Teagasc
Future Food Security

Why is Food Security Important?

Food security ensures that people have adequate access to quality food, sufficient to permit a healthy life. Curtailed access means at worst famine. On a lesser scale it leads to poor health. An adaptive response in all organisms to hunger is stunted growth. This can lead to early death because body systems have not developed fully. Civilisation suffers as people are unfit to contribute to the community and resources are spent in caring; impaired cognitive development has consequences for society as a whole.

The Context

Earth has never known total food security. The *green revolution* of the 20th century was a new dawn. Artificial fertilisers made land more productive. Farmers did not have to rely on the *nitrogen* and other cycles to replenish the ground after harvest. Leaving land *fallow* was no longer necessary.

Extensive new areas were opened up to intensive agriculture by clearance of hedgerows and forests, drainage of marshes and irrigation of arid areas. Improvements in transport and infrastructure enabled the easy movement of food worldwide. *Herbicides, pesticides* and medicine protected crops and animals from *predation* and disease. Nevertheless, development has been uneven.

High technology often comes at a price that developing countries cannot afford. Exports of low cost food to poorer nations have often put local farmers and their sustainable methods out of business. In this way dangerous dependencies have been created.

In modern times, corporations have bought food speculatively and, in times of shortage, sold it at high prices. The resultant insecurity has had consequences ranging from poor nutrition to starvation.

Salt accumulation on soil surface

New Dangers

More fundamental threats are emerging. Glaciers are retreating and this may lead to reduced water levels in some of the great rivers, such as the Ganges and Mekong, on which many largely agricultural communities depend. Melting ice caps would raise ocean levels, inundating low-lying farmland and displacing millions; this would strain resources elsewhere. *Intensive agriculture* is lowering *water tables* worldwide and this is leading to a reduction in grain supplies. Irrigation for cotton has led to the shrinking of the Aral Sea, formerly the fourth largest lake in the world and a great fishery; it is now a tenth of its size in 1960 due to the loss of its feeder rivers. Elsewhere, river flows are decreasing due to agricultural and urban demand. In some arid areas, irrigation has led to increased soil *salinity*.

Crops for Energy

Fossil fuel supplies are peaking and prices rising. This means more expensive fertilisers, herbicides, medicine and transport. Agricultural land has been used for *biofuel* crops. Scientists are working on producing fuel from cellulose. *Cellulose* would be sourced from non-food products such as straw or plants grown on land unfit for food production. This technology is not as yet commercial.

Intensive farming concentrated on a limited number of productive animal breeds and crop types. *Hybridisation* has produced species adapted to different conditions. However, many species have been lost permanently, some of which might have carried traits that would be desirable in the future. It is hoped to produce *genetically modified* (GM) crops that are more resistant to drought and disease, but there are fears about the control of GM technology for-profit by large corporations.

Can we Feed Ourselves?

A serious prospect is that world population will exceed the planet's capacity to feed itself; some authorities believe that we have already reached that point. However, there are many others who believe that the real issues are an economic system that favours developed countries and a consequent lack of willingness (and of political power) to address the problems of production and distribution.

The oceans are a source of food but overfishing has reduced catches in many areas. Fish and mammal species are at risk of extinction. Fertiliser run-off has led to *algal blooms* and oceanic *dead zones*. Oil extraction, mining and waste disposal have polluted the seas. Increased atmospheric carbon dioxide may make the oceans more acidic, changing marine ecosystems and food chains.

Population growth requires land, which is a limited resource. In order to meet the needs of the growing numbers, the on-going development and the expansion of towns and cities, more tracts of agricultural land and of natural vegetation, are taken over every year.

Maize is used to produce biofuel

Poor farming methods have caused a loss of soil nutrients as has the practice of leaving fields bare, rather than fallow, for much of the year. Heavy machinery can upset the integrity of the soil. Compaction drives air from the soil, affecting its texture and ecology. Many areas that were formerly fertile have become deserts.

Limited Supply of Some Fertilisers

Plants require a variety of nutrients. As a rough guide we could say that plants are about 80% to 90% water and 5% to 15% carbohydrate. They get water from the soil and they photosynthesise simple carbohydrates from water and carbon dioxide.

Since plants also contain protein they need nitrogen (and to a lesser extent sulfur). Some soil bacteria can produce nitrogen compounds using nitrogen from the air. However, this process would not meet today's agricultural needs. Since the early 1900's it has been possible to manufacture nitrogen compounds efficiently and so we are no longer dependent on mined nitrate (which in the past came mainly from Chile).

Plants also require phosphate. For example, the outer structure of DNA is made of alternate sugar and phosphate units and the 'energy molecule' in most (if not all) living cells is ATP, adenosine triphosphate. When plants are harvested how is the phosphate replenished? We are in fact dependent on mined phosphate, which is a limited resource whose production may already have peaked. Although supplies may last some decades they will eventually run out.

