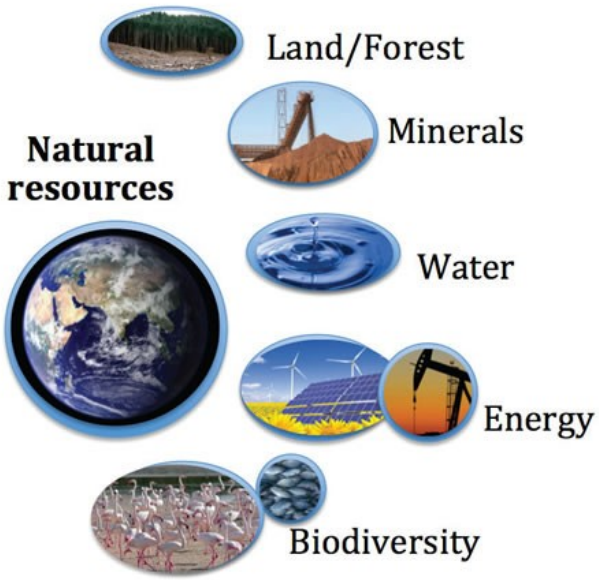
Sustainability focuses on balancing the fine line between competing needs.

- Our need to move forward technologically & economically…

- Our need to protect the environments in which we and others live…

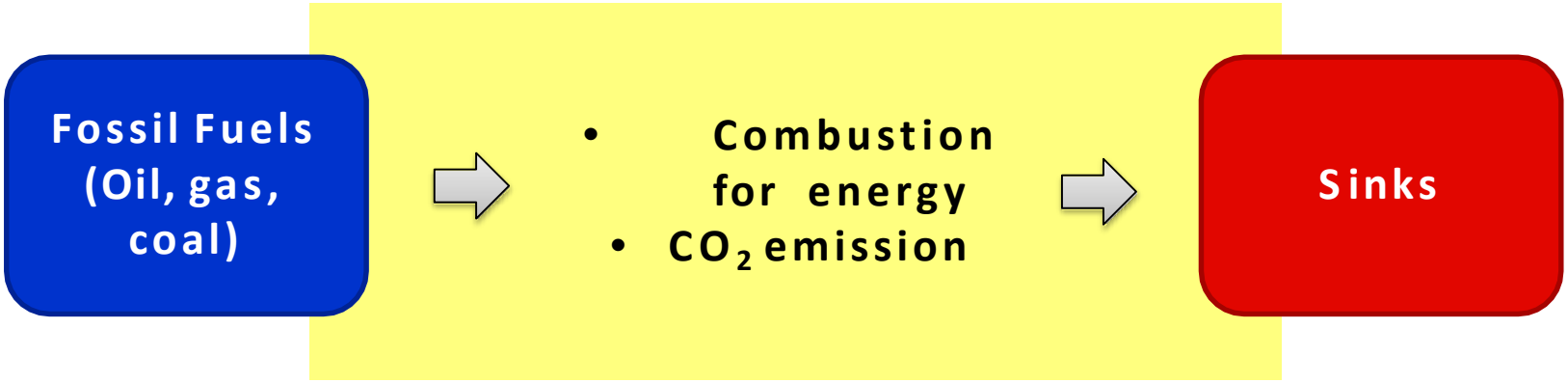
Resource Sustainability & Pollution Limits

Natural Resources → **Human Usage Activities** → **Sinks**



Resource Sustainability & Pollution Limits

E.g. Carbon Fuel Cycle



We may run out of the natural resource:

- Peak gas production will certainly occur in the next 50 years
- Peak oil production will occur much sooner if it has not already happened
- Coal will last much longer ?

OR

- CO_2 absorbed from the atmosphere
  - Uptake by forests for tree growth
- Deforestation?

