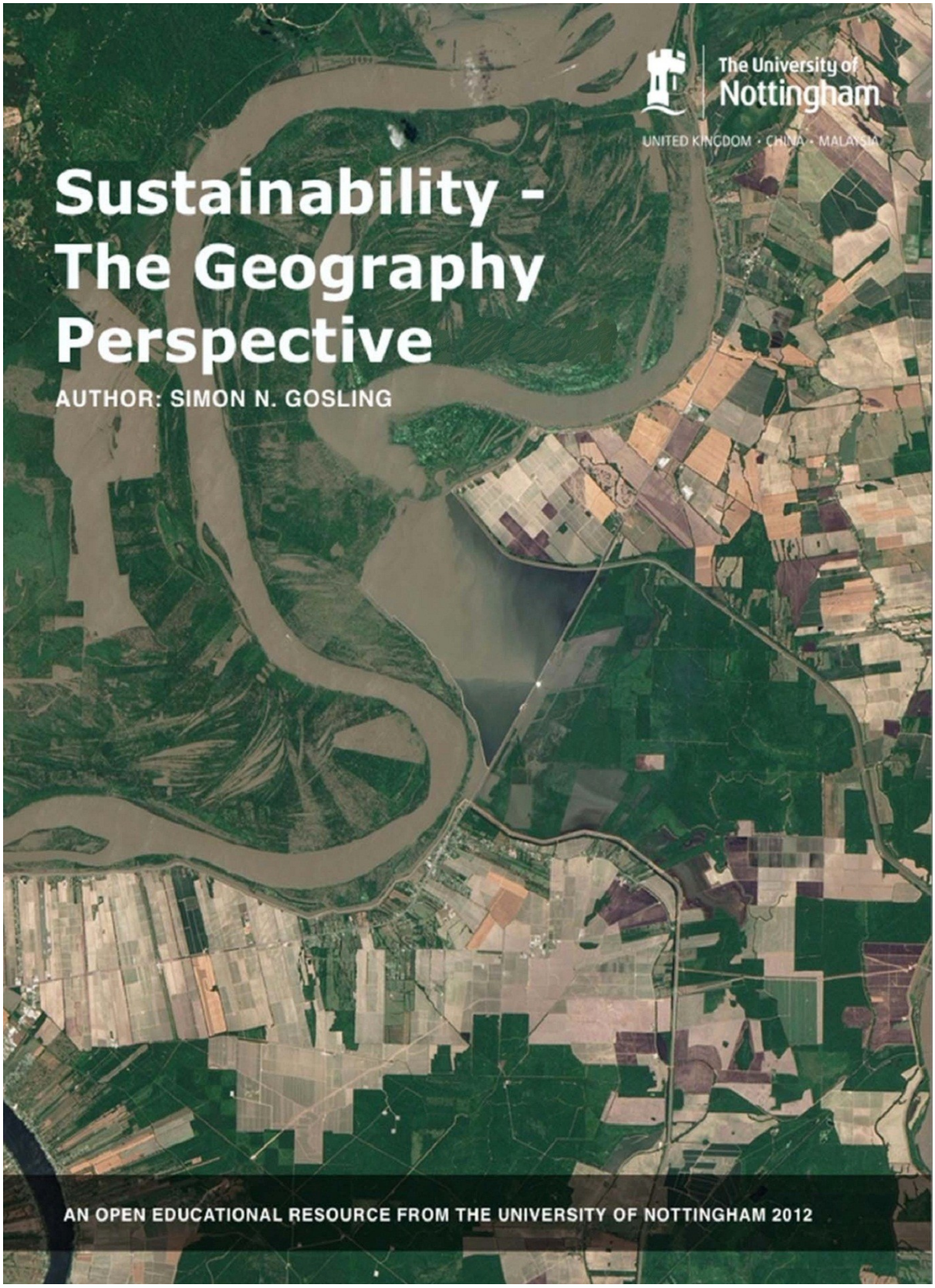
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Sustainability - The Geography Perspective
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Sustainability: The Geography Perspective

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Prelude

"Sustainability" is a word that is being used more and more in the news, by politicians, scientists, and businesses, and non-governmental organisations (NGOs). Yet, surprisingly, few people have a basic understanding of what it means "to be sustainable". In some ways, the word has been adopted by some groups to be indicative of being "environmentally friendly" or "socially responsible". With the word being used ever more, there is a risk that its true meaning becomes lost, to the point where it becomes simply a "buzz word" with little context or meaning. To this end, this module examines the core pillars of sustainability, with aid of everyday examples, in order to develop a holistic understanding of what sustainability means. The module has been written by a Geographer but it is aimed at all people interested in learning about sustainability from the local to the global scale.

An important aspect of Geography is that the discipline aims to understand how physical processes and social patterns operate at a multitude of spatial scales. Geographers often achieve this by exploring specific case studies, which help to place theory into practice. To this end, this module aims to provide a holistic picture of sustainability within the broad context of the geography discipline. This will be achieved by examining numerous case studies and examples of projects and initiatives that aim to encourage sustainability at a variety of spatial scales. For example, the module discusses the Fairtrade movement, the Marks and Spencer (M&S) sustainability plan, and the concept of the Water Footprint, to name a few.

To maintain focus, this module considers sustainability with respect to water, food, agriculture, forestry and energy. For each of these elements of sustainability, the module illustrates why their sustainable management is important, given that we are living within finite environmental limits. A novel aspect of the module is that in most sessions you update your own personal blog (or offline document), which can be used to provide a record of your opinions on sustainability, details on your awareness of sustainability, and specific examples of sustainability. The module is assessed by means of producing and presenting a poster at an internal "Sustainability Conference".

Chapter 1: Introduction to the Module and to Sustainability

An important aspect of Geography is that the discipline aims to understand how physical processes and social patterns operate at a multitude of spatial scales. Geographers often achieve this by exploring specific case studies, which help to place theory into practice. To this end, this module aims to provide a holistic picture of sustainability within the broad context of the geography discipline. Moreover, several case studies and examples of projects and initiatives that aim to encourage sustainability at a variety of spatial scales are explored throughout.

This is achieved, first, by exploring exactly what "sustainability" is (Session 1). Where did the term arise from? What does it mean? What examples of sustainability are there? This module is organised into 10 sessions. The seven sessions that follow this Session explore in detail, specific elements of sustainability. Foe this module, "elements" of sustainability is taken to be various natural resources and activities. We will explore sustainable water (Sessions 2 and 3), sustainable food and agriculture (Sessions 4 and 5), sustainable forest management (Session 6) and sustainable energy (Sessions 7 and 8). These are outlined in **Table 1.1** For each element, we will first explore why there is a need for sustainability; i.e. what are the limits to growth. Then we will explore the options, largely through case studies and examples at a variety of spatial scales, for encouraging sustainability (e.g. with examples such as the Fairtrade movement).

Table 1.1 Outline of the 10 Sessions for this module.

Session	Topic
1	Introduction to the module and to sustainability
2	Sustainable water: Part I
3	Sustainable water: Part II
4	Sustainable food and agriculture: Part I
5	Sustainable food and agriculture: Part II
6	Sustainable forest management
7	Sustainable energy: Part I
8	Sustainable energy: Part II
9	Changing attitudes towards sustainability
10	Synthesising sustainability
	Module assessment exercise

To maintain a holistic picture of the issue of sustainability, in Session 9 we will explore attitudes towards sustainability. This is becoming an increasingly important issue because while global, national and local policies aimed at sustainability can be implemented with the best intentions – unless the public, businesses and institutions accept, understand and believe in sustainability – the success of such policies can be limited. In Session 10, we synthesise everything we have covered in the module and introduce the module assessment exercise.

Sustainability is a very large topic that has grown rapidly over the past 20 years. Clearly, there are other elements of sustainability that we do not have time to cover (e.g. sustainable waste management). The module assessment exercise, which is introduced in Session 10, will give you an opportunity to explore one of these, by applying your knowledge and ideas that you have gained from the module to another area of sustainability.

Increasing your awareness of sustainability

Throughout the module, you will at times be asked to reflect upon your own ideas, awareness and perceptions of sustainability. This is to help you understand how issues around sustainability operate at a multitude of scales, from the global level, right down to the individual level, i.e. you. Moreover, it will increase your awareness of sustainability and highlight ways in which you might be able to manage your day-to-day activities in a manner that promotes and encourages sustainability of natural resources and activities, e.g. water usage.

This will be achieved by updating a blog (or offline document if you cannot setup a blog) in each Session. You will start the blog in this session later. By the end of the module, your blog or offline document will be a useful tangible resource for you to refer to.

Your thoughts on sustainability

Activity

Before doing anything, we first want to get an idea on what your specific understanding of sustainability is.

To do this, you will write a short blog entry, which describes what you think sustainability is. If you are a student at University of Nottingham, you can do this with Moodle. If you are taking this module outside of University of Nottingham, then you could use a free blogging site such as WordPress (http://wordpress.org/; registration required). If you are unable to create a blog, just create an offline word processing document.

Once you have setup your blog or offline document, create a date and title entry called "My thoughts on sustainability: Part I" and record your thoughts here. You could compile your short blog entry by providing examples of projects or initiatives you have heard of that are aimed at promoting sustainability. Or you might like to try writing a formal definition of sustainability. Alternatively, you might like to provide an example or two of something you have done that promotes sustainability. Please do not search on Google for definitions of sustainability. We want to see definitions/examples *in your own words*.

Do not be embarrassed if you do not know anything at all about sustainability. If you knew everything there was to know about sustainability, then you would not be studying this module! It is equally important to hear peoples' opinions on sustainability if they do not know much about it, as it is to hear those opinions of "experts".

And please do not be worried about writing something that is "wrong". There is no right or wrong answer here. We simply want you to express what your idea of sustainability is, before working through this module.

At the end of the module, you will be asked to write another blog, describing your notions of sustainability, and you will be able to compare that with the definition you provide here.

You should spend no longer than 20 minutes writing this blog entry, and it should be fewer than 400 words.

The problem with defining sustainability

It is important to address a question of language that will come up throughout this module. You may already have thought about this use of language when you decided to study this module.

Policy-makers and decision-makers working to address environmental and development issues often use the terms 'sustainable development' and 'sustainability' almost interchangeably. Both terms have at their roots the word 'sustain', which is used in everyday language. It is a word derived from Latin – sub + tenere where sub meant under or towards and tenere – to hold or keep.

There are several detailed meanings defined in most dictionaries, depending on context. Most of them imply supporting or keeping going. 'Keeping going' does not of course mean the same as 'keeping' though some notions of sustainability appear to confuse the two. One understanding is that sustaining implies something that persists but it does not imply something that is static or unchanging. It implies something dynamic and can also imply a radical change in people's practices rather than continuing with 'business as usual'.

There are many types of sustainability – ecological, economic, financial, social, political, and institutional, depending on what is being sustained. Moreover, definitions of the term sustainability are considerably varied. For instance, the following are definitions of sustainability:

"Meeting present needs without compromising the ability of future generations to meet their needs" (World Commission on Environment and Development (WCED), 1987).

"Sustainable means using methods, systems and materials that won't deplete resources or harm natural cycles" (Rosenbaum, 1993).

"Sustainability identifies a concept and attitude in development that looks at a site's natural land, water, and energy resources as integral aspects of the development" (Vieira, 1993)

"Sustainability integrates natural systems with human patterns and celebrates continuity, uniqueness and place making" (Early, 1993).

Other definitions are provided in a compilation provided by the Humanities Education Centre: http://www.globalfootprints.org/page/id/0/5/.

The issue of defining sustainability is highlighted by the Environmental Challenges in Farm Management (ECIFM) group of the University of Reading, here: http://www.ecifm.rdg.ac.uk/definitions.htm . As the ECIFM compilation of definitions shows us, there are numerous definitions of the term, and in some cases, books, chapters and papers, use 'sustainable' or 'sustainability' in the title but do not define either term.