Future Possibilities

In the short term we can feed ourselves, provided we use resources wisely and fairly. In the long term we need to return to more sustainable ways of living. Many resources, such as oil, gas and minerals, that were previously regarded as limitless will become scarce and expensive. Many governments have taken steps to obtain their share (or more than their share) of limited resources.

In future, more food production will have to be produced locally. Fuel for machinery may have to come from *biogas* that will be produced from plant and animal waste. Animal power in the form of horses and oxen may be increasingly used. Fertiliser will be obtained from human and animal waste and farmers living near the coastline will again use seaweed to enrich the soil.

At present, beef is a popular food globally but its production is expensive, and requires much more land than the production of an equivalent amount of vegetable food. More use may be made of animals such as goats and pigs that can live on poor ground and in woodland. While animal food will not disappear, future diets will probably have a greater plant content.

No-till agriculture can maintain soil integrity and reduce the need for land preparation. Greater use of winter *cover crops* would reduce nutrient loss. Research is ongoing into more widespread use of perennial rice and grains that have less physical impact on the soil. Their roots grow deeper and so they make better use of the available minerals. However, *crop rotation* may be problematic and pest populations may increase.

Increasingly expensive chemicals may be partly replaced in the war against pests by ladybirds and parasitic wasps. Gardeners are already aware of the potential of *companion plants*. Finally, planting mixed crops avoids the *monocultures* that are so easily attacked and require the use of chemical sprays.

Cities may yet have apartment blocks where food is grown *hydroponically* using waste water and treated

sewage. The heat from chicken pens may be used to heat greenhouses. In this way land could be freed up to encourage biodiversity. Modern agriculture allowed our planet to sustain a population it could not otherwise hold. In a future of diminished resources and climate change, the challenge will be to provide food for everybody in a sustainable way.

Teagasc

Teagasc is Ireland's agricultural and food development authority. As such Teagasc provides research, advisory and training services for the agriculture and food industry in Ireland. The organisation also works in close co-operation with their counterparts in other countries around the world.

Teagasc employs over 200 scientists and 300 technicians in research, and many other specialist staff in training and advisory roles. In total, over 1,500 staff are employed at over eighty locations throughout the country. The research carried out by Teagasc is essential to the development of competitive and sustainable agricultural and food industries. It also researches the potential use of crops for energy.

Food Research

The Teagasc Food Programme undertakes scientific research leading to the establishment of technological platforms that can be exploited by the Irish Food Processing Industry by adding value and ensures the safety and quality of food products.

The Food Programme incorporates the following departments:

- Food Biosciences,
- Food Chemistry & Technology,
- Food Industry Development,
- Food Safety.

Teagasc Food Programme

Long term the Food Programme in Teagasc will aim to:

- Improve and develop the safety and clean green image of Irish food products.
- Expand and increase dairy product research to serve the expected increase in national milk yield.
- Provide technology and knowledge to the meat processing industry to serve the economic increase in the meat sector.
- Support innovation, growth and export capability in the SME sector (Small and Medium Enterprises).

You can find this and other lessons on www.sta.ie.
Find out about Teagasc, the people who work there and the many scientific projects they are involved in at www.teagasc.ie.

Teaching Notes

Syllabus References

Leaving Certificate Agricultural Science

- Physical properties of soils. Soil structure; soil air; soil density; soil temperature; soil water and soil water control. Chemical properties of soils.
- Principles of soil cultivation with reference to tillage crops and grassland.
- Major and minor elements. Fertilisers and liming.
- Living organisms and their effects. Macro and micro organisms. Interdependence of animals and plants. Decomposition of organic matter; carbon and nitrogen cycles.
- Improving soil fertility.

Leaving Certificate Biology

- 1.4.9 Human impact on an ecosystem
- 1.3. Nutrition.
- 1.4. Ecology.

Leaving Certificate Agricultural Science

- Physical and chemical properties of soils.
- Farm crops.
- Farm animals.

Learning Outcomes

On completion of this lesson, students should appreciate:

- Population growth and environmental degradation are a threat to food supplies.
- Food security may be affected by problems of energy supply, water availability and phosphate depletion.
- Future food security may be helped by GM technology, different agricultural practices and changes in dietary habits.

General Learning Points

The following points can be used to revise the lesson's main learning points and to inform discussion.

- The use of modern technology and artificial fertilisers has allowed the planet to sustain a large population.
- The planet cannot sustain an indefinitely rising population.
- Modern agriculture uses a lot of energy to manufacture fertilisers and other necessary chemicals, and to transport food. The peaking of fossil fuel production has implications for food security.
- Climate change, pollution, problems with water supply and soil degradation have the potential to diminish food production.
- Phosphate availability will be problematic.
- Alternative food production methods and changes in dietary habits may be required to ensure a sustainable food supply.
- The present system of marketing and distribution may need reform.
- Traditional breeding techniques and GM technology may help increase food yields.

Student Exercises

Student Activity

Ireland has had a series of famines, the worst being in 1845-1847. What were the causes, the remedial measures taken and the consequences for Ireland?