Limits of the sink capacity may occur:

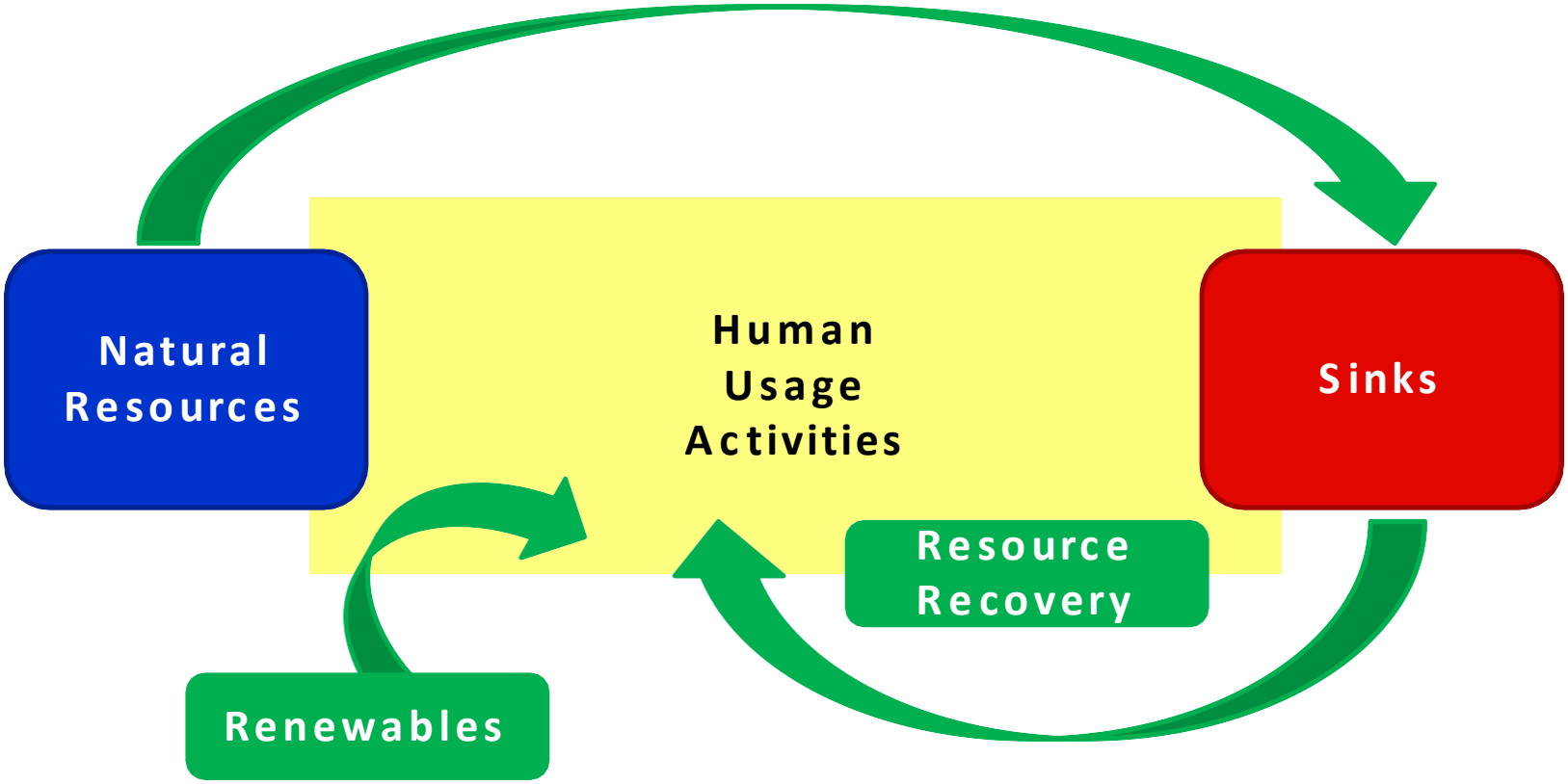
- The impact of CO_2 emission

Resource Sustainability & Pollution Limits

- An activity may be constrained by the **natural resource** limits or by the capacity of the **sink** to safely and naturally absorb pollutants.

