Environmental Innovators

Transition Year Programme

Pilot 2022-23

Agri Aware

EDUCATE • ADVOCATE • ENGAGE

Supporting partners:

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Introduction

The aim of environmental innovation is to reduce the impact of products and production processes on the natural environment.

Innovation simple means new! This programme is all about the environmental challenges of food and how innovations are helping to solve some of the most complicated challenges of our time.

1. increase understanding of the challenges and innovative solutions associated with the food system;
2. encourage solution orientated and critical thinking;
3. offer supportive material to TYs in their journey towards Leaving Certificate and beyond.

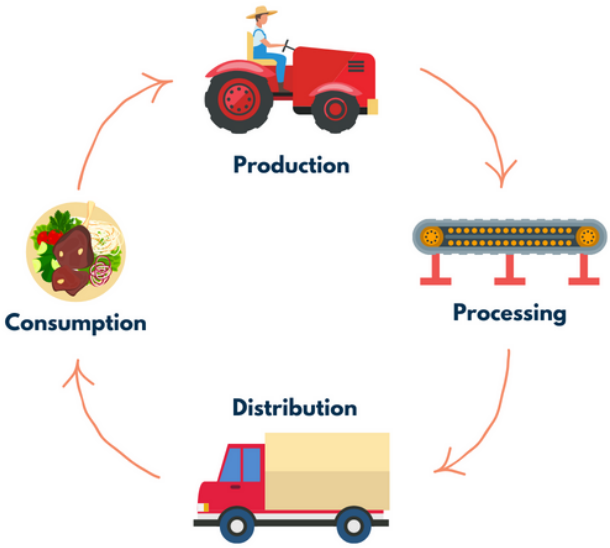
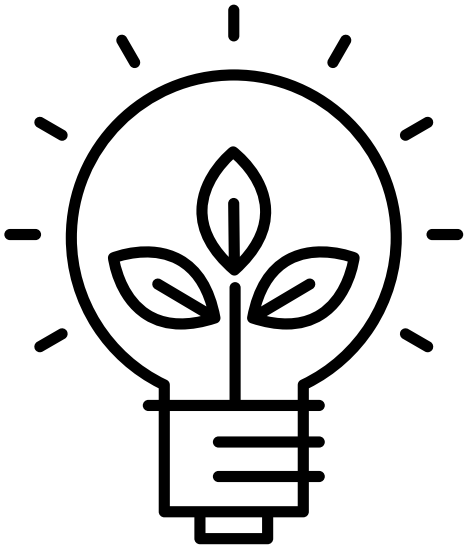


Figure 1. The Food System - The food system includes all of the steps that our food takes to get from farm to fork and beyond; from the production on a farm, the processing in a factory, the distribution through transport systems and the consumption in homes and restaurants.



Across the globe, human consumption of the world's natural resources has increased in line with the demand for food. This means that the way our food gets from farm to fork must evolve to meet global sustainability objectives.

Throughout this programme, students will learn of the various challenges that our environment faces due to the food system and vice versa. The programme will highlight Irish, European and global challenges and innovative solutions.

The food system is responsible for 34% of human created greenhouse gas emissions. This means one of our priorities for change is the way our food gets to our table and beyond. We must lessen our impact on the environment now so that we can continue to produce food into the future.

"Our food system needs you - our Environmental Innovators!"

Project Brief

"The National Champions will receive a grand prize of €250 each"

The food system requires environmental innovators to become more sustainable. This programme presents the various challenges that our global food system faces and invites students to investigate innovative solutions.

Innovations come in many forms such as policy, products, techniques and technology.

For example, planting trees responsibly can sequester carbon from the atmosphere.

In Columbia, when a person recycles plastic they receive a credit receipt to be used on public transport.

Electric vehicles are particularly eco-friendly if the energy they consume is renewable.

Reusable straws, made from a variety of materials, are becoming a popular alternative to the single use disposables.

1 Stucture

Research your chosen challenge using various data sources such as websites, television news, documentaries, news articles and radio. Keep a record of the source.

There are enormous global environmental challenges. Try to choose a challenge that has an achievable solution. Consider solving an issue in your school, home or community.

Do not attempt to solve climate change but do attempt to tackle waste management.

Brainstorm innovative ways to tackle your chosen challenge.

Ask yourself the following questions:

- Which type of food system challenges are you most interested in?
- Who are your stakeholders (people who should be interested in your innovation)?
- Do you know anyone who has expertise in your chosen area who can offer advice?

2 Submission

Please create a video presentation and upload it to YouTube as an unlisted video. A copy should also be uploaded to our submission portal.

The video should be shot in landscape and be between 3-5 minutes in length. Students can use any preferred visual aids e.g. a powerpoint presentation, a 3D model, a drawing etc.

Five group finalists will be chosen to take a trip to BiOrbic Bioeconomy Research Centre at University College Dublin to tour the facilities and to speak to agri-food stakeholders about their innovations.

The National Champions, chosen at the close of the day, will receive a grand prize of €250 each.

Project Brief

You will find some useful resources below that should help you with your end of programme project.

For additional guidance, contact us at office@agriaware.ie

"Can your challenge be tackled with a policy, product, technique or technology?"

A policy is a course of action that is adopted to achieve a particular outcome. For the purpose of this project policies can be drawn up for governments, organisations, schools or individual households.

A product is an object that is created in order to supply a consumer. If you choose to design a product, consider how this object fills a gap in the market. Are there any similar products out there and if so, how can you make them better?

A technique is a way or carrying out a particular task. For example, you will learn about regenerative farming practices. These are all new techniques that benefit the environment and the food system.

A technology is any machinery or equipment that has been developed out of scientific knowledge. One example of this would be wind turbines to generate renewable energy.

- Bioeconomy Map
- Food Vision 2030
- Food Cloud
- Vertical Farming
- DownToEarth
- Mastek
- Renewable Energy Ireland
- Eco Eye: Curlew
- Farming For Nature
- National Food Waste Recycling Week
- Irish Organics Association
- Ireland's Bogs

Chapter 1: Waste

1.1 Introduction
1.2 Recycling
1.3 Food Waste
1.4 Food Security
1.5 The Bioeconomy

Waste

1.1 Introduction

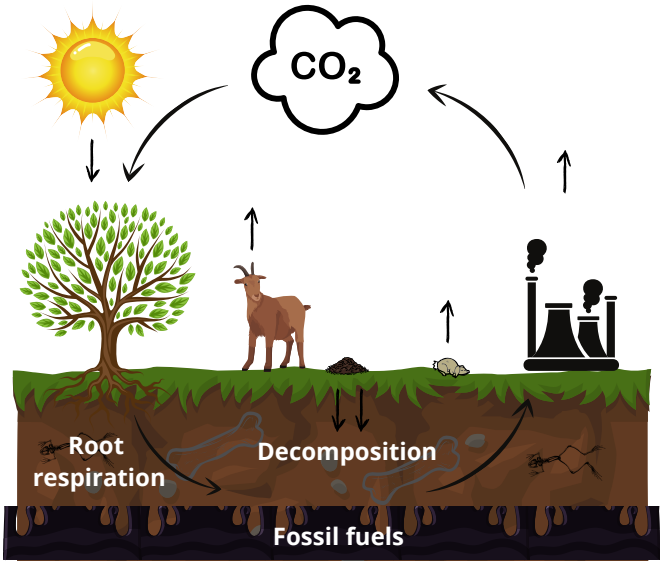
Waste is manmade. Nature does not produce 'waste'. Over hundreds of millions of years, the earth's complex natural systems have evolved to make sure everything created within nature feeds back into nature. This idea may be familiar from the earth's natural cycles; such as the water cycle, the oxygen cycle and the carbon cycle. One important examples of this is the carbon cycle. **Organisms** reuse and recycle carbon. It's movement through the **biosphere** is known as the carbon cycle.