It should now, start to become clear that defining sustainability is not straightforward. The International Institute for Sustainable Development (IISD) has released several videos that include decision-makers' definitions of sustainability. Please view each of these videos:

Vicky Sharpe, IISD board member, and CEO and president of Sustainable Development Technology Canada (SDTC): http://www.iisd.org/publications/pub.aspx?pno=1102

Milton Wong, IISD board member and chairman of HSBC Asset Management (Canada) Limited: http://www.iisd.org/publications/pub.aspx?pno=1100

Stephanie Cairns, IISD board member, and principal of Wrangellia Consulting: http://www.iisd.org/publications/pub.aspx?pno=1104

Sir Mark Moody-Stuart, IISD board member, and chairman, Anglo American: http://www.iisd.org/publications/pub.aspx?pno=1103

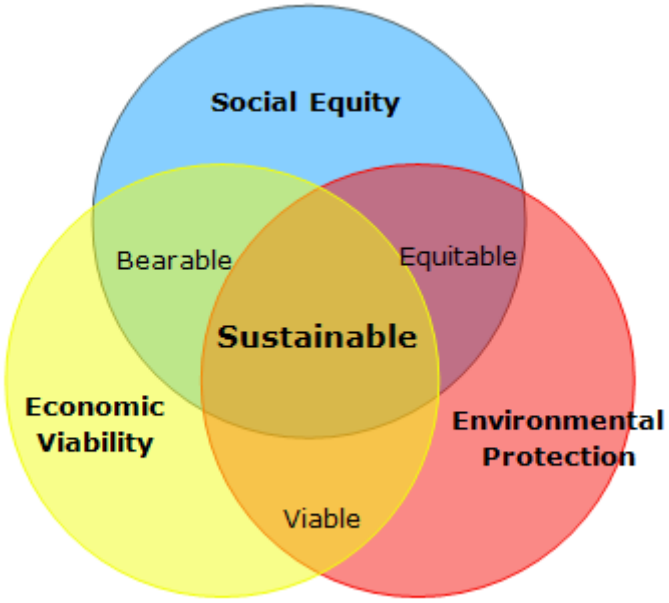
Daniel Gagnier, IISD board chair and chief of staff, Office of the Premier of Quebec: http://www.iisd.org/publications/pub.aspx?pno=1099

Now, return to the blog (or offline document) that you started earlier. Create a new title under today's date entry called "Other definitions of sustainability". Use Google to search for three more definitions of sustainability that we have not seen so far, and add these to the end of the Blog that you started earlier, being sure to reference where you have obtained the definition from (citing the web address and date of viewing is sufficient). This should not take more than about 20 minutes to complete and you should keep to fewer than 300 words in total.

As these definitions you have found, and those described previously all show, an issue with sustainability, is that while the word may be used interchangeably with 'sustainable development', there is no formal, internationally-agreed definition of each term that is routinely applied. Throughout this module, we will use the term sustainability but bear in mind that some web links and videos will use the terms 'sustainable development' and 'sustainability' interchangeably.

Sustainability can be represented diagrammatically in many ways. **Figure 1.1** is one that many people find meaningful, and it implies that there are three pillars of sustainability -- environmental protection, social equity and economic viability. This figure will be referred back to several times throughout this module. Other dimensions besides environmental, economic and social could be represented. For instance, in a more developed form of the figure, 'technical feasibility', 'political legitimacy' and 'institutional capacity' could also be included. However, throughout this module, you will see that these three components of sustainability will be referred to regularly.

Figure 1.1. Sustainable development: where ecological, economic and social aspects overlap.



Before moving on, there is a further cautionary note about language to make. As you work this module it is important to recognise that the concepts of 'environment' and 'development' are used and understood in many ways. The term 'environment' is often understood as that which surrounds and affects an entity. But some people use the term very broadly and others in a much narrower sense. When talking about sustainable development, the term is usually applied when referring only to the 'ecological', 'natural' or 'biophysical' environment. However, the word "environment" may also be used to describe the surrounding vicinity of a person, e.g. the room they are standing in. This can be confusing so when you come across the term 'environment' in this module you may also find it useful to pause and check the sense in which it is being used.

Furthermore, the term 'development' will be used in several ways in this module, for instance to describe:

1. 'World' development in the two different ways that Allen and Thomas (1992) identified as (a) a historical process of change and (b) deliberate efforts by all kinds of organisations and social movements as attempts aimed at progress and improvement.

2. Particular site-based infrastructural projects, such as urbanisation, roads and supermarkets, in the sense of new developments or redevelopments.

Contextualising sustainability in terms of historical events

With the lack of any formal definition on sustainability, it is easier to gain an understanding of the concept of sustainability, by contextualising it in terms of historical events. Moreover, in exploring sustainability situations later in the module and elsewhere you will need to understand some of the references to this history that others make. Many policy-makers and decision-makers have been trying to bring together issues of environment and development at different levels of decision making. While the term may be open to many different interpretations it has already become an established domain of practice for many.

The historical context

History suggests that there have always been people who have been concerned about the future welfare of humankind. This concern has been based upon extrapolations of current activities and awareness that past civilisations have collapsed when challenges have not been faced. Depending upon your disposition you may regard those who are concerned about sustainable development as;

wise people giving timely warnings,

examples of pessimists let loose, or

downright dangerous doom-mongers.

All these epithets have been attributed to people who have issued such warnings. There are many theories as to why for instance the Ancient Egyptian, Sumerian, Mayan and Polynesian civilisations collapsed (you may be familiar with some of them from TV documentaries or books). Among them are theories that the pattern of human demands in those societies damaged their environmental support systems. When combined with other external environmental changes and various social, cultural, political and economic circumstances, this meant that those societies could not adapt to the combination of changes in time and so could not continue their ways of life (Clayton and Radcliffe, 1996; Ponting, 1991). Such interpretations of these events acknowledge multiple causes and systemic effects.

Predictions

One of the better known historical figures who predicted difficulties for the future was Malthus (1798). He noted that whereas food production seemed to increase linearly with time, populations grew exponentially. It does not take long for the exponential growth to exceed the linear growth by a large factor, and thus predict large-scale starvation. Other well-known classical economists, such as Ricardo and Mill (around 1800), predicted that the scarcity of resources would eventually lead to the cessation of economic growth – thereby earning economics the title 'the dismal science'. Observations of the (then) present that had implications for the future (our 'now') were also made. For instance in 1947 Mahatma Gandhi was quoted as saying 'the earth has enough for everyone's need but not for their greed'. Rachel Carson's book Silent Spring in 1965 made connections between use of pesticides in agricultural development and diminishing numbers of birds with predictions that this trend would continue unless farming practices were changed. In 1972 a small book, Limits to Growth was published by an American group who used systems dynamics to develop a model of the global economy. Their analysis purported to show that even making optimistic assumptions about resource availability and curtailing population growth, the world economy would collapse within 50 to 100 years.

These historical examples of prediction are useful in that they make it clear that, whilst concerns about the future may be well founded, the future is unknowable and often turns out to be profoundly different from the fantasies of both pessimists and optimists. Many of the disasters forecast in the past have been avoided by technological developments. Take for example the Victorian forecaster who calculated that if the growth in horse traffic continued at the (then) current rate, by 1950 London would be covered in three feet of horse manure each year! Motor cars replaced horse traffic, so the problem of dung was avoided. Though it is perhaps arguable whether this was more or less of a problem than the present congestion and pollution due to motor traffic! The limited resources referred to in the Limits to Growth model have been expanded many times by advances in technology making it possible to extract oil from hostile environments and precious metals from low grade ores, albeit not without various knock-on effects for communities and their environments. The optimists point to these historical precedents and assume that technology and the ingenuity and abilities of people will always enable us to escape from the dilemmas currently forecast. Indeed from one perspective the forecasts of future disasters are made precisely to encourage people to avoid them – they are self-defeating forecasts.

But is this optimism justified? Are there any reasons why current forecasts of future problems should be taken more seriously than those made in the past? There are several factors that seem to us to make the current position different in principle from the past.

This principle difference is that the scale of human activity on earth is now approaching the same scale as the natural cycles that occur around the globe. The use of fossil fuels over the last one hundred years has changed the composition of the atmosphere. Human engagement with other parts of

ecosystems is causing hundreds of species to become extinct each year and the effects of human activity are evident well beyond the immediate locations in which we live. Many of the resources that were used to drive industrial development in the 19th century are now exhausted, or uneconomic at present to remove, in the areas where they were initially extracted (for example tin in Cornwall (UK) and oil in Texas (USA)). Water extraction rates exceed the annual flow of some rivers (this is covered in detail in **Session 2**). However they do not run dry because wastewater is returned to them. Vickers (1965) noted that the River Thames could once have been considered as an independent physical system, part of the given environment and primarily a way in which water from a stable catchment area found its way to the sea. He reflected on the effects on the river of people's activities (for example flood control, distribution of water, pumping and use for transportation and sewage disposal) and predicted that the Thames would virtually disappear within what he described as a human socio-technical system. He felt it would become dependent on new physical constructions, new institutions, and a new attitude to the use of water and the regulation of the whole water cycle. His observations still seem very appropriate in the context of sustainable development more than thirty years later, as indicated by the following quote from Klaus Topfer, UN Under-Secretary General and Executive Director of the United Nations Environment Programme in 1998.

"At the beginning of the 18th century, there were less than a billion people in the world sharing less than a million cubic kilometres of freshwater. In 1900, there were about 2 billion people sharing the same amount. Now there are more than 6 billion people and the freshwater supply has remained constant."

Another difference is that with the increased scale of human activities comes an increase in associated effects and disparities between rich and poor. For instance a vicious circle relationship has been identified by many between poverty and environmental degradation. Others have stressed the 'effluence of affluence' claiming that the underlying cause of environmental degradation is wealth as opposed to poverty (Holmberg, 1991).

Increases in energy and resource consumption in many parts of the world have also been increasingly inequitable. This has led to differentials in capacity to trade due to differences in power and bargaining positions in world markets. Concern about the future has led to other activities besides prediction, particularly on the international stage. There was increasing recognition among governments, business and industry, non-governmental organisations and international agencies that action by one or a few countries alone would be ineffective unless matched by others.

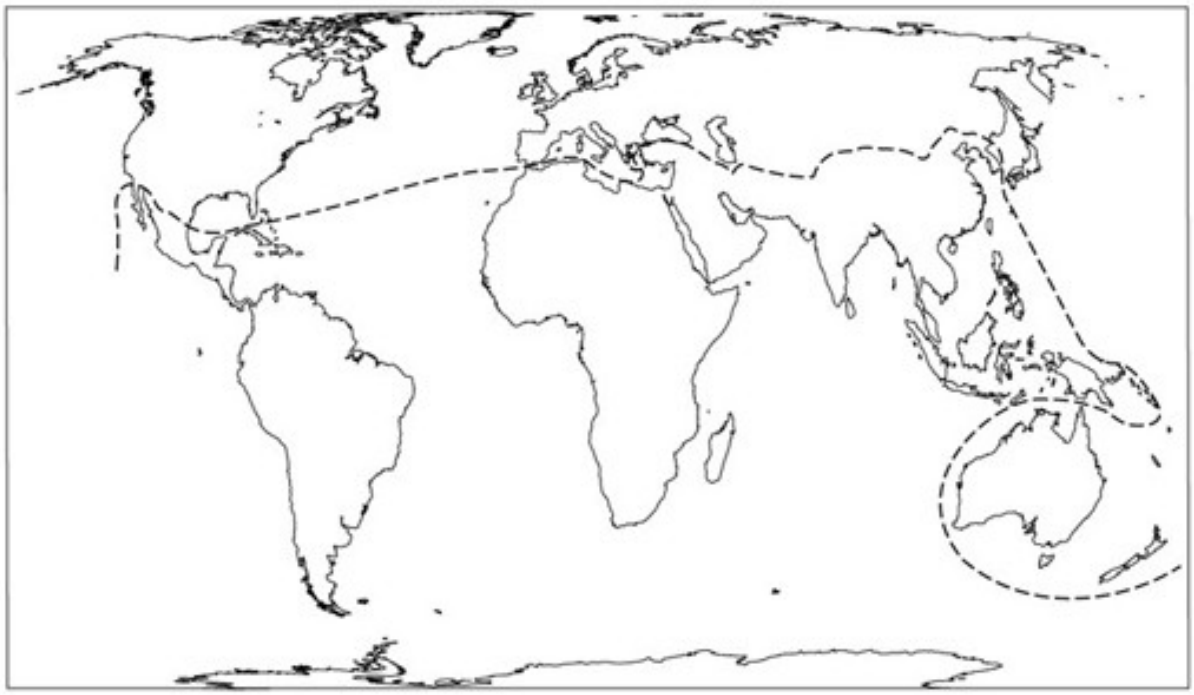
First appearances of wide use of the term "Sustainability" and "Sustainable Development"

In 1972 an international conference held in Stockholm in Sweden attracted large numbers of people from governments and non-governmental organisations (NGOs) who felt they were stakeholders in environmental issues. From that conference emerged a clear theme that environment and development issues were inextricably linked. Around this time the term 'sustainable development' first started to appear.