- **Idealistically:** we can sustainably engineer both the resource supply and sink

Resource Sustainability & Pollution Limits



- There are many feedback loops of varying complexity that impact on the sustainability of human activities.

Externalities

- *Externalities* exist whenever the production or consumption inflicts involuntary costs or benefits on others:
  - external effects or impacts
  - intangible
  - are usually negative, unfair and unsustainable!

- They occur outside of the market
  - affect people not directly involved in the production/consumption of a good or service

Externalities

Examples from production


Air pollution from factories


Pollution from fertilizers


Industrial waste

Noise pollution


Collapsing fish stocks


Methane emissions

https://www.tutor2u.net/economics/reference/negative-externalities

Externalities

Examples from consumption

Vehicle pollution

Household waste

Noise pollution from neighbours

Air pollution from smokers

Traffic congestion

Gambling addiction

Litter from tourists

Spillover costs from obesity

https://www.tutor2u.net/economics/reference/negative-externalities

Tools to Internalise Externalities

- ✓ Regulations
- ✓ Emission fees (i.e. tax on emissions)
- ✓ Marketable permits
  - Need a permit to generate x amount of emissions
  - Can be bought or sold
  - Emissions trading scheme?
- ✓ Emission reduction incentives or subsidies
- ✓ Include natural capital in gross domestic product (GDP)
  - Clean air and water are not included as a part of a countries wealth

1. Water – Energy – Food **Nexus**

- *Nexus = connection!*

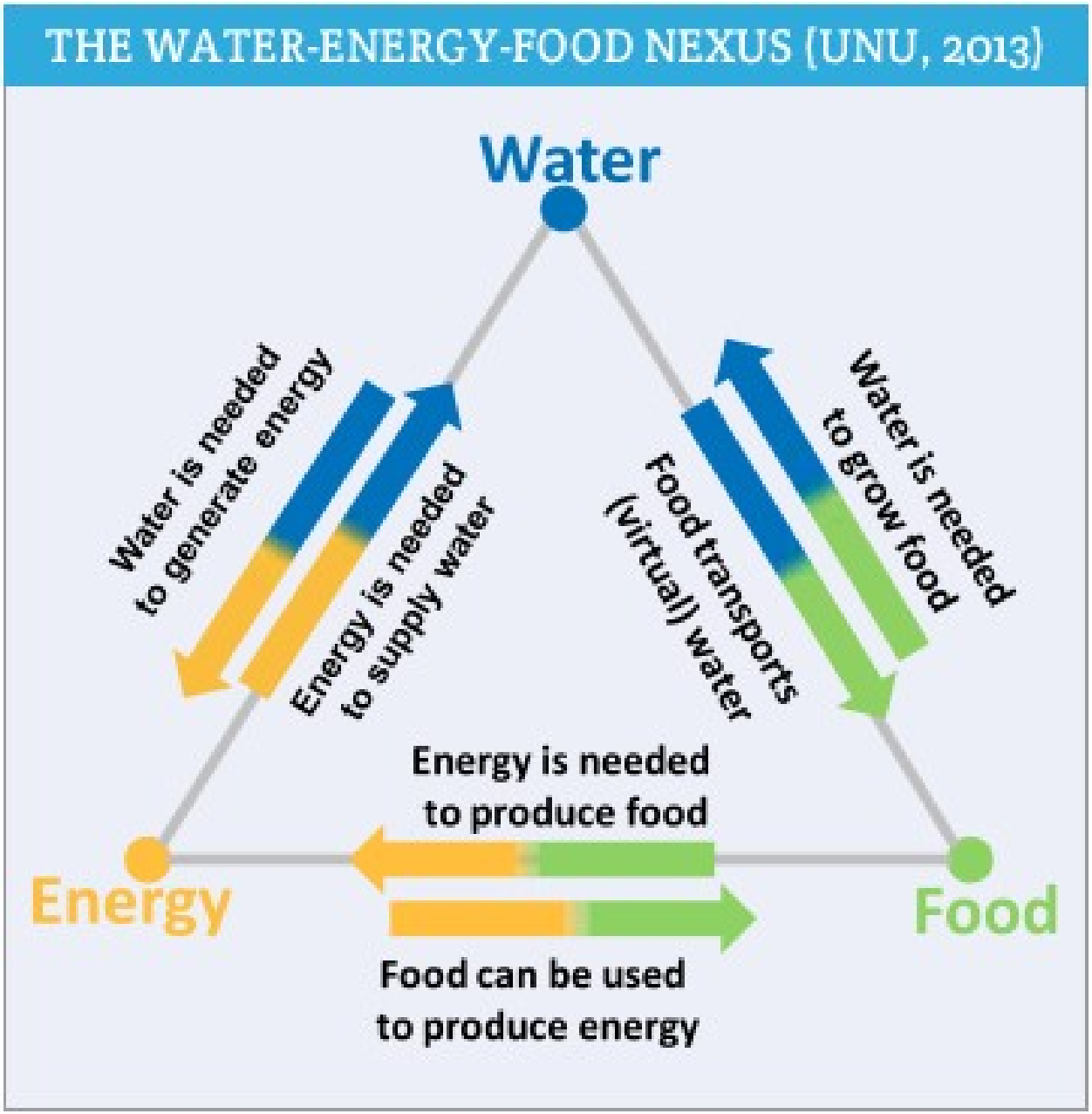
- Three sectors —
  - water security
  - energy security
  - food security