Carbon moves from the atmosphere into plants and is absorbed by animals when they eat the plants. It is released into the atmosphere when living things die, through animal **respiration** and though the burning of fossil fuels. Having too much carbon lingering in the atmosphere contributes to climate change. Carbon dioxide or CO2 is the first of the greenhouse gases you will learn about within this programme in the chapter on climate.

Before You Begin

The following words are key concepts for the upcoming chapter. Write your understanding of the following before continuing with the material. Use a dictionary to aid your understanding.

Organisms
Biosphere
Respiration
Decompose
Translucent
Renewable
Nutrients
Conventional
Biodiversity
Resilient
Finite
Volatility
Consumer



Task 1 (25 mins): Watch The True Cost of Ireland's Waste to learn more about our waste problem, illegal dumping and waste regulation.

Watch

The majority of products made over the last five decades were made to be used and thrown away, with no consideration of feeding back into nature's systems. Materials, such as plastics, do not **decompose** like dead living things. They persist in the environment causing a suite of known and unknown challenges for wildlife and, ultimately for humans.

How we deal with the waste we produce is called 'waste management'. Given that humans are the only organisms that produce 'waste', this concept has only been around for a few centuries. Over the past 100 years, our waste has reached unsustainable levels. This is largely due to two key events; the Industrial Revolution and the birth of plastic.

Plastics are used throughout all stages of the food system. As we learned in 'A Brief History of Plastics', plastics have helped advance the availability and reduced the price of products such as furniture. Plastics have also revolutionised the food system but at a huge cost to our environment. We must work together across the food supply chain to prevent plastic pollution.

Task 2 (10 mins): Watch the video and answer the questions below.

A Brief History of Plastics

1 Who invented the first 'plastic'?

2 Name the material that all modern plastics made out of?

3 When was polystyrene first commercially developed?

4 Name the technique used to insert melted plastics into mould of any shape.

5 List the three priorities for addressing plastic overuse.

We use plastics at every stage of the food system. Some of these uses of plastic are necessary and as a long as they are managed responsibly, their use is likely to continue. Although, there are certain areas of the food system that could benefit from moving away from plastics.

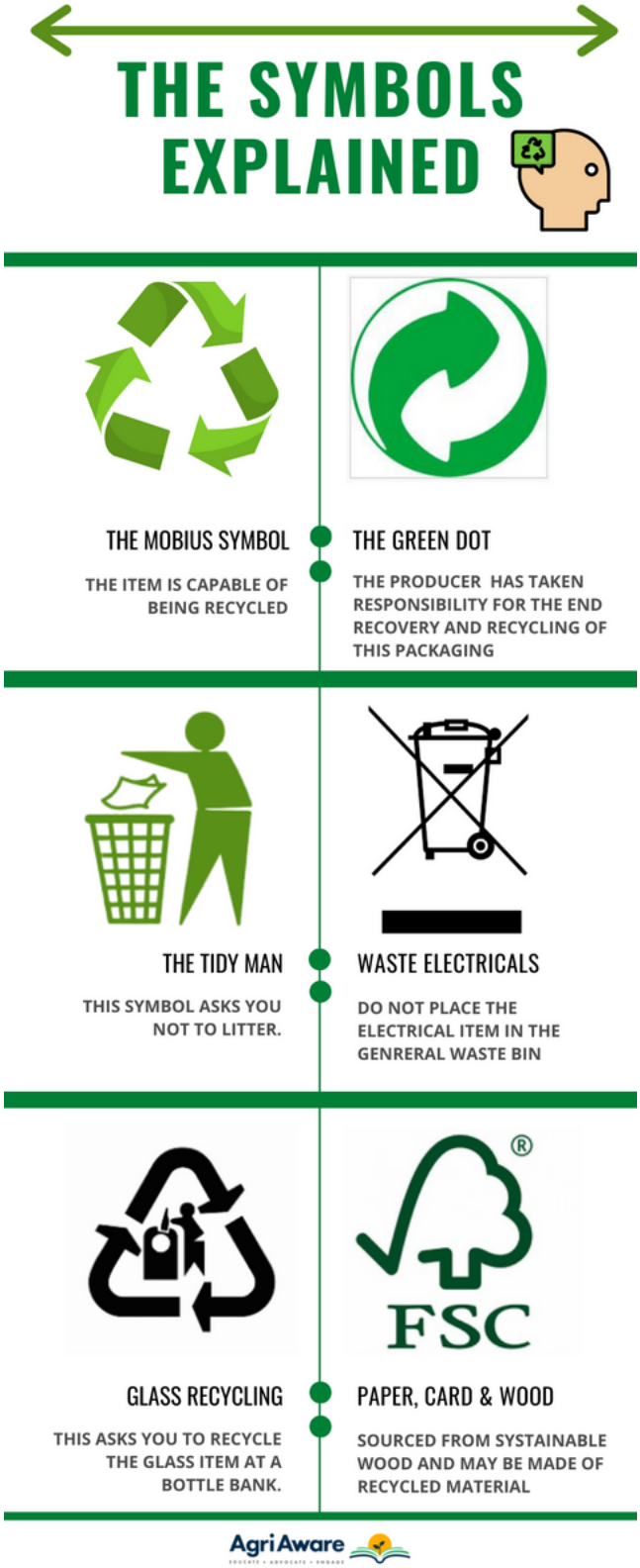
Plastics are also used within food processing. Parts of processing machines are made from plastics. There are many benefits to using plastics for this purpose including shock resistance; plastic piping is lighter in weight and can be made **translucent**.

During distribution and sale of food, it is often wrapped in plastic. Fruits and vegetables with inedible skins should not be wrapped in plastic. As a consumer, choosing the unpackaged option sends a message to the retailer. Produce with edible skins can be washed before consumption, avoiding the need for plastic packaging.

Many plastics are recyclable but just because we are capable of recycling these materials doesn't mean that we do so correctly. Recycling plants have strict rules about recycling materials and in order for recycling to be efficient we must follow them.

Items placed in recycling must be:

- clean and dry
- loose i.e. not stacked inside each other
- free of bin liners



Task 3 (15 min): Watch the video advertisement produced by the European Commission (EC) and answer the following questions:

1. **What message are the EC trying to communicate?**
2. **In your opinion, is this video powerful?**
3. **Do you think this video could change peoples' food waste behaviour?**

Stop Food Waste

Roughly 17% of the food produced on the planet goes to waste. The United Nations Food and Agricultural Organisation (FAO) calculated that €931 million tonnes of food was wasted in 2019. Considering all of the resources that are required to produce this food, it is unacceptable that we allow so much to never fulfil its intended purpose.