In 1980 the International Union for the Conservation of Nature and Natural Resources (IUCN), the World Wide Fund for Nature (WWF) and the United Nations Environment Programme (UNEP), all organisations that see themselves as dedicated to preventing environmental catastrophe, produced the World Conservation Strategy. This strategy stressed the interdependence of conservation and development and called for the vitality and productivity of the planet to be safeguarded.

In 1983 the Brandt Commission, chaired by the former West German Chancellor Willi Brandt, reported on North/South relationships; see **Figure 1.2.** The term 'South' in this context is or was often used interchangeably with the terms 'developing countries' and 'less developed countries'. 'North' in this sense is used to apply to the rest, the so-called 'developed' or 'industrialised' world. With increased globalisation since 1983, while there are still many development issues between regions, the boundaries have changed in some senses and the divisions are considered at time of writing to be artificial and to cause unhelpful polarisation and stereotyping in some sustainability situations. For instance the contrasts between rich and poor occur within as well as between countries and there is considerable diversity in terms of development within both South and North.

Figure 1.2 Map showing Brandt's North/South devide



The Brundtland report

As a result of recommendations from the Stockholm conference and Brandt Commission, the World Commission on Environment and Development (WCED; also known as the Brundtland Commission, after Gro Harlem Brundtland, the then Prime Minister of Norway, who chaired the Commission), produced its report 'Our Common Future' in 1987 (World Commission on Environment and Development (WCED), 1987). The Brundtland definition of sustainable development became particularly well known.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

What this definition succinctly emphasises is that the core issue is one that involves trading some present consumption or development or satisfaction with some aspect of the welfare or development or satisfaction of future generations. This concern has deep emotional roots in human beings, especially in people who have, or expect to have, children of their own. Parents forego many types of current satisfaction in order to provide for the future of their children – and this drive has clear biological and evolutionary advantages. Issues that threaten the sacrifices made by parents generally raise very strong emotional reactions – reflecting the high commitment and value placed on this concern for the future.

A brief account and interpretation of events around the time of the Brundtland report came from Richard Sandbrook, then Executive Director of the International Institute for Environment and Development:

"Two important factors helped bring the report in to the public domain. Firstly Mrs Gro Harlem Brundtland, the chair of the commission, became the Prime Minister of Norway shortly after working on the report in 1987. She was thus in a position to promote the conclusions of the report at the highest possible level. And this she did. Ironically, she was joined by Mrs Margaret Thatcher, the UK Prime Minister who had originally opposed the Commission. But, as a scientist, Mrs Thatcher had become deeply concerned about the discovery of the hole in the ozone layer. As a result she decided to promote the environment issue at the United Nations and was joined by Gorbachev, Mitterrand and Gandhi. Thus the international beauty contest of world leaders was set in motion. By the end of 1988, some 50 national leaders had come out in strong support of the conclusions of the Commission, with many calling for a major event to discuss and act upon the Brundtland report."

The definition of sustainability outlined in the Brundtland report contains two key concepts:

1. The concepts of needs, in particular the essential needs of poverty-stricken populations across the globe, to which overriding priority should be given.

2. The idea of limitations imposed by the state of technology and social organisation on the ability of the environment to meet present and future needs.

The United Nations summits and commission for sustainable development

The major event mentioned by Sandbrook took place in 1992. The Earth Summit – the United Nations Conference on Environment and Development – held in Rio de Janeiro was the largest gathering of heads of government that the world had ever seen. 178 government delegations attended, there were also around 50,000 non-governmental representatives and over 5,000 press and thousands of civil servants (Lindner, 1997). From the Earth Summit conventions emerged on: climate change and biodiversity; a set of guidelines of forest principles; a declaration on Environment and Development and 'Agenda 21', an extensive international agenda for action for sustainable development for the 21st century. Agenda 21 was endorsed by all government delegations present and received a wide range of input and support from NGOs.

After the Earth Summit the UN Commission for Sustainable Development was established to promote the process of sustainability and to address the issues and actions identified in Agenda 21. It includes social, economic, conservation and resource management dimensions. Agenda 21 calls for radical changes in the way many live their lives in order to address global issues, ranging from protecting atmospheric, oceanic and freshwater resources to conserving biodiversity, transfer of environmentally sound technology, managing forests, wastes and biotechnology to combating poverty and protecting human health. Stakeholders in Agenda 21 processes, which take place at a range of different levels – from global to local, include nine overlapping 'major groups' who identified themselves or were identified by others. These major groups are:

- Women, children and youth
- indigenous people
- NGOs
- local authorities
- workers and trade unions
- business and industry
- scientific and technological community, and
- farmers.

There are in addition many participants who identify with issues such as freshwater, tourism and education rather than with the major groups. There were many more events at international, regional, national and local levels that followed the Earth Summit. In 2002 a further summit – the World Summit on Sustainable Development (WSSD) – took place in Johannesburg, South Africa. Whereas the Brundtland era focused on 'North-South' interactions and the realisation that we didn't know enough about the inter-relationships between ecological, social and economic dimensions, WSSD

focused more on political and social dimensions of sustainable development and issues of participation, governance and the creation of networks of stakeholders and partnerships.

Increasing globalisation

Perhaps one of the most significant changes between 1992 and 2002 was increased evidence of globalisation, particularly in economic terms such as trade, finance and growth of multinational companies. Besides conferences and events there are other aspects of this global view of issues associated with development. There are other fundamental reasons why issues associated with sustainability arouse deep feelings within people. It is not accidental that many of the examples of issues are associated with global or international levels of decision making and action. It was one thing for the coal fires in London to create smogs (a mixture of fog and smoke) that caused significant numbers of inhabitants to die of respiratory diseases. It is quite another for the global use of fossil fuels to change the global climate so that sea levels rise and threaten large parts of the world's population with flooding. Most of the interest in sustainability is not parochial – it is not the inhabitants of Cornwall protecting the interests of the future inhabitants of Cornwall. It is a concern for the future inhabitants of the globe as a whole.

The latest views on sustainability

Some of the latest thinking on what sustainability actually is, comes from the Stockholm Resilience Centre (http://www.stockholmresilience.org/), and in particular, from Johan Rockstrom. Rockstrom is a leader of a new approach to sustainability, dubbed “planetary boundaries”. Working with a team of 29 leading scientists across disciplines, Rockstrom and the Stockholm Resilience Centre identified nine key Earth processes or systems and marked the upper limit beyond which each system could instigate a major system crash.

Climate change is one of the components but so are other anthropogenic threats such as ocean acidification, loss of biodiversity and chemical pollution. If Earth is a self-regulating system, it is clear that human activity is capable of disrupting it. Rockstrom notes how human growth has strained the Earth's resources but our advances also give us the science to recognise this and change behaviour. These concepts are discussed in the following 18 minute presentation, which you should watch now:

http://www.ted.com/talks/lang/en/johan_rockstrom_let_the_environment_guide_our_development.html

Summing up

This session has highlighted that sustainability is not easily defined. Various definitions exist. However, insights into what sustainability actually means can be gained by taking a historical perspective. This indicates that concepts such as peoples' needs, and limits of the environment to meet these needs, are central to sustainability. While humans society has resulted in some of these limits and planetary boundaries being exceeded, we do posses the ability to manage the environment in a sustainable way, through economic, scientific and social development.

Throughout the remainder of this module, we will explore a number of examples and case studies that illustrate the importance of sustainability for different environmental resources and activities in the world today. We will see why there is a need to manage some of these, such as water (Session 2), food and agriculture (Session 3), forests (Session 4) and tourism (Session 5). In each of these cases, we will see where limits imposed by the environment have been exceeded, and what the options are for managing them in a sustainable way.

Session 1: extra reading

The following article, which was published in the journal Sustainability, in 2010, provides an excellent overview of the issue of defining sustainability and it gives further details on the historical context of the term: http://www.mdpi.com/2071-1050/2/11/3436/

(Kuhlman and Farrington, 2010).

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Chapter 2: Sustainable water: part 1, water stress – highlighting the need for sustainable water use

Water is one of the most important natural resources to human society. However, there are examples all over the world of where water is not being used sustainably, which leads to populations becoming "water stressed". To this end, water resources can be used as a case study to explore three main themes that are central to the debate on sustainability:

How an important natural resource is currently being used unsustainably in some regions of the globe and how this points towards an urgent need to implement practices that promote sustainable use of that resource in those regions, the wider societal impacts of unsustainable use of that resource, and the available options to facilitate a move towards maintaining sustainable use of that resource.

Due to the large scale of the issue of water stress, we will cover this topic in two sessions. This session will address the first theme above, and the next session will address the other two themes.

In this session, we will introduce you to the latest evidence for why water needs to be managed sustainably. We will first explain what water stress is and how it can be calculated. Then we will look at present day water stress at the global, regional and national scales, to highlight parts of the globe where sustainable water management is needed. Then we will explore how water availability and water stress might change in the future. This is important, because by understanding which regions of the world will experience increases in water stress due to climate change and assumptions about future water use, human society can focus efforts on exploring and developing adaptation mechanisms in those regions, to alleviate some of the increases in water stress that are projected for the future, and move towards sustainable water use.

In the next session we will explore – through several case studies – the options for moving towards sustainable water use, which will be particularly applicable to the regions highlighted in this session as being water stressed in the present, or vulnerable to water stress in the future.

What is water stress?

The United Nations (UN) defines water stress as:

"The point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully" (United Nations, 2012).

The key point here to note, is that water stress is a function of water availability and water quality. More specifically, water stress can be described as "Physical" water stress or as "Economic" water stress (POST, 2011). Physical water stress occurs when demand exceeds local availability. Economic water stress occurs where poor governance, or a lack of technical training and financial resources limit access to water.

In general terms, the larger the amount of water that is withdrawn from the environment and used and discharged back into rivers, the more degraded and/or depleted the resource becomes, and the higher the water stress. Competition between users and between society and the requirements of ecosystems increases with the amount of water stress. A level of severe water stress is indicative of a very intensive level of water use that causes the rapid degradation of water quality for downstream users (where wastewater treatment is not common) and absolute shortages during droughts (Alcamo et al., 2007). Moreover, climate change could lead to changes undesirable to society (e.g. reduced average water availability), or to aquatic ecosystems (e.g. unfavourable changes in river flow regime), so the notion of water stress also inherently includes the pressure on water resources caused by climate change.

How can water stress be calculated

Much like the issue of defining sustainability, which we discussed in Session 1 of this module, a formal scientific definition of how to calculate water stress has not fully been agreed. There are, however, two methods that are applied commonly, to calculate water stress; the "water resources vulnerability index" and the "water stress indicator".

The water resources vulnerability index

An index of water stress that is often calculated is the "water resources vulnerability index". The index is a measure of pressure on water resources and it can be readily applied to multiple watersheds. The index calculates the ratio of annual water withdrawals to annual runoff (renewable freshwater supply). Watersheds where withdrawals are less than 20% of supply (i.e. a ratio of less than 0.2) have low or no water stress, watersheds with a ratio between 0.2-0.4 have medium stress, and watersheds where withdrawals are greater than 40% of supply (i.e. a ratio of greater than 0.4) have high stress (Alcamo et al., 2007; Hanasaki et al., 2008).

The threshold of withdrawals being greater than 40% of supply, has been arbitrarily chosen amongst the scientific water resources modelling community as an indicator of high water stress, since the larger the amount of water that is withdrawn from the environment and used and discharged back into rivers, the more degraded and/or depleted the resource becomes, and the higher the water stress (Alcamo et al., 2007). In this sense, 100% of the resource does not need to be withdrawn for a watershed to be classed as water stressed.

The water resources vulnerability index tends to highlight pressures in watersheds with large amounts of irrigation, because the index is largely based upon withdrawals. Projections of future withdrawals are contingent upon future population change and assumptions about future changes in domestic, industrial and agricultural water use intensity. Note, however, that this metric does not account for water quality.

The water stress indicator

The "water stress indicator" is based on water availability per person. A threshold of 1000 m3/person/year is generally used to indicate exposed to water resources stress; i.e. if there is less than 1000 m3 of water available for each person in a year, then that region is classed as water stressed. The measure is simple to calculate but it assumes that water resources pressures are a function of the numbers of people only, not the amount of water that those people actually use.