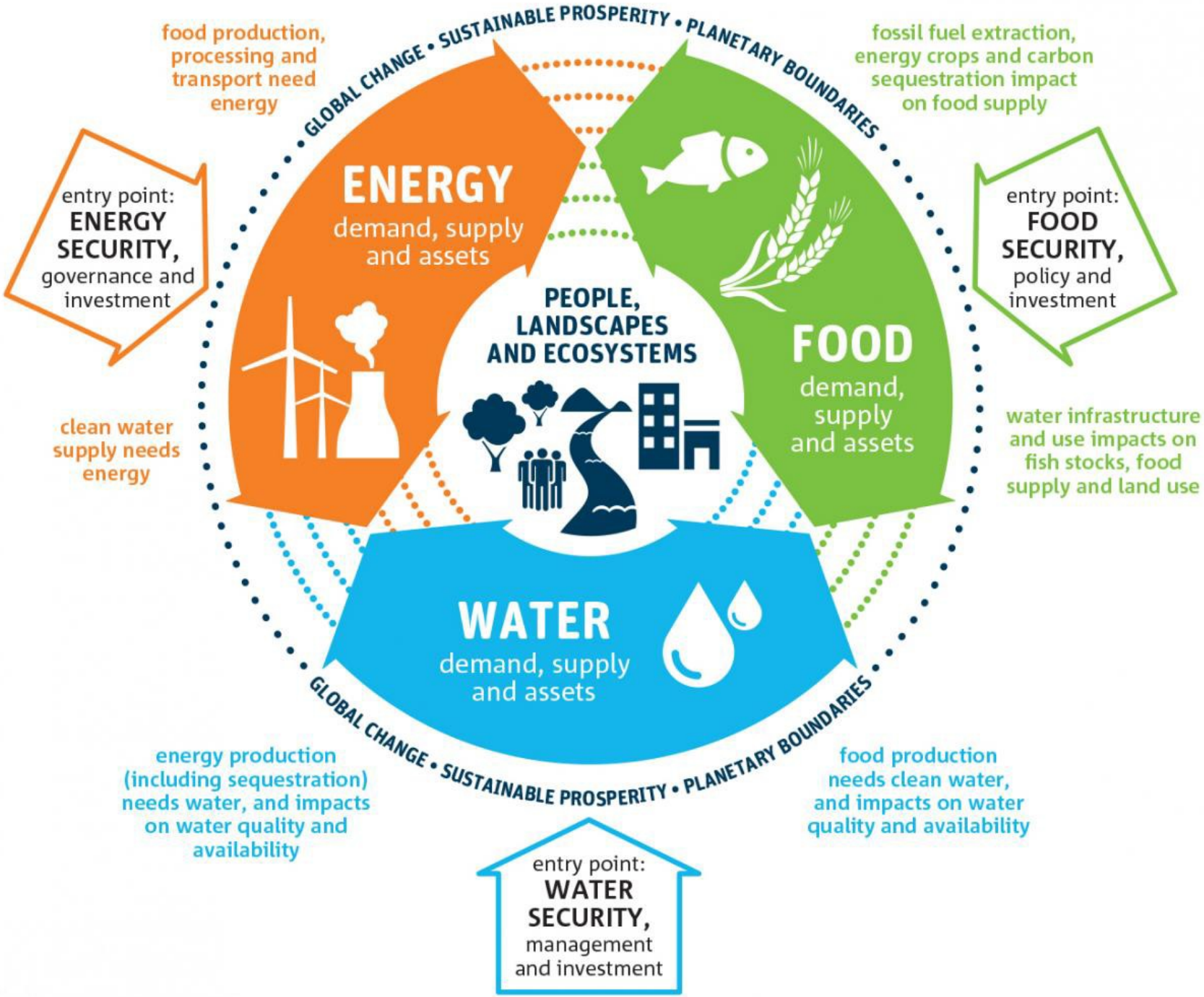
  } are inextricably linked