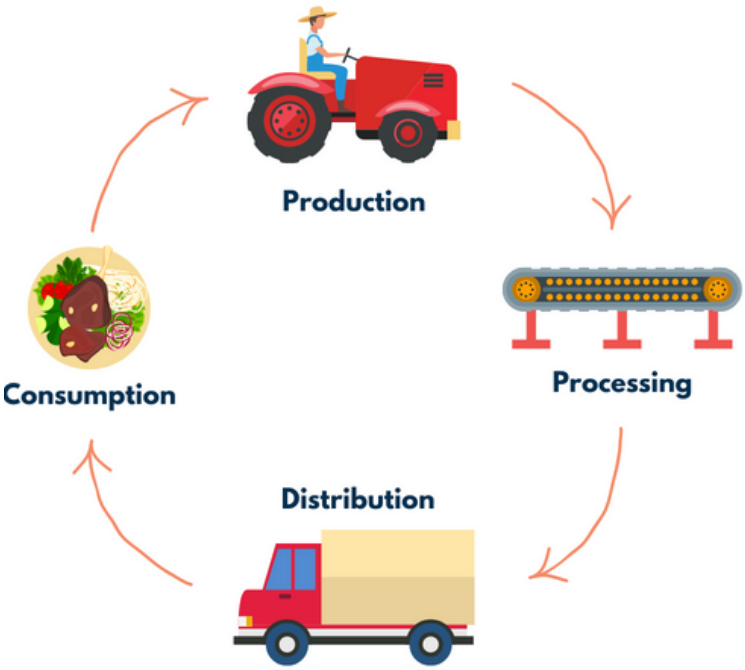
Food loss and food waste occurs at every stage of the food system. Remember! The food system includes the entire route that food takes to get to your home and beyond. A well functioning and planned food system can bring economic, environmental and social benefits. This means that a poorly functioning system can also damage these benefits.

Production Crops are lost due to poor weather, pests and disease. Animals are lost due to illness, disease and death of young livestock.

Processing Food that does not meet 'quality standards' cannot be sold. Often misshapen fruits and vegetables are overlooked for not being visually appealing.

Distribution The incorrect storage of foods during distribution or the failing of storage systems can lead to catastrophic food waste.

Retail & Consumption Food is thrown away because it has spoiled or is past its sell by or use by date.



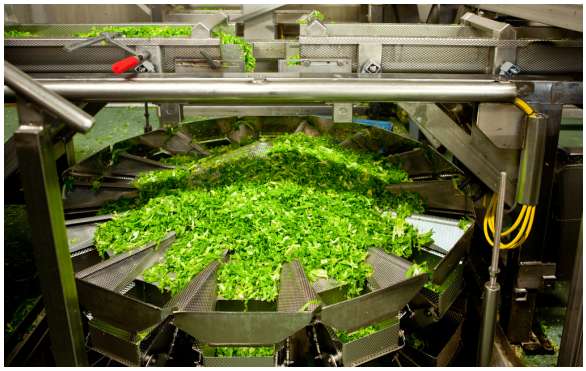
One of Ireland's primary goals for the year 2030 is to reduce food waste in the home and in the service industry by 50%. Nearly two-thirds of all food waste occurs at the household level. This means that behavioural change at the **consumer** level is urgently needed.

Task 4 (15 min): Work in groups to come up with strategies for avoiding food loss and waste across the food system. Use the headings of production, processing, distribution and consumption.

Example: During the production of food, quarantining sick animals may help to reduce the likelihood of illness spreading throughout a herd, reducing food loss.

When food is wasted, all of the resources used to produce those foods are also wasted. This is counterproductive for our global sustainability journey. The production of food contributes directly to climate change but we must produce food in order to survive. Therefore, the production of food is non-negotiable. Below are some examples of the resources we use to produce food. When food ends up as food waste, these resources are also wasted.

Energy The food system requires energy to produce food. The use of farm vehicles and energy in processing plants requires fossil fuels to power them. Although there has been movement towards **renewable** sources of energy, such as air and water, the technologies for electric vehicles remain too expensive for conventional farming and most processors. When we waste food, we also waste energy.



Water Fresh water is needed throughout the farm-to-fork story. Although water is a renewable resource, the rate at which we use it outcompetes the natural water cycle. Water is needed for animals to drink, to grow crops and to prepare and process food. When we waste food, we also wastewater.

Soil Nutrients Soils hold **nutrients** that crops require to grow. When crops are planted in soils they use the nutrients to grow. In **conventional** farming, chemical fertiliser is typically used to encourage crops to grow. This increases the speed of growth and thus the supply of food. Therefore, when we waste food, we also waste soil nutrients.

Space for Nature **Biodiversity** includes all living things from the smallest single-celled organisms right up to the tallest oak trees. Food production can impact biodiversity negatively. The most direct effect is the amount of space food production takes up. Because we are using space for food production; when we waste food, we also waste space.

Given all of the above, it is incredibly wasteful to throw away food. If global food waste were a country, it would be the third largest contributor to greenhouse gas emissions in the world. A final point to consider is the social-inequity consideration for food waste. There is vast inequality across the globe when it comes to the supply of food. Those who have far less access to food do not waste what they have.

Therefore, food waste can be considered a luxury.

If we redistributed all the food available across the world, there would be food leftover. But it is the poor access to safe, quality, affordable and **resilient** food supplies that causes food insecurity or food poverty.

Countries are ranked on the Global Food Security Index (GFSI). Food security is based on four attributes:

1. Affordability of food - Ireland is #1
2. Availability of food - Ireland is #3
3. Quality and safety of food - Ireland is #4
4. Natural resources and resilience - Ireland is #3

"Food waste is a luxury that many people cannot afford"

According to the GFSI, Ireland is in a very fortunate position when it comes to the security of our food supply. But we must remember that we are still dependent on other nations for the availability of this food. The availability of food typically depends on the climate, energy supply, economics and politics; all of which require international cooperation.

Our ability to produce food is dependent on the local and global climate, energy supply, economics and politics. Ireland is known for its grass-fed beef and dairy, both of which are vitally important exports for our economy. Roughly 90% of the food that is fed to cattle is grass and grass derivatives, but there are also imported concentrates that are required to meet the energy and protein requirements of our livestock. The production is firstly dependent on climate. For example, protein-based feeds are grown in the Americas (North and South) and in some other EU countries. Without suitable climate conditions, these crops can fail causing feed shortages.

Another serious consideration is the processing and distribution of this feed and the energy that it takes to do this. Animal feed must be mixed on a huge scale to distribute and feed livestock all over the globe. This distribution also requires energy through the use of fossil fuel-powered vehicles such as trucks, planes and ships. Ireland does not produce any of the fossil fuels that are required to power these vehicles and furthermore, fossil fuels are a **finite** energy resource.

Finally, the availability of our food is dependent on politics and economics. Price **volatility** is an increasing concern amongst farmers. This can be influenced by politics i.e. the Russian invasion of Ukraine in 2022 caused feed and fertiliser prices to skyrocket. This was due to continued demand for these products while supply dropped.

So given that Ireland is dependent on many other countries to produce its beef and dairy, can we really consider those food supplies as secure as they were once thought to be?

Nonetheless, in comparison to other countries the GFSI considers Ireland to be in a strong food security position. The task below will help you to learn more.

Task 5 (25 min): Research the Global Food Security Index (GFSI) of a chosen country and answer the following questions. Consider climate, energy, economics and politics

GFSI

1. **Is your chosen country ranked above or below Ireland for affordability of food? Why do you think this is?**
2. **Is your chosen country ranked above or below Ireland for availability of food? Why do you think this is?**
3. **Is your chosen country ranked above or below Ireland for food quality and safety? Why do you think this is?**
4. **Is your chosen country ranked above or below Ireland for natural resources and resilience? Why do you think this is?**

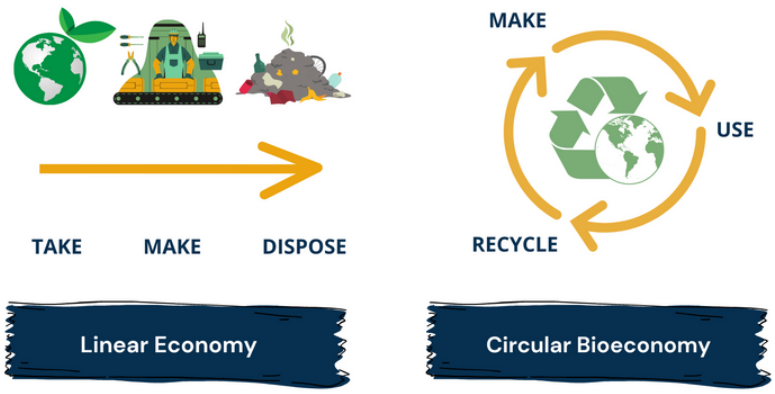
The bioeconomy is the part of our economy that uses biological resources and services from agriculture, forestry, and the marine to produce food for humans, feed for animals and the materials we need to make everyday products and energy.