Find out about Easter Island. It provides an insight into what happens when a finite world can no longer sustain its people.

Obtain Sach's water culture tablets. Place seedlings in different tubes containing 1, 2, 3, 4 etc. of the tablets that contain all the nutrients necessary for growth. Investigate if more fertiliser is always better. You could try a similar experiment with potted seedlings and different amounts of fertiliser.

Draw large posters of the nitrogen, carbon and phosphorus cycles.

Find out about the history of bee-keeping in Ireland. What problems were caused by bad summers, introduced species and disease?

Sewage can be used as fertiliser for land. What risks are associated with its use? Are there optimum times for applying fertiliser to land in general?

Companion planting. Nasturtium is often planted next to cabbage as insects prefer it for laying their eggs, leaving the cabbage alone. Clover is a good companion to grass because of its nitrogen-fixing ability. Make a list of companion plants and say how they benefit each other.

Compare the prices of processed and unprocessed food. Discuss the advantages/disadvantages of food processing.

True/False Questions

(1) Climate change may open some places to agriculture.

(2) In Vietnam, farmers are being encouraged to switch from rice to aquaculture because of increased flood frequencies.

(3) In biblical times, drought forced Jacob and the Canaanites to migrate to Egypt.

(4) Louis Pasteur pioneered artificial nitrogen fixation.

(5) A typical Mediterranean diet requires more fertiliser on the land than a typical Irish diet.

(6) The rate of artificial nitrogen fixation exceeds that of natural nitrogen fixation.

(7) Excess environmental nitrogen has been associated with loss of biodiversity.

(8) Mobile phones can be of assistance to farmers in poorer countries.

(9) Much food is lost because of poor storage facilities.

(10) Malnutrition reduces farm productivity.

Check your answers to these questions on www.sta.ie.

Examination Questions

Leaving Certificate Agricultural Science (OL) 2008, Q. 9

(a)

(i) Describe two advantages of crop rotation.

(ii) List three methods of weed control in tillage crops.

(iii) Name an insect pest of a cereal crop.

(iv) How does the pest you have named damage the crop?

(v) What is the difference between a selective herbicide and a total herbicide?

(b)

(i) Name a fungal disease of plants and name the crop which it affects.

(ii) List two symptoms of the disease in the crop named in part (b) (i).

(iii) Describe one method of preventing this disease.

(iv) Name a beneficial activity carried out by micro-organisms in soil.

Did You Know?

- Water-conserving alternatives exist to large-scale irrigation.
  - *Aeroponics*. Plants are held in air infused with water and nutrients. Good for root crops.
  - *Hydroponics*. Plants are held in troughs while water laden with nutrients circulates around their roots. Has been used with some vegetables.
  - *Drip irrigation*. Water with nutrients dissolved in it is dripped directly at the base of the plants' stems. Can be used with cereals.

- Only 2-5% of food ingested by animals is converted to utilisable food for people.
- The American dust bowl of the 20th century was caused by drought and over-exploitation of the prairie. Millions were forced to migrate.
- Cassava is a major source of food energy for people in the tropics. Traditional hybridisation methods have helped improve its nutritional quality. GM technology could theoretically improve it further but is as yet a very expensive option.
- Producing a tonne of nitrogen fertiliser requires anything from 25 – 78 GJ of energy, enough to keep a 2 kW heater running continuously for 145 – 451 days. Don't forget the transport costs!

Biographical Notes

Thomas Malthus (1766-1834)

An academic and clergyman, Thomas Malthus owes his fame to his theories on the factors affecting population. Improved subsistence conditions led to population increase which eventually put such pressure on the Earth's carrying capacity that checks came into play. There were positive checks such as disease, hunger and war. Negative checks ranged from birth control to celibacy. His ideas were not greeted with universal approval but they impressed many, including Darwin and Wallace.

Norman Borlaug (1914-2009)

"Father of the green revolution", he brought scientific knowledge and method to world agriculture on a large scale. Born in Iowa, he initially worked in forestry. Later, as a microbiologist, he led research into fungicides, bactericides and preservatives. As organiser of a wheat research program run by the Mexican government and the Rockefeller Institute, he helped develop a disease-resistant high-yielding wheat strain. A committed humanitarian, he collaborated with scientists from many countries. New productive wheat strains were grown worldwide. Receiving the 1970 Nobel Peace Prize, he declared that permanent progress in eradicating hunger was achievable if the agencies fighting for increased food production united with those fighting for population control.

Revise the Terms

Can you recall the meaning of the following terms? Reviewing terminology is a powerful aid to recall and retention.

Algal bloom, biofuel, biogas, carbon cycle, cellulose, companion plants, cover crop, crop rotation, dead zone, desertification, extensive agriculture, fallow, fossil fuel, GM, green revolution, herbicide, hybridisation, hydroponics, intensive agriculture, monoculture, nitrogen cycle, no-till agriculture, perennial crop, pesticides, phosphorus cycle, predation, salinity, terracing, water table.

Check the Glossary of Terms for this lesson on www.sta.ie.