Water stress in the present climate, at the global and regional scale

The unsustainable use of water resources across the globe, mean that millions of people are currently at risk from water stress. Based upon calculations using the water resources vulnerability index to calculate water stress, it has been estimated that globally, in the year 2000, 2.4 billion people (40% of the world's population) were exposed to high water stress (i.e. where the water resources vulnerability index is greater than 0.4) (Arnell et al., 2011). Around 1.8 billion of these people were in Asia, 96 million in Africa, and 240 million in Europe.

This highlights that global water stress is already a pressing issue, especially with respect to sustainability, and climate change has the potential to exacerbate it. Indeed, as Professor David Grey and Genevieve Connors stated at the 5th World Water Forum in 2009, "With a myriad of crises facing the world today, the problem of water security is often overlooked. However, it needs to be placed at the top of the political agenda."

Figure 2.1 shows that globally, water is abstracted from rivers, lakes and groundwater for a number of purposes, of which agriculture is the greatest. Abstraction for agriculture varies markedly across the globe, e.g. 3% of water within the UK is abstracted for agricultural purposes but in Africa, the figure is 86% (UNESCO, 2009). Nevertheless, the importance of water security for the agricultural sector is immense. Indeed, Peter Brabeck-Letmathe - the Chairman of Nestlé - the largest food and nutrition company in the world, acknowledged at the 2011 World Water Week in Stockholm that water is the biggest challenge for food security and beyond that, for economic growth.

Figure 2.1. Global abstraction of freshwater (%) (POST, 2011).

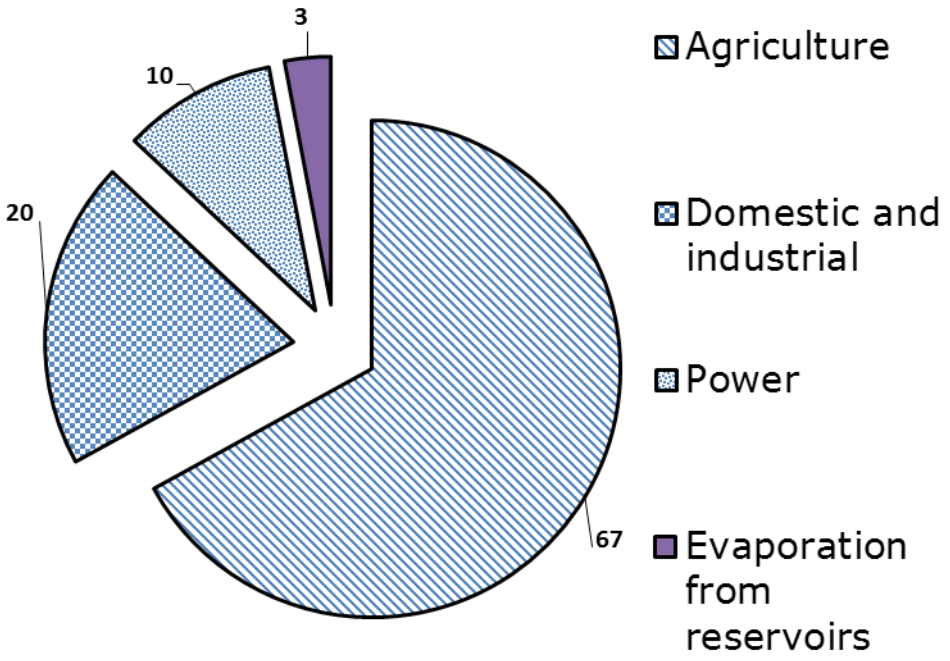

Figure 2.1 reproduced for the purposes of this ebook. Reproduced with permission from POST (Parliamentary Office of Science and Technology) http://www.parliament.uk/business/publications/research/briefing-papers/POST-PN-385

Figure 2.2 (next page). Shows the present day global water use and distribution. Many of the people in water scarce regions are in countries with high population growth rates and their water problems are increasing rapidly. Some water-stressed countries also have another water problem apart from stress — the water is often unsafe to drink. Every year, over 2 million people die from water-borne diseases. So having sufficient water is not enough; it must be unpolluted water. Access to safe water varies with region; see **Table 2.1.**

Figure 2.2. Global water use and distribution. The bar charts show percentage use by category.

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http://openlearn.open.ac.uk/mod/oucontent/view.php?id=399875&section=1

Table 2.1. Access to water supply and sanitation. Data are for 1999.

Region	Population (millions)	Percentage of population with access to:	
		Water supply	Sanitation
Africa	784	62	60
Asia	3682	81	48
Europe	728	96	92
Latin America and the Caribbean	519	83	76
North America	309	100	100
Oceania	30	87	93
Total	6052	82	60

The access to water in cities, about 94%, is much higher than in rural areas, where it is only about 71%. Globally, 18% of the population lack access to safe drinking water. This equates to over 1 billion people. Lack of safe water is due both to lack of investment in water supply systems and to inadequate maintenance of the systems. About a half of the water in supply systems in the developing world is lost to leakage, illegal abstractions and vandalism. In some countries, water is highly subsidised for those connected to the system, while poorer people not connected rely on unsafe sources or expensive private sellers. Globally, 2.4 billion people lack access to adequate sanitation. In developing countries over 90% of sewage is dumped untreated into waters where the water supplies can be polluted.

Even in parts of the world where there is little or no water stress, environmental side-effects of water use are often becoming of great concern. This includes not only the obvious pollution, particularly of sewage and nitrates, but also the destruction of natural wetland habitats by diversion of water elsewhere, falling water tables due to over-extraction, and the drowning of land by enormous reservoirs. About half of the rivers and lakes in Europe and North America are still seriously polluted, despite improvements in recent years. Water quality may be the biggest emerging water problem for the industrialised world.

The United Nations Development Program (UNDP) has produced a video that highlights the importance of water quality. Indeed, remember that water stress is a function of both water availability and water quality. Please watch the video here:

http://youtu.be/3jYr8MFTXrM

Please now read only Part 1 (pages 1-12) of the Lloyd's 360 Risk Insight report; “Global Water Scarcity”, which can be viewed here:

http://www.lloyds.com/~/media/Lloyds/Reports/360%20Climate%20reports/7209_360_Water_Scarcity_AW.pdf (Lloyds, 2010).

Part 1 provides an accessible description of the current pattern of water stress, at the global scale, and it highlights the need for sustainable water management. The report also introduces the notion of “virtual water” and “water footprints” - because all products contain embedded water, this creates a “virtual” global water trade. These ideas, within the context of sustainability are discussed later in the next session. The Lloyd's 360 Risk Insight report shows economic growth, population shifts and climate change will contribute to severe shortage and degradation of global water supplies and ecosystems over the next 30 years, particularly in the developing world. To this end, the availability and geographical location of water resources are subject to change in the future, which has important implication for sustainability. As water is a local product, it is difficult to transport and traditionally has been used close to its source. The report concludes that companies working on water management and sustainability strategies need to look at very local issues.

An excellent summary of water stress under the present climate is presented on the first side of a poster that has been prepared by the World Water Assessment Programme (WWAP) of the United Nations Educational, Scientific and Cultural Organization (UNESCO). The second side of the poster is relevant to the next Session. Please view this poster at: http://unesdoc.unesco.org/images/0014/001446/144620E.pdf . The assessment for this module will involve you producing a poster similar to this UNESCO poster, and presenting it to other students studying on this module.

The UN Food and Agricultural Organisation (FAO) have produced a short three and a half minute video, which summarises the key facts we have covered in this section; please view the video here:

http://www.youtube.com/watch?feature=related&v=XGgYTcPzexE&gl=GB

Water stress in the present climate, at the national scale

Up until now, we have looked at the effects of the unsustainable use of water at the global and regional scale. In this section, we will look at two case studies, which highlight the effects of unsustainable water management at the national and sub-national scale;

The Aral Sea

The Ogallala Aquifer

Both case studies highlight the need for sustainable water use management practices. Later in this session, we will explore some of the projects that are aimed at managing water in these two areas in a sustainable manner.

The Aral Sea

The Aral Sea is a landlocked endorheic sea between Kazakhstan and Uzbekistan. An endorheic sea has no outflow of water. This means that once water falls into the sea by precipitation, it remains there permanently, and can only leave the sea by evaporation or transpiration. To locate the Aral Sea, go to: maps.google.co.uk and search for "Aral Sea".

The Aral Sea is fed by 2 rivers: the Amu Darya and Syr Darya rivers (**Figure 2.3**).

Figure 2.3 The Aral Sea is fed by 2 rivers: the Amu Darya and Syr Darya rivers

The Soviet Union decided to divert the rivers to irrigate the desert. This was to grow rice, cereal and cotton and it was part of the Soviet plan for cotton ("white gold") to become a major export. The plan was somewhat successful, since Uzbekistan is now one of the world's largest exporters of cotton.

Large scale building of irrigation canals began in the 1930s. Many were poorly built, however, meaning that water leaked or evaporated easily. For example, 30-70% of water in the Qaraqum Canal was wasted. Today, only 12% of Uzbekistan's irrigation canal length is waterproofed.

By 1960, 20-50 km3yr-1 of water was going to the land for irrigation, instead of entering the Aral Sea. The diversion of all this water meant the Aral Sea started to shrink. For instance, during 1961-1970 there was 20 cm depth loss each year. This increased to 50–60 cm per year in the 1970s and by the 1980s there was 80–90 cm loss in depth each year. The result is that the Aral Sea's surface area has shrunk by 60%, and its volume by 80% since the 1930s. In 1960, the Aral Sea had an area of 68,000 km² but by 2004 it was 17,160 km². The effect of the declining water level has been that the Aral Sea's salinity has increased from about 10 g/l to about 45 g/l over the same period.

In 1987, the continuing shrinkage split the sea in two, creating the North Aral Sea and the South Aral Sea. An artificial channel was dug to connect them. Continued shrinkage meant the connection had effectively disappeared by 1999. In 2003, the South Aral further divided into eastern and western basins. The following satellite imagery produced by NASA, shows the extent to which the Aral Sea has declined during 2000-2011. Please view the satellite imagery here:

http://en.wikipedia.org/wiki/File:Shrinking_Aral_Sea.ogv

The demise of the Aral Sea has had numerous impacts. Higher salinity has destroyed the ecosystem of the Aral Sea and the river deltas feeding into it. Crops in the region are destroyed by salt deposition onto the land. The receding sea has left plains covered with salt and toxic chemicals. These are picked up and carried by the wind as toxic dust and spread to the surrounding areas. To this end, there is a high occurrence of health problems, including cancer and lung diseases in the region surrounding the Aral Sea.

Moreover, people living in the area are suffering from a lack of fresh water. The fishing town of Muynaq in Uzbekistan employed approximately 60,000 people once but now the town lies miles from the shore. The only significant fishing company left in the area has its fish shipped from the Baltic Sea, thousands of kilometres away.

Now please watch and make notes on the following 10 minute video, which gives a graphical representation of the impacts of unsustainable water use, which were just described: http://youtu.be/NC5UIEx83fo.

The Ogallala Aquifer

The Ogallala Aquifer in central U.S., is another example of unsustainable water use. The following video introduces the situation for Nebraska, which is one of the eight states that overlies the aquifer and which extracts water from the aquifer for domestic and industrial use (mainly irrigation): http://youtu.be/tIBw25BziZY

The aquifer covers 450,000km2 across 8 US states (see **Figure 2.6**). 27% of the irrigated land in the entire U.S. overlies the aquifer. Over 90% of the water that is pumped from groundwater is used to irrigate crops. Overall, around $20 billion/yr in food and fibre depend on the aquifer and the region supplies over 20% of the total U.S. annual agricultural harvest.

The irrigation around the Ogallala Aquifer is largely by centre-pivot irrigation, a method which involves the irrigation machinery revolving around a central pivot (see **Figure 2.7**). Observed from above the land surface, centre-pivot irrigation appears as a unique patchwork of circular fields (see **Figure 2.8**).

Work by the USGS shows that yearly groundwater withdrawals increased by 500% between 1949 and 1974 and that in some places farmers were withdrawing 4-6 feet a year, while natural recharge was only 0.5 inches. This has resulted in substantial declines in water availability in the region and continued unsustainable water use is reflected in withdrawals exceeding 40 feet per year in some areas (see **Figure 2.6**).

Figure 2.6. Map of groundwater-level changes in the Ogallala Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, 1980 to 1995.

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http://en.wikipedia.org/wiki/File:Ogallala_changes_1980-1995.svg

How will climate change affect water stress?