The Circular Bioeconomy

Many of the products and services we use today are produced using unsustainable fossil resources that can harm our climate, nature & society.

The bioeconomy helps us to apply knowledge and innovation to how we use and consume natural resources, such as those that come from our soils, fields, forests and seas. It is important that our use of these resources respects nature and increases social equality by reducing our use of fossil resources and developing green practices, products and local jobs.

Our current economic model is predominantly a linear model, where we take the resources we need, make products from them and then dispose of them after use. This is not a sustainable model - we must adapt to a circular model, where all resources are reused or recycled (including waste), to make new products.



Case Study One: Biorefinery Glas

Click here to learn more

'Biorefinery Glas' 2014-2020 was jointly funded by the EU and the Department of Agriculture, Food and the Marine. Within Ireland, many of our livestock graze on fresh grass throughout the spring, summer and autumn months. In the winter, grass stops growing so we must feed the livestock alternatives to fresh grass. Some farmers import animal feed that is often made of mixed grains and soybeans. These feeds are less healthy for the animals, relatively expensive and more challenging for greenhouse gas emissions. Biorefinery Glas converts fresh grass into a range of preserved products that are better for our animals, our environment and sustainability.

The hope is that these products will become an option for conventional agriculture, avoiding the need for less sustainable imported feedstuff.

Case Study Two: Bio-Plastics

Scientists in Ireland are bringing bio-based, biodegradable and compostable plastics to the market. Plastics like these will help to reduce your carbon footprint and slow plastic pollution. At present, there are compostable plastics and there are biodegradable plastics.

Compostable plastics need to be industrially processed at very high temperatures to be broken down.

Biodegradable plastics will break down in the environment but only under the correct conditions.

This means that unless these bioplastics are disposed of correctly, they are just as harmful as any other type of waste pollution. Although they are less toxic, it would still take 450 years for a bioplastic cup to degrade in the ocean!

Case Study Three: WAVA (WAste VAlorisation)

WAVA is a research project that has been set up to explore innovative ways to turn food waste into commercial products. Food waste valorisation simply means 'finding value for food waste'. It is an important goal within sustainable development. We have previously learnt about food waste and how it impacts our resources and how careless it is to throw away 'good' food.

WAVA does not aim to reuse household food waste that is destined for industrial composting, instead the project is looking to tackle food waste from the supermarkets and the processing sector of the food system.

In Ireland, 36,900 tonnes of fruit and 758,650 tonnes of vegetables are wasted each year within the processing sector. This wasted food highlights a valuable untapped source of materials and an opportunity to reduce careless food waste.

WAVA is working on the development of technology that can convert food waste into new resources such as electricity and fertilisers.

Anaerobic digestion is the process by which bacteria break down organic matter, such as food waste or animal slurry, into energy. This energy can be harnessed and used to power machinery or heat homes. This process is typically very demanding and can take a long time. WAVA is working on ways to speed this up.

The WAVA project is also investigating the repurposing of the byproducts of anaerobic digestion to produce important chemicals (possibly for fertilisers) and additives to fortified animal feeds (vitamins and minerals).

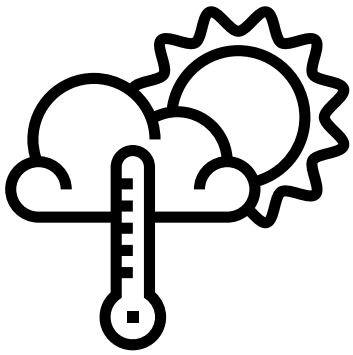
One of the by-products of this process is carbon dioxide (CO_2). WAVA will capture this gas using photosynthetic microbes called algae, preventing additional emissions.

This project addresses Sustainable Development Goals (SDGs) 2, 7, 12. Click on the graphics to learn more.

Task 6 (5 min):

Click the graphic below to learn more about anaerobic digesters.

Chapter 2: Climate



2.1 What is climate change?
2.2 Greenhouse Gases
2.3 Farm Zero C
2.4 Carbon Footprints

Climate refers to the average range of weather experienced in a **region** over a long period of time. Climate change is the changing of global climates, meaning that certain geographic locations are getting hotter and others are getting colder. This disrupts everything from ocean currents, sea levels, **survivability** of wildlife and of course, our ability to grow crops and raise **livestock**. A huge challenge for agriculture and food production is its reliance on a predictable climate. So when the earth's natural cycles and functions are disrupted, this challenges our ability to produce food.

Most human activities contribute to climate change and one of those is the production of food. When we look at the global food system, it is responsible for 26% of **greenhouse gas** emissions (Our World in Data, 2019). This includes greenhouse gas (GHG) emissions during food production, processing, distribution and consumer food waste. Within this 26%, food production (livestock, crops and land use) is the strongest emitter of GHGs.

We must consider the challenge of reducing GHGs as a cooperative endeavour. In Ireland, agriculture is responsible for a large proportion of Ireland's GHGs, however this is not expected to change. The goal is to reduce each sector's emissions to achieve targets for a more **sustainable** existence. Out of necessity, agriculture will likely continue to be the largest contributor to GHGs; although improvements are needed. We will learn more about GHGs and various **innovative** solutions in the following section.

Before You Begin

The following words are key concepts for the upcoming chapter. Write your understanding of the following before continuing with the material. Use a dictionary to aid your understanding.

Region
Survivability
Livestock
Greenhouse gas
Sustainable
Innovative
Emissions
Reforestation
Bogs
Photosynthesis
By-product

Agricultural **emissions** are dominated by methane (CH4), followed by nitrous oxide (N2O), with minor CO2 emissions.

Carbon Dioxide Emissions

Carbon dioxide or CO2 is responsible for a minor amount of emissions (5.3%) when compared to other gases but we will go through it in more detail regardless.

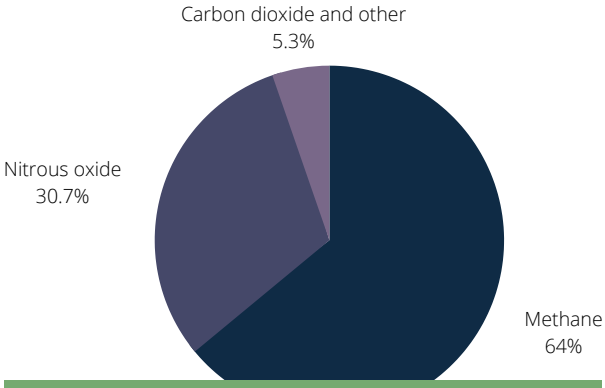
As we learnt in chapter one, nature produces carbon dioxide (CO2) and recycles it through the carbon cycle. However, humans are over-producing carbon and overwhelming the carbon cycle. Therefore, there is excess carbon dioxide in the atmosphere and this contributes to what we call 'global warming' or 'climate change'.

The expansion of agriculture, which began approximately 10,000 years ago, contributed to CO2 emissions through the permanent removal of forests and natural grasslands. These habitats typically stored carbon but were removed for the purpose of food production and settlement. The permanent removal of forests is still carried out today in some regions of the world, often due to a growing demand for food and income. Trees have also been planted over time for the timber industry and for **reforestation**.