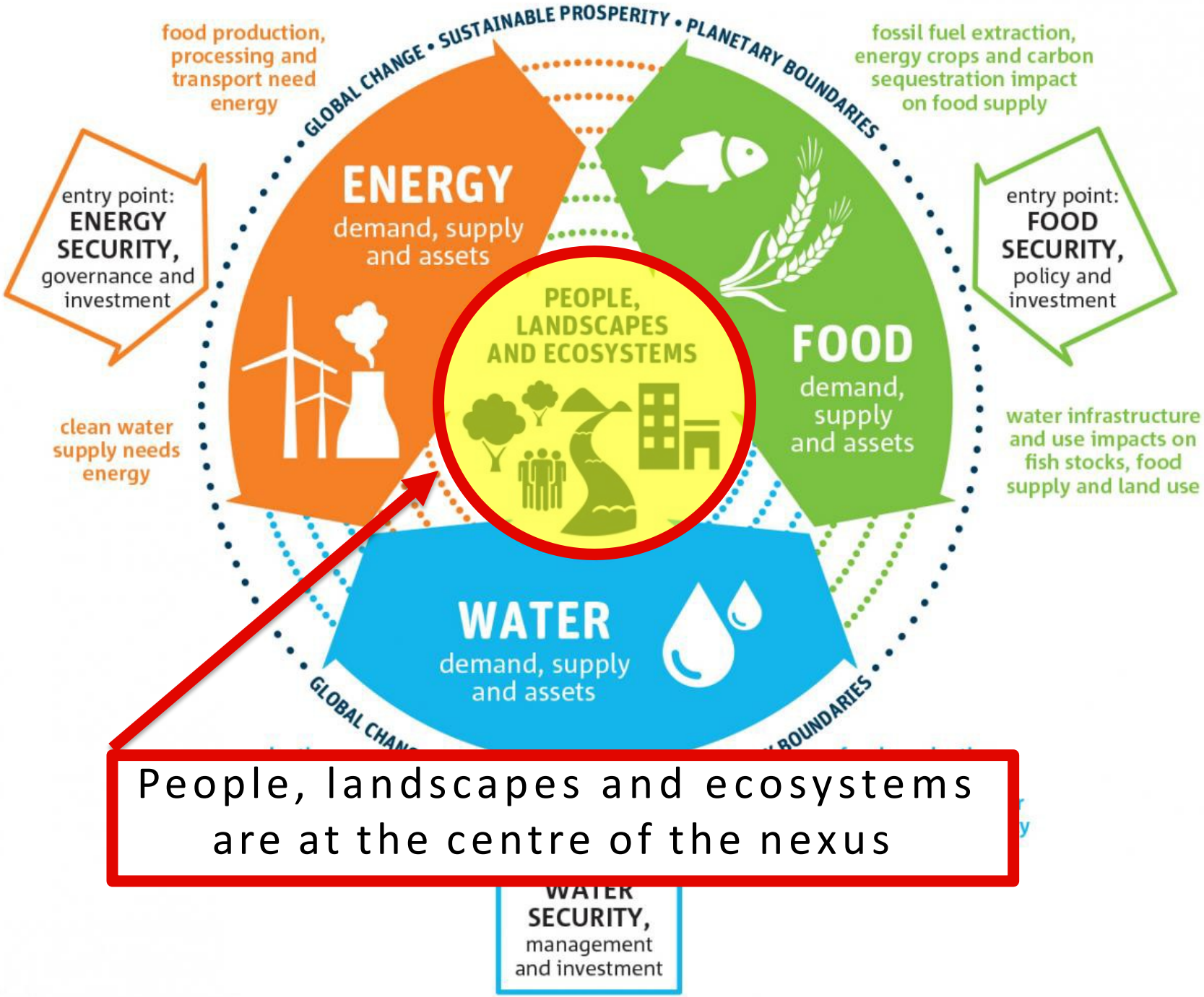
- Actions in one area have impacts on one or both of the others.