Figure 2.9 shows how average annual runoff (runoff is water that flows over the surface of the earth, e.g. in rivers) will be affected by climate change, when simulations of the future climate from four different climate models are applied to a global hydrological model (Arnell et al., 2011). Each simulation assumes un-mitigated climate change, whereby global-mean temperature rise relative to pre-industrial times reaches 4°C by the year 2100. **Figure 2.9** shows, as an indication, how runoff might change by 2050. Four different models are used in figure 2, because it is not reliable to interpret the results from only a single climate model. By using the results from four different models, it is possible to consider the inherent uncertainty there is in estimates of future river flows that arises from using different models. Different models will produce slightly different results because they include different (but plausible) assumptions and representations about how the climate system works. Water stress is more than only a function of river flows, since water abstractions and population numbers are important drivers. However, **Figure 2.9** shows which regions of the world experience increased water availability with climate change and those regions that see decreases in water availability.

Figure 2.9

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http://equellatemp.nottingham.ac.uk/uon/file/6b51401f-d00f-c72b-fad6-319393a548ca/1/Geog_eq2.zip/Geography%20sustainability.old/26_how_will_climate_change_affect_water_stress.html

https://itunes.apple.com/gb/book/sustainability-geography-perspective/id584830658?mt=11

Regions of the globe where water availability decreases and what this means

There is uncertainty across the four different climate models, e.g.two models project increases in runoff across much of China; two project decreases. Generally, however, the hot spot areas include central USA, South Africa, the Middle East, Amazonia, and especially the countries located around the Mediterranean basin, e.g. Spain, Italy, Greece, much of northern Africa and Turkey. This has been confirmed in other studies (Gosling et al., 2010). In some of these countries, average annual runoff could decrease by up to 50%. This represents a severe impact – the effects of water declines by up to 50% could have serious implications for hydro-electric power generation, irrigation and farming, desertification and overall sustainability of water supply in these regions.

Recent research has identified the southern Mediterranean and its ecosystems as particularly vulnerable to desertification under climate change conditions, as a consequence of large projected decreases in precipitation and glacier meltwater, and consequent drought stress (Giorgi and Lionello, 2008). In particular the central and southern portions of the Iberian, Italian, Hellenic and Turkish peninsulas, parts of southeastern Europe, Corsica, Sardinia and Sicily could experience desertification with climate change. For example, under a business as usual climate change scenario with no mitigation, one study showed that the magnitude of drought that currently occurs once every 100 years, could occur every 40 years, or in extreme cases 10 years, over Portugal, countries in the Mediterranean basin, Hungary, Bulgaria, Romania, Moldova, Ukraine, and south Russia (Lehner et al., 2006). This implies that in the future, it will be critical that water is managed sustainably in these regions. Another study showed that severe future alterations in discharge regimes with climate change, such as those presented in **Figure 2.3 (as seen in section 2.5)** would lead to unstable regional trends in hydropower potentials across Europe (Lehner et al., 2006). Reductions of 25% and more in hydropower potentials for southern and southeastern European countries were projected due to decreases in runoff, which indicates that climate change has implications for not just sustainability of water supply, but sustainability of energy supply too.

Regions of the globe where water availability increases and what this means

Figure 2.9 (As seen in section 2.6) shows that climate change is associated with increased annual river flows in most of the models, across much of the high northern latitudes (e.g. Canada and Siberia), much of South Asia, coastal eastern Africa and regions of Sub-Saharan Africa. However, in the last case, it needs to be noted that annual river flows increase by only a minor amount in absolute terms; a matter of millimetres.

While increased water availability might alleviate the risk of water stress and make it easier for water to be managed sustainably, it should be noted that infrastructure might not be in place to store and distribute this extra water that would be available in the future. Increased water availability may also be tempered by an increase in flood risk. For example, the Thailand floods in 2011, where one third of the total land area of the country was inundated due to flooding, were triggered by rainfall over the past few months that were around 25% higher than what is historically typical for that time of year. The effects in Thailand included inundation of around 12% of Thailand's rice paddy fields. Thailand is the globe's largest exporter of rice but according to the Thai Rice Exporters Association, shipments declined by around 50% from November to January as a state-buying policy raised costs and flooding disrupted transport. The automotive industry was severely affected too. Japanese automakers lost production of about 6,000 cars a day during the floods, according to the Japan Automobile Manufacturers Association. Consequently, Thailand's central bank revised its 2011 economic growth forecast to 2.6% from 4.1% at the end of October, because of the flooding. While the events in Thailand can not be attributed to climate change, the situation is somewhat indicative of what could happen in regions where water increases by over 25%, which places the projections in **Figure 2.9 (As seen in section 2.6)** into context.

To what extent do changes in water availability affect global water stress?

The latest evidence from the scientific literature notes that more people will experience a decrease in water stress under climate change than experience an increase. This finding was reported in one of the leading journals on Climate Change, 'Climatic Change' in 2010 (Hayashi et al., 2010). However, this is nothing new. The UN Intergovernmental Panel on Climate Change (IPCC) arrived at this same conclusion back in 2007, in their Fourth Assessment Report (Kundzewicz et al., 2007).

However, this general finding does not mean that climate change impacts on global water stress are of little concern for sustainability. It is irrational and incorrect to calculate a net change in global water stress with climate change. Just because some regions experience decreased water stress with climate change - as a result of receiving more rainfall - does not mean that it offsets those regions of the globe where water stress increases. By understanding which regions of the world will experience increases in water stress, we can focus efforts on exploring and developing adaptation mechanisms in those regions, to alleviate some of the increases in water stress that are projected with climate change, and move towards sustainable water use.

Unmitigated climate change by 2100 (4 °C warming) could lead to increased exposure to water resources stress for between 11 - 18% of global population (0.9 and 1.8 billion people respectively), and reductions in exposure to stress for between 9 - 31% (0.8 and 2.8 billion people respectively) (Arnell et al., 2011). Other studies have projected changes in water stress due to climate change similar in magnitude to this (Gosling et al., 2011; Kundzewicz et al., 2007). The declines in water stress are largely due to projected increases in rainfall in highly populated regions of south and north east Asia. As mentioned previously, this confirms previous findings that more people will experience a decrease in water stress under climate change than experience an increase, but a net change should not be calculated because a decrease in water stress in one part of the globe will not offset an increase in another part of the globe.

Figure 2.10 shows how the spatial pattern of water stress is affected by climate change in 2100, for each of the four climate models that were used in **Figure 2.9 (As seen in section 2.6)**, under unmitigated climate change (4°C global warming) (Arnell et al., 2011). The water resources vulnerability index was used to calculate water stress. It was assumed that irrigation withdrawals per m2 of irrigated area remain constant (implying any effects of climate change are offset by efficiency gains), but irrigation area increases as a function of population growth so irrigation withdrawals increase. Around 1,300 watersheds across the entire globe were assessed, and the effect of climate change on water stress was broken down into six classes, to demonstrate how the pattern of water stress across the globe may change in the future. Areas white in colour, are classed as not water stressed in the present-day climate and are projected to remain in this class in the future. Areas in blue, are currently water stressed, but climate change (e.g.

increased rainfall) and/or socioeconomic changes (e.g. population decreases and decreased water abstraction) in the future mean that these regions are no longer classed as water stressed in the future. Green regions are where populations are currently water stressed, and continue to be in the future, but to a lesser extent than they are at present. Yellow indicates that the region is water stressed at present and that it will still be water stressed to the same extent in the future. Orange indicates a region that is not currently water stressed but then becomes water stressed in the future. Red regions are where populations are currently water stressed, and continue to be in the future, but to a greater extent than they are at present. Essentially, yellow, orange and red regions, are those of concern, in terms of future water stress and water sustainability.

Figure 2.10

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http://equellatemp.nottingham.ac.uk/uon/file/6b51401f-d00f-c72b-fad6-319393a548ca/1/Geog_eq2.zip/Geography%20sustainability.old/26_how_will_climate_change_affect_water_stress.html

https://itunes.apple.com/gb/book/sustainability-geography-perspective/id584830658?mt=11

While there is uncertainty across the four models, the hot spot areas for increases in water stress with climate change that appear in the majority of models are:

• New South Wales in Australia

• A region spreading from north India, westwards across Pakistan, Iran and Saudi Arabia, to Iraq and Turkey.

• Central and south-western USA

• Watersheds in the northern areas of Tunisia, Algeria and Morocco

• Some watersheds along the Chile-Argentina border

These are the regions, therefore, where efforts toward increasing sustainability of water supply should be focussed.

One model (CGCM1) shows that a large area that could experience a significant increase in water stress is the watersheds bordering western China and eastern Kazakhstan but the other three models suggest either no change in stress, or an improvement in the situation here. It is noteworthy that a number of watersheds that experience increases in water stress cross national and state boundaries. This is an important issue, because the unsustainable use of water in country A, which may be upstream from country B, can in turn adversely affect water availability for country B, and decrease its capacity for sustainable water management. This can lead to international disputes – this is covered in detail in **Session 3.**

Please now watch the following video (3 minutes) which summaries how climate change might affect access to water resources in the future, if the global climate warms by 4°C. The results discussed in the video are similar to those presented in **Figure 2.10**. Please watch this video:

http://youtu.be/qQdFXKLYMXw

Activity

Start a new date and title entry on the blog or offline document that you started writing last week. Call the title of today's entry "Areas of the world where efforts towards securing sustainable water use could be important". In no more than 400 words, write a summary of the regions of the world which would appear to benefit from the implementation of sustainable water use practices, based upon what has been covered in this session. This should take no more than 25 minutes. You could focus on the present-day situation, or the future, or both. An additional resource (optional), which you may wish to use for this activity is the Foreign and Commonwealth Office (FCO) Google Earth Map of the impacts of climate change in a 4°C world. One of the main impacts is water resources. You will need Google Earth installed on your computer, which you can download for free from here: http://www.google.co.uk/intl/en_uk/earth/download/ge/. After Google Earth is installed, you then need to install the FCO layer from here: http://www.fco.gov.uk/google-earth-4degrees.kml. You can then zoom and move around the world to see which areas are vulnerable to water stress if global warming reaches 4°C warmer than present.

Summing up

Water stress may be defined as the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully. It is a function of the available water resource and the pressures on that resource from society.

Global water stress is often calculated by comparing the annual amount of water withdrawals to the available resource. A region is water stressed if withdrawals are greater than 40% of supply.

67% of the globe's freshwater resource is withdrawn for use in agriculture (e.g. irrigation).

In the year 2000, 2.4 billion people (40% of the world's population) were exposed to high water stress (i.e. people living in regions where withdrawals are greater than 40% of supply). Around 1.8 billion of these people were in Asia.

Climate change projections show that the available annual water resource could decrease by as much as 50% by 2050 under unmitigated climate change, in regions including central USA, South Africa, the Middle East, Amazonia, and countries located around the Mediterranean basin.

Droughts could become more severe in these regions and there would be a greater risk of desertification. Hydro-electric power potential would also decline.

Parts of south Asia and coastal eastern Africa are projected to experience increases in annual water availability of over 50% by 2050 under unmitigated climate change but infrastructure may not necessarily be in place to store this extra water.

Furthermore, these large increases in surface water could be associated with increased flood risk; e.g. the October-November 2011 floods in Thailand were caused by monsoon rains 25% higher than average for the time of year.

Unmitigated climate change by 2100 (4 °C warming) could lead to increased exposure to water stress for between 11 - 18% of global population (0.9 and 1.8 billion people respectively), and reductions in water stress for between 9 - 31% (0.8 and 2.8 billion people respectively).

These increases and declines cannot be summed because the changes occur in different parts of the globe. It is also important to note that the geographical pattern of water stress changes. The range is due to uncertainties from climate modelling.

Hot spot areas for increases in water stress with climate change include: New South Wales in Australia; a region spreading from north India westwards across Pakistan, Iran and Saudi Arabia to Iraq and Turkey; central and south-western USA; northern areas of Tunisia; Algeria and Morocco; and parts of the Chile-Argentina border.

The large regions of the globe that are currently experiencing water stress, plus those that are projected to see increases in water stress, highlight that there is an urgent need to work towards sustainable water use in these regions because water is either not currently being used sustainably in those regions, or it is projected to be used unsustainably in the future.

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Chapter 3: Sustainable water: part 2, political implications of unsustainable water use and options for sustainable water use

In this session, we will first explore the wider societal impacts of unsustainable water use; i.e. international disputes over water resources. Then, through a selection of multi-scale case studies, we will explore the available options for moving towards maintaining sustainable water use. We will look at examples of projects implemented in different countries and by international companies and we will introduce the concept of the "Water Footprint".