Oppose

Propose

Task 6 (20 mins): Assign groups on either side of the deforestation debate. The videos linked above should help complete this task.



Greenhouse gas emissions from Irish agriculture (Teagasc 2021)

Climate action is goal number 13 of the United Nation's Sustainable Development Goals (SDGs). Click the graphic above to learn more.

The permanent removal of forests is still carried out today in some regions of the world, often due to a growing demand for food and income.

Carbon Dioxide Emissions continued

Carbon sequestration is an important consideration in the fight against climate change. It is the absorption and locking of carbon within landscape features such as soils, **bogs**, forests, bodies of water and grasslands. Many of these features occur on farmland. This means that while agriculture contributes to carbon emissions, these landscapes also have a key role to play in sequestering atmospheric carbon. Researchers in Ireland are currently investigating the strength of carbon sequestration on Irish farms. The hope for agriculture is that it can become carbon neutral or net-zero. This is when the carbon emissions from a sector or business are the same as the carbon sequestration efforts. The text boxes on the right further explain carbon terms.

Carbon emitting

Releasing more carbon than actively sequestering

Carbon nuetral

Releasing the same carbon as actively sequestering

Carbon negative

Releasing less carbon than actively sequestering

Case Study: Carbon sequestration on a farm

The Devenish Lands at Dowth is a research farm in Co. Meath, with over 180 hectares of grassland and natural woodlands. It is a sheep and beef farm with the ambition to become carbon neutral by 2025.

In 2017, using special technology called Lidar, Devenish discovered that trees, hedgerows and soils on their farm sequester 656 tonnes of carbon each year. This prompted researchers to investigate ways to increase this carbon sequestration and to investigate ways to reduce GHG emissions on the farm. Some of the research areas include; soil improvement to promote soil carbon sequestration, sowing of multi-species swards to reduce fertiliser inputs and sowing trees within grazing pastures. By sowing trees in the grazing pastures at a rate of 400 trees per hectare, the carbon sequestration could be tripled. This could also extend the length of the grazing season which would reduce feed inputs, housing costs and energy consumption.

DEVENISH™ Beyond Nutrition

Click the logo above to learn more.

Methane Emissions

Methane is another GHG, just like CO2. It is shorter lived than CO2, but it has a much greater warming potential - meaning that is stronger than CO2. This is a cause for concern in tackling the climate crisis.

Biogenic methane is a form of methane that is emitted from living sources such as plants and animals. Just as we have seen with the carbon cycle, the methane that is released can be recycled back into the earth, depending on how much is being produced. Cattle consume grass, which contains carbon that has been taken from the atmosphere through **photosynthesis**. As the cattle digest their food, a process known as enteric fermentation takes place. This process involves bacteria breaking down feed in the animal's gut, with methane forming as a by-product of this action. When cattle belch, methane is emitted into the atmosphere.

A much smaller proportion of biogenic methane emissions come from landfills and wetlands, again due to the presence of specific bacteria. Current advice from climate specialists is to reduce methane emissions, primarily from cattle and other ruminants. Several pathways are being explored.

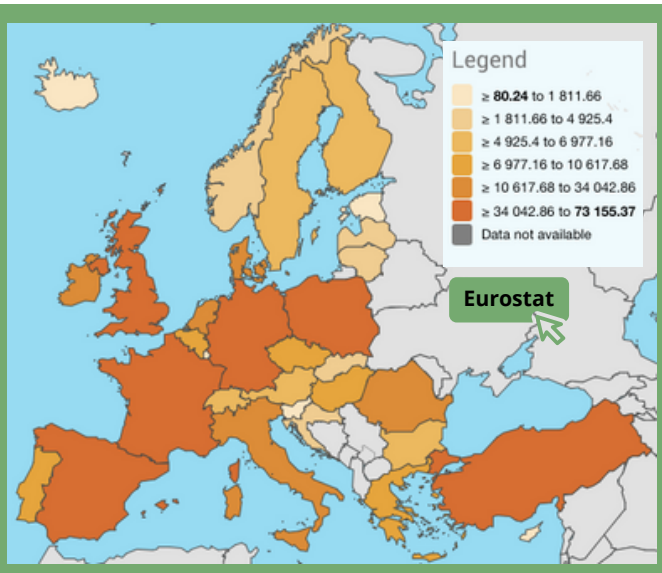
Reducing Methane

Nitrous Oxide

Nitrous oxide or N2O (the gas form of nitrogen) is another GHG that contributes to climate change. Just like methane, N2O is produced as a by-product of bacterial activity. Within agriculture, the emissions result from the application of artificial fertiliser and areas of livestock excrement hotspots in pastures, slurry and manure. The highest proportion of N2O emissions comes from the use of artificial fertilisers to grow grass. Reducing the use of artificial fertiliser and using alternatively formulated artificial fertilisers i.e. protected urea, can help reduce these emissions.

Task 7 (15 mins): Use the map of Europe and the accompanying legend to answer the following questions.

1. **Name three countries that are in the highest emitting category.**
2. **Name two countries that are in the lowest emitting category.**
3. **Ireland is in the second highest category. Considering what you have learnt so far, is this what you would expect?**
4. **Name one country that is listed as 'data not available.**



Agricultural greenhouse gas emissions per capita (Source: Eurostat)

Case Study: Farm Zero C

Farm Zero C is a project that aims to establish the world's first 'net-zero' carbon dairy farm. Farms have the ability to both emit carbon as well as absorb it. For example, the plants on farms such as grasses will take carbon out of the atmosphere and 'sequester' (or store) it in the soil. Therefore to be balanced, a farm should emit no more carbon than its sequesters. If a farm can emit the same amount as it stores, then it can be considered 'carbon neutral' or 'net zero emissions'. Scientists are looking at ways they can alter farming practices on Shinagh Dairy Farm in West Cork to reach that net-zero goal. Farm Zero C aims to place farms at the centre of the solution and form strategies that can be embraced elsewhere. The researchers are looking into the carbon sequestration potential of the farm and the creation of renewable energy.

Other research areas include:

'Climate friendly animals' - The project scientists are trialing different livestock diets that may reduce methane emissions. They are also studying different breeds of livestock to determine if there is a way to breed 'climate friendly' animals. Breeding involves selecting animals that have desireable traits, such as lower levels of methegenic bateria, and creating offspring from those animals.

Mixed species grass swards - Legumes, such as clover, can be sown with other grasses. Clover has a special root system that form a symbiotic relationship with soil bacteria. This increases the availability of nitrogen to plants and reduces the amount of fertiliser required. These types of swards are better for soil and animal health.

Biodiversity habitat - Much of the wildlife habitat available in Ireland is located on farms. Shinagh Dairy Farm aims to manage 10% of the farm as natural habitat. This is important for both biodiversity and to restore natural services that biodiversity provide to the farm. We will learn more about these services in Chapter 3.

FARM ZERO C
Farming for a sustainable future

biorbic

To learn more about Farm Zero C, click on the link to the video.

Farm Zero C

Carbon Footprints

A carbon footprint is the amount of greenhouse gases that are generated because of human actions. They typically take into account household, travel and lifestyle habits to create the approximate amount of carbon dioxide produced by an individual. But despite the name of these calculators, there is more than just carbon dioxide emissions taken into account. The term carbon footprint is used to make it easier to create a numeric total for our actions. The number that is calculated is typically carbon dioxide equivalents (CO2e), whereby all GHGs are converted to their respective CO2 equivalents. For example, out of all the GHGs - CO2 is found in the highest concentrations in the atmosphere but the most potent GHG is Sulphur Hexafluoride (SF6). Because they are not of the same strength, they must first be converted into CO2e. If we did not use CO2e, adding the numbers together would be similar to adding fractions with different denominators - which is something that we cannot do.