We Depend on Nature

- We exchange energy and matter with our environment as we:
  - Eat
  - Drink
  - Breathe
- We use:
  - Energy for heat and mobility
  - Wood for housing and materials
  - Food and water for living
- Nature:
  - Absorbs our wastes
  - Provides climate stability
  - Protects us from ultraviolet radiation


THE WATER-ENERGY-FOOD NEXUS (UNU, 2013)
Water
Water is needed to generate energy
Energy is needed to supply water
Food transports (virtual) water
Water is needed to grow food
Energy is needed to produce food
Energy
Food
Food can be used to produce energy


GLOBAL CHANGE • SUSTAINABLE PROSPERITY • PLANETARY BOUNDARIES
food production, processing and transport need energy
fossil fuel extraction, energy crops and carbon sequestration impact on food supply
entry point: ENERGY SECURITY, governance and investment
entry point: FOOD SECURITY, policy and investment
ENERGY
demand, supply and assets
FOOD
demand, supply and assets
PEOPLE, LANDSCAPES AND ECOSYSTEMS
WATER
demand, supply and assets
clean water supply needs energy
water infrastructure and use impacts on fish stocks, food supply and land use
energy production (including sequestration) needs water, and impacts on water quality and availability
food production needs clean water, and impacts on water quality and availability
entry point: WATER SECURITY, management and investment
GLOBAL CHANGE • SUSTAINABLE PROSPERITY • PLANETARY BOUNDARIES



People, landscapes and ecosystems are at the centre of the nexus

2. Sustainability Metrics

- Aim to track two things:
  - Human demand & availability of natural capital
  - Regenerative and waste absorptive capacity within the biosphere

- Metrics are essential for
  - Assessing current ecological supply and demand
  - Setting goals
  - Identifying options for actions
  - Tracking progress toward stated goals

Sustainability Metrics

Examples

- Ecological Footprint
- Triple bottom line
- Sustainable Process Index

- Others environmental assessment tools
  - Ecological rucksacks
  - Material intensity per service unit
  - Etc.

2.2. Sustainability Management Tools

- Micro level tools
- Standardise sustainability practices in various industries
- **Examples**
  - Environmental Impact Assessment (EIA)
  - GRI Sustainability Reporting Guidelines
  - Life Cycle Analysis (LCA)
  - ISO 14000 Environmental Management Systems