International disputes associated with unsustainable water use

Water shortages have caused major international disputes in many parts of the world, which highlights the importance of sustainable management of water resources. Some examples of international disputes over water are included in **Table 3.1** Water management is particularly difficult in areas where the catchment of a river crosses many countries. Egypt, for example, obtains most of its water from the River Nile. The Nile originates mainly from seven upstream countries. In the Middle East, water resources are of strategic concern, and a major cause of political conflict. Full-scale water wars are unlikely, but tension between countries competing for water is escalating to the extent that in some areas war has been threatened. The following quotes illustrate points of view on water disputes:

"Whisky's for drinkin', water's for fightin' "; attributed to Mark Twain

"Why go to war over water? For the price of one week's fighting, you could build five desalination plants. No loss of life, no international pressure, and a reliable supply you don't have to defend in hostile territory"; a considered view from a country involved in water disputes, from an Israeli Defence Forces analyst (Wolf, 1999).

Table 3.1

Rivers or Aquifers	Countries involved in dispute	Subject of dispute
Nile	Egypt, Sudan, Ethiopia, Uganda, Kenya, Democratic Republic of Congo, Eritrea	siltation, flooding, water flow/diversion
Eupheates, Tigiris	Iraq, Syria, Turkey	dams, reduced water flow, salinisation, hydroelectricity
Jordan, Yarmouk, Litani, West Bank aquifers	Israel, Jordan, Syria, Lebanon, Palestinians on the West Bank	water flow/diversion, allotment of water from common aquifers
Brahmaputra, Ganges	Bangladesh, India	siltation, flooding, water flow/diversion
Mekong	Kampuchea, Laos, Thailand, Vietnam	water flow, flooding, irrigation
Parana	Argentina, Brazil	dam, land inundation
Lauca	Bolivia, Chile	dam, salinisation
Rio Grande, Colorado	Mexico, United States	salinisation, water flow, agrochemical pollution
Great Lakes	Canada, United States	water diversion
Rhine	France, Netherlands, Switzerland, Germany	industrial pollution
Danube	Austria, Slovakia, Hungary	water diversion, hydroelectricity

At the Davos World Economic Forum in 2008, Ban-Ki Moon, the UN Secretary General stated that:

"Today everyone knows Darfur. More than 200,000 people have died. Several million have fled their homes. There are many factors at work in this conflict, of course. But almost forgotten is the event that touched it off - drought. A shortage of life's vital resource. We can change the names in this sad story. Somalia. Chad. Israel. The occupied Palestinian territories. Nigeria. Sri Lanka. Haiti. Colombia. Kazakhstan. All are places where shortages of water contribute to poverty. They cause social hardship and impede development. They create tensions in conflict-prone regions. Too often, where we need water we find guns… Population growth will make the problem worse. So will climate change. As the global economy grows, so will its thirst. Many more conflicts lie just over the horizon".

There are a number of international water sharing or water division agreements in place across the globe. For example, agreements exist between India and Pakistan (Indus Water Treaty),India and Nepal (Mahakli Treaty), and Canada and the USA (International Boundary Waters Treaty Act). However, there is also potential for conflict. For example, the eastern Mediterranean and Middle East are two regions that are projected to experience large increases in water stress with climate change. It has been suggested that here, climate change will act as a "threat multiplier – exacerbating water scarcity and tensions over water within and between nations linked by hydrological resources, geography, and shared political boundaries" (Friemuth, 2007). It has been noted that the effort by Israel and Jordan to secure an additional 50 million cubic meters of water for Jordan could be problematic if water stress increases in the region - as the late King Hussein of Jordan stated, water is the one issue "that could drive the nations of this region to war" (Eckstein, 2009).

Importantly, it must be noted that there is limited evidence to support the argument that conflicts over water have occurred in the past and so are also likely to occur in the future. For example, one study showed that neighbouring countries that share water resources experience low-level interstate conflict more frequently than countries that do not share resources (Gleditsch et al., 2006), but a companion study found that they also tend to cooperate more (Brochmann and Gleditsch, 2006). Moreover, it has been argued that cooperation consistently overcomes conflict with shared international water resources (Yoffe et al., 2003). For instance, the Chinese Government recently expressed an interest in diverting parts of the Brahmaputra, which would have affected river flows to India substantially. However, in October 2011 the Chinese stated "possible impact on state-to-state relations" as a reason for cancelling their diversion plans.

This supports the contention that "Because international freshwater is shared, unequally divided, scarce, and has the potential of being mismanaged; nations often have two choices: conflict or cooperation" (Dinar, 2002). The degree to which nations will resort to conflict in the future in areas where water stress increases, remains uncertain – largely due to a lack of supporting historical evidence.

However, an important point to note is that while current trans-border water agreements may help to resolve differing interests between countries in the present climate, whether the agreements will still be honoured in the future when water availability changes and a nation's water resource is threatened, is another matter. It is often noted that the link between a nation's security and water should not be underestimated, particularly where another nation poses a threat. Indeed, in 2007, at the Security Council Debate on Energy, Security and Climate, Ban-Ki Moon stated that:

"The adverse effects of changing weather patterns, such as floods and droughts, and related economic costs, including compensation for lost land, could risk polarizing society and marginalizing communities. This, in turn, could weaken the institutional capacity of the State to resolve conflict through peaceful and democratic means, to ensure social cohesion, and to safeguard human rights."

It may not necessarily be a certainty that future water stress will "cause" conflicts, but it could well be a contributing factor that acts as the tipping point for conflict. This is a point echoed by the UN World Water Development Report (UNESCO, 2009):

"Water is linked to the crises of climate change, energy and food supplies and prices, and troubled financial markets. Unless their links with water are addressed and water crises around the world are resolved, these other crises may intensify and local water crises may worsen, converging into a global water crisis and leading to political insecurity and conflict at various levels."

Case Study: The Middle East

An interesting case study on water resources and its unsustainable use and conflict is the Middle East. The Middle East is an area of low precipitation and high evapotranspiration, much of it with less than 200 mm precipitation a year and potential evapotranspiration of over 2000 mm; this defines it as 'arid'. It has a few rivers, arising in the mountains, two of which, the Euphrates and Tigris, are a major source of water in the region (see **Figure 3.1**). Another river, the Jordan and its tributaries, is of significance to the west of the region. The limited water resources of the region have led to international disputes over water supplies , the two main disputes being between Israel and its neighbours, and between Iraq, Syria and Turkey over the Euphrates and Tigris rivers.

Figure 3.1 The Middle East, with major rivers: the Jordan, Euphrates and Tigris.

http://openlearn.open.ac.uk/mod/oucontent/view.php?id=399875&section=2.1

Many of the countries in the Middle East experience water stress; Israel for example has about 300 m3 of fresh water available per person per year and Kuwait about 1m3 of water available per person per year. In recent years, large population increases into some areas resulting from immigration (e.g. Israel) or high birth rates have made agreement on equitable distribution of water imperative. This has been exacerbated by a series of Arab–Israeli conflicts and disputes between Arab countries.

Secure water supplies have been a primary concern for Israel ever since the creation of the state in 1948, and in the 1950s there were plans to share the waters of the Yarmouk River (a tributary of the River Jordan) and Lake Tiberias with Jordan and Syria. However, Syria objected to Israel's plans to divert water from the Jordan above Lake Tiberias and Israel objected to a Syrian scheme to dam the Yarmouk as it would reduce flow into the Jordan. The 1967 war resulted in Israeli occupation of the Golan Heights, southern Lebanon and the West Bank, which strengthened Israel's water supply position, as it controlled the headwaters of the Jordan and aquifers of the West Bank. However, drought and increased extraction during the late 20th century reduced the levels of Lake Tiberias and increased its salinity to levels that threaten its aquatic life, and increasing groundwater exploitation above the safe yield has lowered aquifer levels, causing saline intrusion into the coastal aquifer. To increase its water security, Israel is constructing desalination plants. However, water continues to be a central feature of peace negotiations in this area.

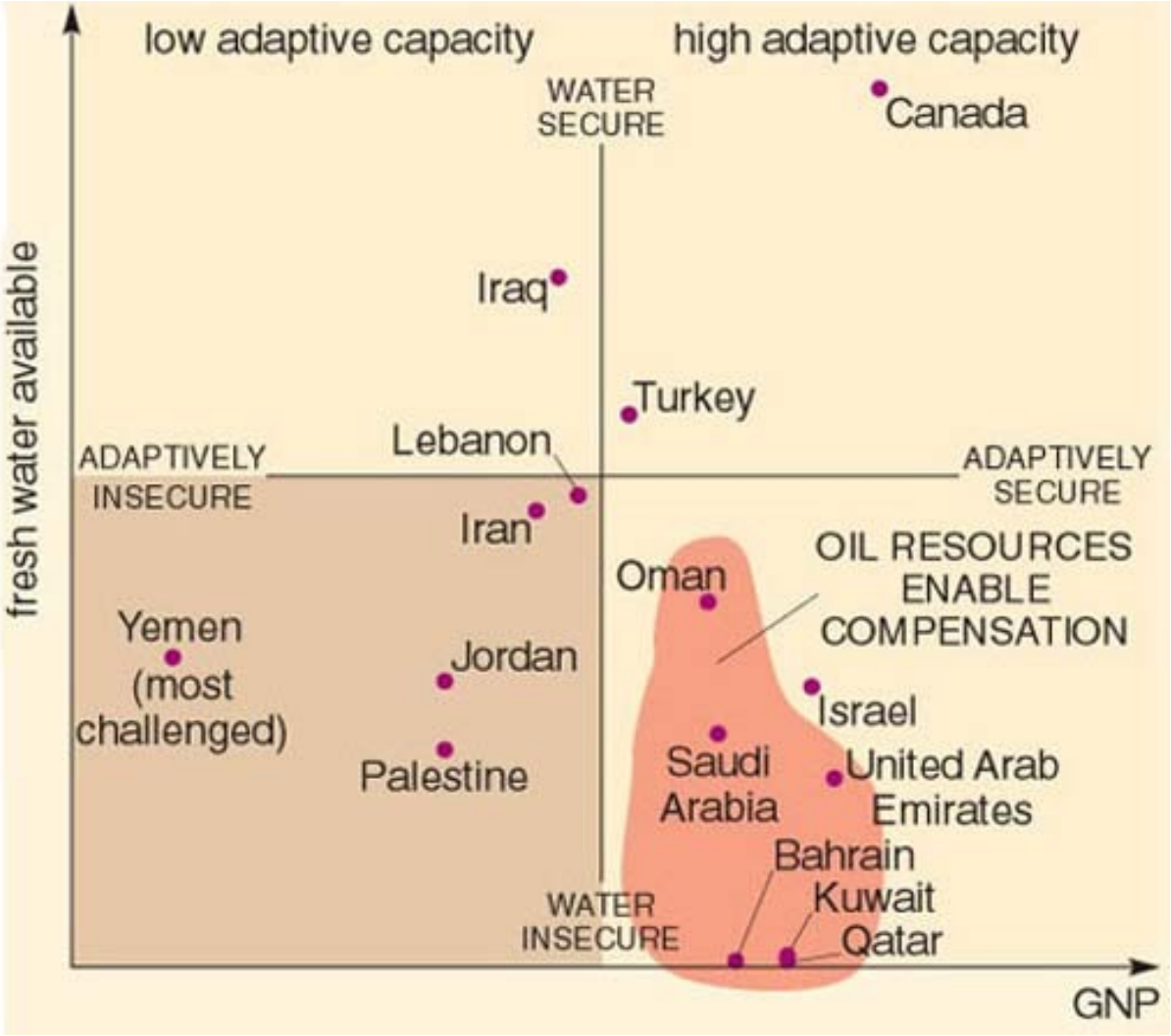
The other major area of water dispute in the Middle East involves the Euphrates and Tigris rivers, which rise in the mountains of Turkey and flow southwards into Syria and Iraq, dependent on these rivers for most of their water supply. Turkey, as the upstream country, claims the right to control the water that originates within its border. Iraq claims historical rights to the rivers as its people have depended on them for thousands of years, in what was Mesopotamia, using them for large-scale irrigation. Syria claims both ownership rights and historical user rights. Unfortunately there is just not enough water for all the counties, leading to conflict and, at times, threats of war.