Carbon footprint calculators are important because if an individual or organisation knows how much they are emitting, they can make changes to their actions.

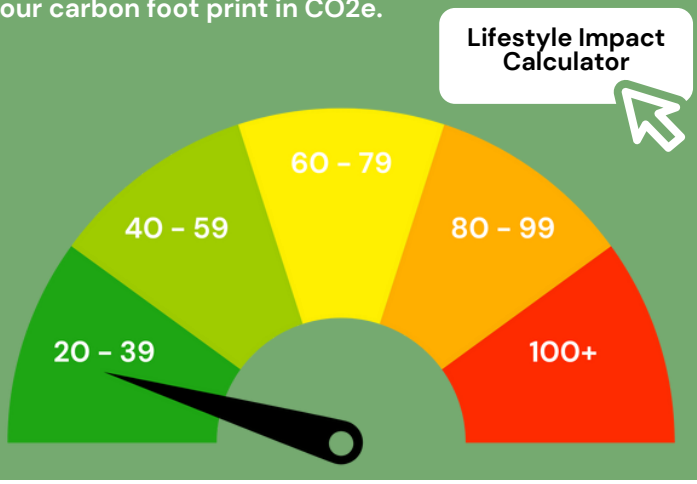
We have previously learnt about carbon dioxide, methane and nitrous oxide, but there is another collection of gases that should be considered when learning about the impact of the food system on climate change. Fluorinated greenhouse gases or F-gases are man-made gases used for refrigeration, air conditioning and fire extinguishers and others. EU policy requires that alternatives to F-gases be used where possible and that leakage into the atmosphere be prevented.

The three F-gases are: Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); Sulphur Hexafluoride (SF6).

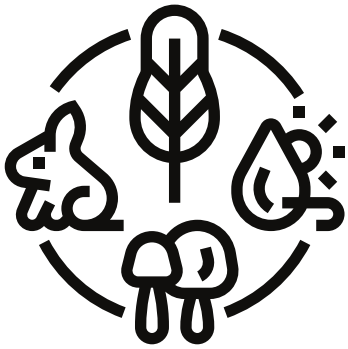
Task 8 (20 mins): Lifestyle Impact Calculator

All human activities contribute to greenhouse gas emissions, resulting in the greenhouse effect and ultimately climate change. As an individual, your lifestyle impacts the environment - from the food choices that you make to the clothes that you buy. The linked Lifestyle Impact Calculator takes into account your use of devices, waste management, school commute, air travel, food choices and wardrobe. The scoring is for the purpose of the below exercise. It does not calculate your carbon foot print in CO2e.

Step 1: Use the Lifestyle Impact Calculator to determine your score.
Step 2: Compare your lifestyle impact scores with the rest of your class and discuss possible reasons for high or low totals.
Step 3: Create a graph to represent the data.
Step 4: Discuss strategies to reduce your lifestyle impact score.



Chapter 3: Biodiversity



3.1 Introduction
3.2 Ecosystem services
3.3 Coexistence of wildlife and farming
3.4 Conservation Instruments

Agriculture has changed the world. Without such innovation in the production of food, humans would likely never have had the time to advance in other areas such as science, technology and art. Humans, originally hunter-gatherers, spent a significant amount of time sourcing food. This service is now provided by farmers and others in the food supply chain. Unfortunately, there have been **consequences** to this system shift. Over centuries, natural **habitats** were cleared across the globe to create space for human settlements and the domestication of animals and crops to secure the human food supply. This has somewhat been achieved - although we must bear in mind that the food that is produced is not shared equally - this means that creating and maintaining habitat for biodiversity is more important than ever.

Biodiversity encompasses the variety of all life on earth. Bio means 'life' and diversity means 'variety'. Every living thing is included in this categorisation including our domesticated plants, animals and even humans. Society has evolved to value one life above all others, with humans being front and centre.

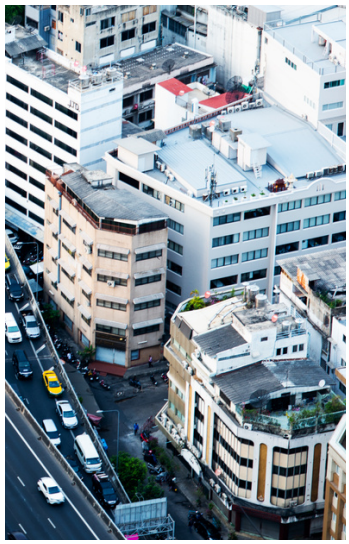
Human-made mass (weight), for the first time in history, now outweighs natural living mass. This was proved for the first time in 2020 but has been predicted for decades. Human-made mass includes all active and solid objects that exist on earth, including buildings, surfaces and livestock.

This time period of human dominance is referred to as the Anthropocene. It has put the planet out of balance and impacted biodiversity, natural habitats and the earth's natural cycles.

Before You Begin

The following words are key concepts for the upcoming chapter. Write your understanding of the following words before continuing with the material. Use a dictionary to aid your understanding.

Consequences
Habitats
Crisis
Ecosystems
Detritivores
Cattle
Cultivation
Forage
Accustomed



Ecosystem Services

The biodiversity **crisis**, declared in Ireland in 2019, is a little more complex to understand than the climate change crisis. One of the reasons for this is that we do not know how many or exactly what kind of species are required to protect the earth from collapse. For reference, scientists know that global warming must be kept below 1.5 degrees Celsius. We do not have this information for biodiversity.

Each species, plant or animal, has a role to play within the earth's **ecosystems**. These roles are referred to as ecosystem services. Some species supply general services to humans and others supply more unique services. An example of a general service that a species can provide is carbon sequestration by all tree species. An example of a unique service is the dung beetle and its facilitation of decomposition. Dung beetles facilitate the decomposition of cow pats by drinking the liquid. This dries up the animal's waste, preparing it to be decomposed further by earthworms and other **detritivores**.

Task 9 (15 mins): Research the ecosystem services or roles provided by the below species. Consider the types of habitat they live in, what they eat and how they interact with their surroundings to come up with your answers. The linked video should help you with this task.

Biodiversity

Honeybee *Apis*

Bramble *Rubus*

Red fox *Vulpes vulpes*

Common Pipistrelle
Pipistrellus pipistrellus

Herring gull
Larus argentatus

Robin
Erithacus rubecula

In Ireland, 60% of our wildlife habitat is found on farms, making farmland an important source of wildlife habitat. The grazing of **cattle**, maintenance of hedgerows and the **cultivation** of crops, has created a unique set of conditions where certain wildlife species can live and thrive.

Wild geese love grazing on grassland that has been created for cattle. In Ireland, the majority of our grasslands have been altered by farming practices in order to feed our livestock a primarily grass diet. This is very fortunate for geese. When farmers graze their cattle late in the summer it keeps the grass sward at an appropriate length throughout winter. The grass is at the perfect height providing geese with a key winter food source. This is, of course, not ideal for the farmer who would rather rest their grass in winter.

Case Study: Ground Nesting Birds

Whinchat are a species of bird that take advantage of grasslands and pastures that are maintained by agricultural practices. They use these landscapes to forage for insects, which are in particularly high demand during the breeding season. The birds also uses hay meadows to build their nests and rear their young. The adults use fence posts and trees along the edges of fields to perch and scan for prey and predators. These breeding conditions are created by agricultural activities, indicating a level of harmony for birds and farming; however there are other agricultural activities that can impact the birds negatively.