In 1974 Syria cut off the flow of the Euphrates to Iraq in order to fill a new reservoir. Iraq assembled troops on the Syrian border and threatened invasion, with the result that Syria hastily released water back into the river. In 1990, Turkey stopped the flow of the Euphrates to fill the reservoir behind the Ataturk Dam (see **Figure 3.2**); Syria and Iraq insisted that Turkey restore the flow, which it did, but a month later. Greater cooperation between the three countries to manage the rivers on a catchment scale, and changes to agricultural practice will be necessary to manage the water resources of these major rivers in a sustainable way, but there are many obstacles to this, especially as water issues have a political role in the area.

Kuwait, with its extreme water scarcity, is one of the Middle Eastern countries with a different approach. There is no water shortage in Kuwait; it does not depend on rain to provide its fresh water, it depends on desalination. This requires large amounts of energy but Kuwait also has huge energy resources.

Although desalination is expensive, it is definitely not out of reach for an oil-rich state in the Gulf. It shows clearly that sufficient water can be obtained — if the country can pay for it. Poverty is the villain that often forms the root problem, not the environment or resource limitations. An economically rich country (e.g. the Gulf states) or one which can adapt (e.g. Israel) has greater water security (see **Figure 3.3**).

Figure 3.3. Water security in the Middle East, in relation to fresh water availability, economy (measured by gross national product, GNP) and adaptive capacity.



http://openlearn.open.ac.uk/mod/oucontent/view.php?id=399875&section=2.1

Water has been previously undervalued as a resource, although that is now changing—it has been called the 'blue gold' of the 21st Century. Managing demand through conservation and appropriate use, rather than continuously striving to meet greater demands in an unsustainable fashion is beginning to be recognised as the most environmentally sound solution. In the next section, we will explore some of the ways that water can be managed in a sustainable way.

Activity

Now, use the internet to search for further details on one of the water disputes listed in Table 3.1, or one that is not included in the table. Then go back to the blog (or other document) that you started in Session 1 and have been writing in since, and create a new title and date entry called "An international dispute related to water stress – the need for sustainable water management". In this section of your blog, provide a summary of no more than 500 words that includes details on the following aspects of the water dispute you find:

- Where the dispute has occurred.
- Which countries were involved.
- Is the dispute still ongoing?
- If the dispute has ended, why did it end?
- What triggered the dispute.
- Were any factors other than unsustainable water use responsible for the dispute?

Do not spend more than 40 minutes on this activity.

Managing water resources sustainably to alleviate water stress – options

The Food and Agriculture Organisation (FAO) of the United Nations agues that actions are required at global, international, national, local, and watershed levels to address water stress. Specifically, the FAO recommends that collaboration between nations and/or shared management of water resources are formed, in an "inter-sectorial and multidisciplinary approach, to manage water resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Food and Agriculture Organisation (FAO), 2011). Demand for water should be addressed by enhancing water productivity (the volume of production per unit of water), and protecting and restoring the ecosystems that naturally capture, filter, store and release water, such as rivers, wetlands, forests and soils, to increase the availability of good quality water. Generally, a range of methods can be applied that attempt to alleviate water security, including:

- water efficiency schemes,
- engagement between large scale water users and other stakeholders,
- life cycle assessments, and
- global greenhouse gas emission reductions.

Each of these is now considered in turn.

Water efficiency schemes

Nestlé, the largest food and nutrition company in the world, which employs around 280,000 people in over 100 countries, has taken steps to address water stress. Over the past decade, Nestlé has reduced total water withdrawals by over 30% and more than doubled the water efficiency of their internal operations (SIWI (Stockholm International Water Institute), 2011). Another example is "Plan A" of Marks and Spencer (M&S), which is the M&S sustainability plan (this is explored in detail in **Session 10**). The plan aims to better manage the water consumed in products sourced from UK farms, the production of cotton and the import of flowers from Kenya. M&S also aims by 2020 to source 50% of its supplies from the Better Cotton Initiative, which promotes better agricultural practices to reduce the environmental and social impacts connected with cotton cultivation (POST, 2011).

Engagement between large scale water users and other stakeholders

Water use efficiency alone will not alleviate global water stress completely and achieve full water sustainability. Neither will it immunise the companies that apply water efficiency schemes to the potential reputational and regulatory consequences of being located in a river basin with social tension or ecological collapse related to water scarcity or contamination (Lloyds, 2010). To this end, a complimentary means to alleviating water stress involves companies engaging with stakeholders to improve the management

of water resources in a sustainable way. This type of engagement typically occurs at the local and/or watershed scale.

For example, Anglo American is investing considerable capital in mining operations in South America. The company is the largest user of water in South America. In collaboration with government authorities, Anglo American is developing a river basin water strategy to improve clarity around future water allocation and management in the region. In Rustenburg in South Africa, Anglo Platinum have made water efficiency savings within local operations, and worked with local communities to assist them in accessing household water on the basis that total water use would not increase. More generally, the Coca-Cola Company requires all operations to develop water source protection plans with local stakeholders by 2013, based on an understanding of river basin vulnerabilities.

Life cycle assessment and the "Water Footprint"

Measuring water use and assessing its environmental impacts on a life cycle basis (i.e. assessing the use of water associated with all the stages of a product's life from cradle-to-grave) is one way of raising public awareness of water stress as well as a step towards making companies accountable for the water they use – and so towards sustainability.

A widely-used example is the Water Footprint approach (Hoekstra et al., 2011). The approach separates the quantity of water consumed in space and time based on whether it is "blue" (from lakes, rivers, or groundwater), "green" (rain water stored in soil moisture or captured directly) or "grey" (volume of freshwater polluted) (POST, 2011). Products can then be given a "water footprint", which is a clear indicator of freshwater use in production. It can be calculated at the individual, business, river catchment, national or global scale.

The concept of the Water Footprint is directly relevant to sustainability of water and it was developed with water sustainability in mind. For example, the water footprint within a river catchment needs to meet certain criteria in order to be sustainable. As we saw in Session 1, sustainability has environmental, social and economic dimensions (see **Figure 1.1 as seen in chapter 1.4**). The "Water Footprint Assessment Manual" (Hoekstra et al., 2011) specifies how water should be managed within each of these dimensions:

• Environmental sustainability: Water quality should remain within certain limits; "ambient water quality standards" that people have agreed upon, and river and groundwater flows should remain within certain limits compared to natural run-off, in order to maintain river and groundwater-dependent ecosystems and the livelihoods of the people that depend on those ecosystems.

• Social sustainability: A minimum amount of the freshwater available on the globe needs to be allocated to "basic human needs", such as domestic water supply for drinking and washing, and a minimum allocation of water to food production to secure a sufficient level of food supply to all.

• Economic sustainability: Water needs to be allocated and used in an economically efficient way. The benefits of a Water Footprint that results from using water for a certain purpose should outweigh the full cost associated with this water footprint. If this is not the case, the water footprint is unsustainable.

The "Water Footprint Assessment Manual" (Hoekstra et al., 2011) states that when the green, blue or grey water footprint in a catchment does not fulfil one of the criteria of environmental, social or economic sustainability, the water footprint cannot be considered as "geographically sustainable".

The developers of the Water Footprint did not intend for it to be used as an index, so the water footprint is measured in volumetric terms. Therefore, although the Water Footprint indicator is useful from the water-resource

management perspective, it does not reflect the potential environmental and social impacts of water withdrawals, which is often cited as a limitation of the approach (Jeswani and Azapagic, 2011). To this end, there is no agreed life cycle assessment method for estimating the impacts of freshwater use (although different methods exist), much like there is no scientific formally agreed definition for calculating water stress. Different life-cycle methods of assessing water use and its impacts are available but there is large variation in the results between them, which demonstrates the need for a standardised methodology for assessing the impacts of water use on a life cycle basis (Jeswani and Azapagic, 2011).

Activity

Now go back to the blog or offline document that you started earlier. Start a new title after the entry you wrote earlier ("An international dispute related to water stress – the need for sustainable water management"). Call the new title "My Water Footprint". We are now going to calculate your own Water Footprint. To do this, go to the website: http://www.waterfootprint.org/?page=cal/WaterFootprintCalculator . Answer each of the questions on the Water Footprint Calculator as best as you can. When you have answered each question, click on the "Submit" button at the bottom of the webpage. Your Water Footprint will now have been calculated in units of m3/year. Now go back to your blog/document, and type in what your Water Footprint is (the units are "cubic meters of water per year"). Also type in what the components of your Water Footprint are, for food, domestic and industrial usage (this information is in the "Components of your total water footprint" graph). In your blog/document, write a paragraph (fewer than 400 words and in under 20 minutes) on your thoughts about your Water Footprint; e.g. you might want to comment on:

• Is your Water Footprint lower or higher than you expected?

• Are there any steps you can take to lower your Water Footprint?

• How does your Water Footprint compare to that of the average person living in other countries and/or the global average; e.g. the Water Footprint of the average person living in China is 1,071 cubic meters a year, in the USA it is 2,842, and in India it is 1,089 (Hoekstra and Mekonnen, 2012). Accounting for all the people on the globe, the average is 1,385 cubic meters a year (Hoekstra and Mekonnen, 2012).

• Is a large contribution of your Water Footprint from meat consumption (see the graph "Contribution of individual food category towards the total water footprint")? Remember that in the lecture you viewed a little while ago, Professor Arjen Hoekstra made the point that consumption of meat is a major driver of Water Footprints.

Global greenhouse gas emissions reductions

Climate change mitigation policy could have benefits for global water stress. Recent research has calculated the impact of unmitigated climate change (a 4°C world in 2100) on global water stress, and then compared this with water stress in a world where global-mean warming was limited to 2°C in 2100 (an aggressive climate change mitigation scenario) (Gosling et al., 2011). Under this mitigation scenario, global greenhouse gas emissions are reduced by 5% per year, from the year 2016 onwards, to a low emissions floor of 6GtCO2.

The research showed that with global climate change mitigation policy, around 20% of the impacts of climate change on increased water stress under unmitigated climate change could be avoided by 2050. By 2080, 35% of impacts could be avoided and by 2100 almost 40% could be avoided. These values are equivalent to around 171, 410, and 380 million people avoiding an increase in water stress in 2050, 2080 and 2100 respectively. However, it should be noted that these results assume an aggressive climate change mitigation policy that would require international cooperation on reducing global emissions.

Managing water resources sustainably to alleviate water stress – national scale case studies

Different countries will have various ways of managing water sustainably. In this section, we will look at several national-scale case studies.

The Aral Sea

Firstly, it is worth considering the solutions to sustainable water management that have been implemented to restore parts of the Aral Sea (remember that the Aral Sea is one of the case studies we examined earlier in this Session). Response to the Aral Sea disaster has included:

• Attempts to restore part of the North Aral Sea. Irrigation works on the Syr Darya have been repaired and improved to increase its water flow.

• A concrete dam (Dike Kokaral) was built in 2005 to separate the North and South Seas. As a result:

Salinity has decreased.

Sea level has risen to 125 feet from a low of less than 98 feet.

The sea had receded 100 km south of the port-city of Aralsk but it is now only 25 km away.

The Ogallala Aquifer

We also explored how water has been used unsustainably in central USA, around the Ogallala Aquifer. The Texas Coalition for Sustainable Integrated Systems Research (TeCSIS) and the Texas Alliance for Water Conservation (TAWC) designed a project (named "TeCSIS/TAWC") that involves scientific researchers, educational institutions, government agencies, and local area farmers (producers) that are trying to find answers to extend the life of the Ogallala Aquifer and promote more sustainable, economic viability for the region. Please watch and make notes on the following short documentary (27 minutes long), which provides a summary of this long-running research and demonstration project:

http://www.youtube.com/watch?v=vdN8ZiPVKeQ

Kenya and Uganda

In Kenya, the International Atomic Energy Agency is helping farmers make the most of limited water resources. Sustainable water use, through an innovative irrigation technique called drip irrigation, which supplies tiny drops of water directly to the roots of plants, and nuclear techniques, enable communities to grow stronger crops while protecting the environment. Please watch and make notes on the following short video (4 minutes), which has been produced by the UN:

http://www.unmultimedia.org/tv/webcast/2011/11/kenya-water-scarcity.html.