Because these birds, and many other species that nest on the ground, build their nests in grassland in spring and summer; the breeding season clashes with hay and silage making. This can have an impact on the bird's populations through habitat loss and direct casualties from machinery. Farmers and conservationists are working together to come up with innovative solutions that promote co-existance of birds and farming activities.

Within Ireland, large-scale land-use change ended decades ago and today's biodiversity has grown **accustomed** to its surroundings. However, there is still work that can be done to improve the quality of our existing wildlife habitats.

There are researchers and policymakers all over the world working on the coexistence of biodiversity and farming systems. As briefly explained above, agricultural landscapes can be both a source of habitat for biodiversity and a competitor for space. Let's take a look at the different types of biodiversity habitats on farmland and how farmers can encourage biodiversity both in Ireland and internationally.

Bats may use buildings to roost. They do not cause damage and should be left alone.

Maintaining permanent plants at the side of rivers can catch fertiliser and reduce water pollution and protecting wildlife.

Allowing wildflowers to grow at the sides of fields and at the base of hedges supplies nectar to pollinators and seeds for birds.

Maintaining semi-natural forests on farmland provides habitat for many species, including pine martens and red foxes.

Task 10 (5 mins): Hedgerows are critical habitats for wildlife on farmland. Watch the linked videos and answer the following questions.

1. **Why is hedgerow height important?**
2. **Why is the presence of flowers in hedgerows important?**

Hedgerows

Conservation Instruments

There are a number of conservation instuments within Ireland that aim to protect our native biodiversity. Investing in our native biodiversity also invests in human wellbeing and our food supply now and into the future.

Responsible Outdoor Behaviour

There are several guidelines that should be followed when participating in outdoor recreation. Our environment is a fragile place that should be respected so that people may continue to experience nature.

Please keep to the path | Please keep dogs on leads | Please keep quiet | Please do not pick flowers | Please do not feed the birds | Please do not litter

National Parks

There are six national parks throughout Ireland. They have been designated to protect the biodiversity that lives within them and to protect the ecosystem services that they contribute to people.

National Parks

Protected Sites

Ireland is home to 28 species of land mammal, over 400 species of birds, more than 4,000 plant species and over 12,000 species of insect. If we want all of this to survive, we must ensure that there are enough suitable areas for all these species to flourish. Natural heritage areas (NHAs), special areas of conservation (SACs) and special protection areas (SPAs) are a network of protected sites that are governed under national and European laws.

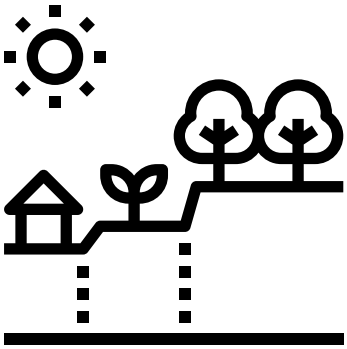
Protected Sites

Agri-Environment Schemes (AES)

These schemes provide funding to farmers that helps them to farm in a way that is environmentally responsible. The funding comes from the European Union under the Common Agricultural Policy (CAP) .

CAP

Chapter 4: Land-Use



4.1 Ireland's Land Use
4.2 Imports and Exports
4.3 Organic Farming & Regenerative Practices
4.4 Regenerative Agriculture
4.5 Regenerative Horticulture

Half of the world's habitable land is used for agriculture. This land is worked in order to feed the world's 7.9 billion people (2022).

The majority of Ireland's land use is used for agriculture (67.6%). The main agricultural class is pasture (55.1% of national land cover), followed by land principally occupied by agriculture (primarily pasture), which is interspersed with areas of natural vegetation (6.9%), and arable land (4.5%). In the task below, there are more categories explored relative to general land cover.

Soils and land cover differ in their **capacity** to support certain land uses. As a result, some soils are better suited to grazing cattle and others for growing crops. Crop production is mostly confined to the east of the Shannon, with almost entirely **pasture** for livestock to the west.

Before You Begin

The following words are key concepts for the upcoming chapter. Write your understanding of the following before continuing with the material. Use a dictionary to aid your understanding.

Capacity
Pasture
Dominant
Silage
Mean temperature
Unparalleled
Revenue
Economy
Enterprise
Adequate
Nutritious
Prohibiting
Regenerating
Imports
Exports

Task 11 (10 mins): Use World Cover to investigate the land cover across the world and carry out the following tasks.

1. **Navigate to Ireland and determine which areas have the most 'build-up' land cover. List the counties there are in.**
2. **Within Ireland, is there more cropland to the east or west of the country? Give one possible reason for this.**
3. **Name one country that has less grassland cover that Ireland.**
4. **Name one country that has more forestry cover than Ireland.**
5. **What is the dominant land cover type in the Ukraine?**
6. **What is the dominant land cover type in Sri Lanka?**
7. **What is the dominant land cover type in Egypt?**
8. **What is the dominant land cover type in Greenland?**

World Cover

Grassland is the **dominant** land cover type within Ireland. Within agriculture, the purpose of this land use is to feed our livestock; either through grazing or the harvesting of grass to make hay and **silage**. In dairy systems, cows are fed 90% grass and conserved grass. This is called a pasture-based system and is one of the reasons why Ireland's dairy is considered more carbon efficient than other EU countries. Relying on homegrown grass over internationally grown and imported feedstuff reduces dairy's carbon footprint.

Arable land, land under temporary crops, makes up the smallest proportion of our land use. Ireland grows crops for animal consumption (e.g. fodder rape, maize) and human consumption (e.g. potatoes, apples). This is a relatively small proportion of land dedicated to crops to feed people. However, in order for economies to compete at an international level, they must play to their strengths.

Ireland is not well suited to growing vegetables and it is unique to roughly 200 farmers in the country. Ireland's mild temperate oceanic climate is better suited to the growth of grass. Our annual **mean temperature** is 9-10°C - grass grows well in temperatures above 5°C.

The production of high-quality grass-based meat and dairy has allowed Ireland to **export** food on an **unparalleled** level. Ireland is known for producing grass-fed and antibiotic-free beef and dairy, benefiting animal welfare and human health. Roughly 90% of the food produced in Ireland is exported. This helps secure food supplies in other countries as well as create **revenue** for the Irish economy.

Ireland supplies roughly half of its required vegetables but the rest are imported. This is partly due to climate but also due to the viability of the enterprise. This will be covered in more detail in the next section.

In 2017, the top imported fruits and vegetables were bananas and apples and potatoes and onions respectively. Bananas are not suited to the Irish climate, therefore local bananas are not possible. However, Ireland is capable of growing potatoes, apples and onions; so why do we import so many of them?

The **economy** plays a huge role in the decisions to export and import food. Consumers have a role in this but it is unclear if the market leads this or vice versa. It is perhaps a chicken and egg scenario. Within Ireland, potatoes are not as popular as they once were. Nowadays, it is more convenient to buy long shelf-life pasta and rice. This means the demand for potatoes is relatively low hence, farmers are less likely to commit to a potato **enterprise**. Farms are businesses and often the main source of income for families. It is easier to import cheap potatoes from multiple countries than to produce them at home where the demand changes frequently. This is why it is so important to buy Irish produce and support Irish producers.

An overly simple solution to this is to increase the cost price of potatoes to make the enterprise more profitable for farmers. However, this would increase the price consumers must pay for their food and create a suite of additional challenges around food poverty.

Food poverty is the inability of people to secure an **adequate** and **nutritious** diet. It affects people in both developing and developed countries.

Task 12 (20 mins): Bring in 2-3 clean, empty packaging from food each.

1. **Determine the country of origin (most fruit and vegetable packaging will be labeled).**
2. **Match the country to the continents - Oceania, Africa, Europe, South America, North America and Asia.**
3. **Calculate the percentage of food from i) each continent and ii) Ireland.**

Organic farming practices are those that aim to produce food using natural substances and processes. Anyone can produce organic food but in order to label food from animals or plants as organic, producers must go through a European Union organic certification process. The organic unit of the Department of Agriculture, Food and the Marine (DAFM) manages the certification process for Ireland.

The hard rules for organic farming include i) **prohibiting** the use of genetically modified organisms (GMOs) ii) restricting the use of artificial pesticides and herbicides iii) prohibiting the use of hormones and restricting antibiotic use to only when necessary. Many of these rules are also adhered to by farmers in conventional farming systems also. Under no circumstances are GMOs or hormones permitted within Irish farming. There are also additional rules for the use of antibiotics for animal health and welfare whereby animals must be withdrawn from the food chain for their period of treatment and recovery.

Along with organic farming, there is another term that is appearing more frequently. Regenerative farming and regenerative practices are those that focus on **regenerating** the natural processes on farms. There is no EU certification process to become a regenerative farm but the methods that regenerative offers can be integrated into conventional farming. Many regenerative practices relate to soil and one of the main reasons for this is that healthy soils can help reduce greenhouse gas emissions.

Minimum tillage or min till is a regenerative practice that prepares soil for planting in a lesser damaging way than other methods.

Cover crops can be planted before and after a profitable crop. They protect the soil from erosion and re-introduce nutrients for regrowth.

Multispecies grass swards are a planted mixture of grasses, legumes, brassicas and herbs. This creates diversity within grassland, benefitting soil and animal health.

All of these practices can be considered under the umbrella of regenerative practices. They are extremely important for agriculture's sustainability journey.

Task 13 (10 mins): Watch the EU produced video on The Regenerative Agriculture Revolution and answer the questions below.

Watch

1 What are the five key principals of regenerative agriculture?
2 List three regenerative agriculture practices you have learnt about.
3 Suggest any one barrier to implementing regenerative agriculture in Ireland.

Regenerative Agriculture in Conventional Farming

Thomas Tierney's farm is located next to the River Siur in County Tipperary. He and his family are using regenerative agriculture practices on the farm that aim to put soil health first.

The soil on the farm was last ploughed (tilled) in 2014. Limiting the disturbance of soil is important for soil structure and the storing of carbon. The Tierneys have chosen a no-till system for this reason. Instead of tilling the soil to prepare it for planting, a direct-drill is used to drill the seeds into the soil with very little disturbance.

Approximately 50% of the farm is planted with cover crops ahead of the spring planting season. These cover crops protect the soil and reintroduce soil nutrients.

For soil health and nutrient composition, Tommy uses a combination of chopped straw, slurry and relatively small amounts of urea (nitrogen).

Fungicides are typically required on tillage farms to protect cereals from disease. The Tierneys avoid their use as much as possible by using home-made natural alternatives.

Pollinator strips offer alternative habitat to insects at the edge of fields, keeping pests out and limiting damage to crops. This is a method that protects both insects and the soil.

The tillage farm is being prepared for a future with reduced pesticide and fertiliser use. At present, the crop yields on the Tierney's farm are lower than conventional systems. Tommy hopes this will increase over time as soil health improves.

Case Study: Regenerative Horticulture at Airfield Estate

Airfield Estate is a 38 acre working farm within the village of Dundrum, County Dublin. Its food production entity is made up of livestock rearing and; fruit, vegetable and herb gardens. In conventional farming systems, the use of chemicals is standard practice for soil fertilisation, weed control and pest control. Artificial chemical application can make the production of large quantities of food more consistent and standardised but it can also cause problems for soil health and for the general environment.

At Airfield Estate the farm and horticulture teams have made the switch to regenerative farming. 'We applied the last application of any form of pesticide in 2017. This has enabled a healthy & balanced ecosystem and biosphere to develop whereby pests and weeds are managed by natural competition'.

A keystone principle of regenerative horticulture is that plants form a symbiotic relationship with microbes that live in the soil. Plants release fluid from their roots on which the soil microbes feed. In return, the soil microbes supply the plants with essential nutrients enabling healthy plant growth. This relationship ceases when we apply artificial fertilisers to the soil. Plants stop producing these fluids and instead absorb the freely available artificial fertiliser.


Green manure


Compost

This can make the plant reliant on the continued application of fertilisers in order to grow. Plants and crops then become reliant on human help and this then creates a yearly cycle of high inputs and work by the farmer. Airfield aims to break this dependency.

Avoiding bare soils at all times of the year is key to creating healthy soil. Airfield achieve this by growing cover crops (green manures) and applying compost to bare soil. Cover crops not only help support soil life but also help retain nutrients and increase organic matter in soil. Compost applied to soil can suppress weeds while also feeding soil microbes in the absence of living roots in the ground.

Airfield have also installed a biodigester that creates liquid digestate from compostable material (food waste, coffee cups etc.). This digestate also feeds the soil.

Origin Green, Ireland's food and drink sustainability programme, collaborates with members across 55,000 farms and 300 leading Irish food and drink companies. The aim is for Ireland to be able to demonstrate and improve the sustainability of the food produced.

Origin Green enables the industry to set sustainability targets and to measure progress over time. In order to assess if Origin Green is making progress, it must be measurable. Therefore, all targets set by farmers and companies must be measurable.

Farmers, manufacturers, retailers and those in the food service industry are eligible for membership of the Origin Green programme. The programme gives members access to the tools needed to produce food and drink in a sustainable manner.

At farm level, improving sustainability performance under Origin Green is undertaken through the Bord Bia's Sustainability & Quality Assurance schemes across the horticulture, beef, lamb, dairy, eggs and poultry sectors. These schemes see more than 100 auditors undertake over 650 independent farm audits each week. Farmers get feedback after the audit, which helps them to make more informed decisions on improving their farm's sustainability.

Farm Level Achievements (so far):

SBLAS

1. The sustainable beef and lamb assurance scheme (SBLAS) members recorded a 6.3% average reduction in CO_2 per unit of beef (2013-19).
2. Approximately 290,000 carbon footprints have been calculated to date at farm level.

At the manufacturing level, the focus of Origin Green is to help companies to develop a sustainability plan in accordance with the Origin Green Sustainability Charter within three key areas:

Origin Green

1. Sourcing sustainable raw materials
2. Development of sustainable manufacturing processes such as renewable energy and limiting food waste
3. Prioritising social sustainability in areas such as employee wellbeing, diversity, and inclusion.

Companies can only become members of Origin Green when their sustainability plan has been verified by independent auditors.

Project Template

Answer the following questions to help you to refine your project submission idea.

- Which type of food system challenges are you most interested in?
- Who are your stakeholders?
- Do you know anyone who has expertise in your chosen area who can offer advice?

"Can your challenge be tackled with a policy, product, technique or technology?"

Presentation guidelines

Create a 3-5 minute video presentation on your chosen challenge and innovative solution. We have covered a range of challenges across the food system from packaging waste to food insecurity.

You may record yourself and your team presenting live in class or record a screen presentation with audio in PowerPoint.

Your challenge and proposed solution can be outside of the themes covered as long as it is linked to the food system. Proposed innovations should not have a negative impact on the environment.

Your presentation must address the following points.

- Why does your chosen challenge require a solution?
- Is your solution something that works locally or globally? (Hint: local solutions are easier to comprehend and implement).
- Who can this innovation help?
- How does your innovation work?
- Does your innovation address any of the Sustainable Development Goals?