Lake Victoria, which has shores in countries including Uganda and Kenya, is another example of water stress – there has been a lack of sanitation by the lake, associated with rapid population growth along its shores. As a result, child deaths from cholera, typhoid and diarrhoea are common. The following video (7 minutes duration), produced by the UN, presents an overview of how water quality in the area is being improved, thanks in part to a United Nations Development Program project that has introduced ecological toilets that can turn human waste into compost. This has been an important step towards managing the water resource of Lake Victoria in a sustainable way. Please view and make notes on the following video:

http://www.unmultimedia.org/tv/21stcentury/2011/09/africas-lake-victoria-turning-the-tide.html

Sri Lanka

In Sri Lanka, chemicals are contaminating ground water and threatening people's health. Excessive use of chemical fertilisers and pesticides, which runoff into rivers and seep into groundwater, are associated with respiratory problems, skin problems and birth defects in people in some regions of Sri Lanka. A low-cost solution has been applied to respond to this environmental disaster; letting trees grow in the concerned areas so that the water can pass through a dense net of roots that filters it. Filtering the water, in combination with an organic agriculture will help restore the natural balance of the ecosystem in the long run and promote sustainable water quality management. The UN have produced a short 5 minute video on this; pleased watch and make notes on the video, which can be viewed here:

http://youtu.be/jHda2_JaK7o

Your own case study

Now go back to the blog or offline document that you have been preparing. You will now add some text to the section you started and called "An international dispute related to water stress – the need for sustainable water management" (this should be before the entry called "My Water Footprint" that you wrote earlier). Conduct an online search to find out whether any solutions for managing water in a sustainable way have been suggested for the dispute you blogged about. If they have, summarise these in no more than 300 words in this section of your blog/document. If you cannot find any, try suggesting a few potential solutions yourself, bearing in mind whether they are feasible and practical, and make it clear that these are your suggestions, as opposed to techniques that have actually been implemented. Do not spend more than 20 minutes on this activity.

Managing water resources sustainably to alleviate water stress – case studies from companies

Lloyds (2010) note that some retailers are investigating the sustainability and ethics of how their suppliers use water. This is not just for reasons of improving overall sustainability of water supply and quality, but also in part to combat possible reputational damage. Lloyds (2010) argue that countries and companies will be judged by the way in which they jointly manage and share water resources in the future. They highlight three distinct pathways: 1) competition over water will increase through conflict and protectionism, 2) commercialisation of water or agricultural products containing water will lead to increasingly variable and risky markets driven by climate change, and 3) cooperation between companies and governments will lead to sustainable management of water resources.

With respect to how companies may work towards sustainable management of water resources, Lloyds (2010) show that the response of companies can be divided according to responses that a company has direct control over, and responses that address water stress or river basin concerns. For instance, the most straight forward response is to reduce the volume of water required and waste discharged, through operational efficiency and recycling, which is relevant where these operations are in a river basin with existing or threatened stress, or water quality concerns (Lloyds, 2010). Specific case studies of companies that have adopted this response are cited in the "Global Water Scarcity" report available at:

http://www.lloyds.com/~/media/Lloyds/Reports/360%20Climate%20reports/7209_360_Water_Scarcity_AW.pdf

and include SABMiller Levi Strauss & Co and Marks & Spencer. Other responses may address water stress or river basin concerns by companies engaging with other stakeholders to improve the management of water resources. This tends to occur at the local and/or river basin scale and is most effective where a company recognises the diversity of stakeholder perspectives. Specific case studies of companies that have adopted this response are cited in the "Global Water Scarcity" report, and include Anglo Platinum, Coca-Cola, Flamingo Flower Holdings and Anglo American.

Summing up

Unsustainable water use has the potential to cause international disputes.

There are a range of options for encouraging sustainable water use and we have explored a number of case studies across the globe that show how efforts are being made to manage water quality and quantity sustainably.

We have also looked at how businesses are taking responsibility for managing water sustainably.

The Water Footprint is a specific technique for encouraging sustainable water use and it can be calculated for individuals, companies, cities, countries and entire continents. Think back to earlier in this session when you calculated your own Water Footprint and how this compared to that of people living in other countries, and the steps you could take to reduce your footprint if it appeared higher than you expected.

Extra reading

If you are interested in learning more about the Water Footprint, then please read the "Water Footprint Assessment Manual" by Hoekstra et al. (2011), which is available online here:

http://www.waterfootprint.org/downloads/TheWaterFootprintAssessmentManual.pdf .

You may also like to explore the website of the Water Footprint Network here:

http://www.waterfootprint.org

A useful summary of what we have covered in Session 2 and Session 3 is provided in the POST briefing note, "Water in Production and Products" (POST, 2011), which is available online here:

www.parliament.uk/briefing-papers/POST-PN-385.pdf

An excellent summary of projects across the globe that are aimed at enhancing water sustainability is presented on the second side of a poster that has been prepared by the World Water Assessment Programme (WWAP) of the United Nations Educational, Scientific and Cultural Organization (UNESCO). This is the second side of the poster that you viewed in the previous Session. Please view this poster at:

http://unesdoc.unesco.org/images/0014/001446/144620E.pdf .

The assessment for this module will involve you producing a poster similar to this UNESCO poster, and presenting it to other students studying on this module.

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Chapter 4: Sustainable food and agriculture part 1 – reasons for concern and national and local scale solutions

Like water stress, agricultural production and food security are central to human survival and they operate at various scales; from the global level to the individual level. Moreover, there are a number of direct links between ensuring sustainability of water resources (Session 2 and Session 3) and sustainability of agricultural and food production. To allow us to explore the importance of sustainable food and agriculture in sufficient detail, we will study this topic over two sessions; Part I in this session and Part II in the next session.

In Part I, we will explore what sustainable food and agriculture means and why there is a need to drive towards sustainability of these resources, given the pressures of a growing population and climate change. We will then look at a number of national- and local-scale projects that have aimed to encourage sustainable food and agriculture in developing and developed countries. In Part II, we will explore a global-scale case study of a project aimed at sustainable food and agriculture; the Fairtrade Foundation, which introduced Fairtrade labelling in the 1980s.

Defining sustainable agriculture

You may have already noticed that a recurring theme in this module regards the definition of terms associated with sustainability. Maintaining this trend is the issue that numerous definitions of sustainable agriculture exist.

For example, the American Society of Agronomy (1989) provide the following definition:

"A sustainable agriculture is one that, over the long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fibre needs; is economically viable; and enhances the quality of life for farmers and society as a whole."

The US 1990 Farm Bill (United States Congress, 1990) states that under law, sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that over the long term will:

• Satisfy human food and fibre needs.

• Enhance environmental quality and the natural resource base upon which the agricultural economy depends.

• Make the most efficient use of non-renewable resources and on farm resources and integrate, where appropriate, natural biological cycles and controls.

• Sustain the economic viability of farm operations.

• Enhance the quality of life for farmers and society as a whole

The issue of defining agricultural sustainability is further highlighted by the Environmental Challenges in Farm Management (ECIFM) group of the University of Reading, here: http://www.ecifm.rdg.ac.uk/sustainable_agriculture.htm . ECIFM (2012) note that there is no universally accepted definition of sustainable agriculture, but they point to the definition used by the UK Department for Environment, Food and Rural Affairs (DEFRA), which lies behind thinking in current agricultural:

• Ensuring the continuing availability to the consumer of adequate supplies of, wholesome, varied and reasonably priced food, produced within accordance with generally accepted environmental and social standards.

• Maintaining a flexible and competitive industry which contributes to an economically viable rural society.

• Ensuring effective protection of the environment and prudent use of natural resources

• Conserving and enhancing the landscape, wildlife, cultural and archaeological value of agricultural land.

• Respecting a high level of animal welfare.

ECIFM (2012) also refer to the definition adopted by the United States Sustainable Agriculture Network (SAN), which defines sustainable agriculture as: Sustainable agriculture refers to an agricultural production and distribution system that:

• Achieves the integration of natural biological cycles and controls.

• Protects and renews soil fertility and the natural resource base.

• Optimises the management and use of on-farm resources.

• Reduces the use of non-renewable resources and purchased production inputs.

• Provides an adequate and dependable farm income.

• Promotes opportunity in family farming and farm communities.

• Minimizes adverse impacts on health, safety, wildlife, water quality and the environment.

Defining sustainable food

The Kindling Trust have produced a short film, "What is Sustainable Food?", which explains the various elements society needs to consider in building a sustainable food system. Over 10 minutes, the film runs through eight principles, which are also discussed in the report "Sustainable Fayre" (Walsh and Woodcock, 2011), published by Kindling:

1.Local and seasonal.

Food now travels further than ever before with money leaking from local economies. Local and seasonal food offers a way to minimise energy use in transportation and storage, increase freshness and quality, strengthen local distinctiveness and build more resilient communities, whilst supporting local food outlets and farmers.

2. Organic and sustainable farming.

Organic and low-carbon farming avoids artificial fertilisers and genetically modified organisms, while maximising crop diversity. This encourages biodiversity, and offers a long-term investment in soil fertility for future food production, as well as countering climate change through soil carbon sequestration.

3. Reduction of waste and packaging.

Approximately 70% of primary packaging is used for food and drink which becomes contaminated by residues of the original contents, making it difficult to recycle. Purchasing local and seasonal food reduces the need for unnecessary packaging, minimising the negative impact on the environment from the current large scale disposal of inorganic waste.

4.Reducing foods of animal origin and maximise welfare standards.

Meat and dairy products are among the most energy and greenhouse-gas intensive food products of all.

5. Excludes fish species identified as at risk.

Overfishing is the greatest single threat to marine wildlife and habitats, with nearly 80% of world fish stocks fully or overexploited

6. Fairtrade-certified products.

Fairtrade ensures producers are paid fairly for their work, offering a strategy for poverty alleviation and sustainable development. It creates social and economic opportunities for producers and workers who have been exploited, disadvantaged or marginalised by the conventional trading system.

7. Promote health and well being.

A sustainable food system is about health and well being for all – individually, locally and globally. This includes tacking both childhood obesity and malnutrition.

8. Food democracy.

According to Walsh and Woodcock (2011): “The mainstream food system and supply chain is unfair and unsustainable. Decisions and profits are taken by a handful of large companies driving down prices and maximising profits at the expense of farmers, local communities and the environment. Our current unsustainable food system has turned us into a nation of passive consumers in a top down system from which we expect unlimited 'choice' but over which we have little control. Food democracy is about reconnecting people to food and taking responsibility for it, ensuring control by and fairness among local producers, suppliers and consumers, and working to reduce inequality in the food supply chain.”

The documentary also showcases some of Manchester's leading sustainable food projects including: Abundance Manchester, Glebelands City growers, Unicorn Grocery, Fairfield Materials Management and Wild at Heart. Generally, the video provides an excellent overview of the importance of food sustainability from the UK perspective.

View the video here: http://kindling.org.uk/what-sustainable-food

The pressure of a growing population and climate change

Despite record cereal harvests in 2008 and 2009, over 1 billion people – mostly in developing countries – did not have enough food to meet their daily needs in 2009 (DFID and DEFRA, 2010). This was partly due to increased food prices and declining household incomes. It is evident that increased natural resource degradation and climate change which will pose severe sustainability and productivity challenges for the future.

For example, DFID and DEFRA (2010) note that the global population is set to rise to between 9-10 billion by 2050 (it is 6.5 billion now) and economic growth will continue (real incomes are forecast to be 3-4 times higher), which will lead to increased demand for food, especially meat. The United Nations Food and Agriculture Organisation (FAO) estimates that food production will need to increase by 70% (relative to 2005-07 levels) to keep up with demand (DFID and DEFRA, 2010). To this end, activities to increase availability of, and access to, existing food supplies, reducing post-harvest losses and pursuing trade reform, will be paramount in ensuring the sustainability of future food supplies.

The International Food Policy Research Institute (IFPRI) have published a major report that assesses changes in food security by the year 2050, in response to population change, economic development, and climate change (Nelson et al., 2010). The report shows that climate change exacerbates the challenges in reducing the number of malnourished children across the globe, although the effects of climate change are mitigated by economic development. Also, for all regions of the globe, the negative effects of climate change on crop productivity reduce food availability and human well-being in 2050 (Nelson et al., 2010). The report finds that climate change results in even higher world food prices in 2050 and it causes an increase of between 8.5-10.3% in the number of malnourished children in all developing countries, relative to if no climate change occurred at all. Importantly, however, the IFPRI report shows that international trade plays an essential role in compensating for various climate change effects and that properly targeted agricultural productivity investments can mitigate the impacts of climate change and enhance sustainable food security. The report includes a very useful summary on pages xv-xxi, which you may like to read if you are interested in reading more; the report can be downloaded from here:

Lecture: Sustainability, Food Security and World Food Problems

Please now view a comprehensive (70 minutes) lecture on "Sustainability, Food Security and World Food Problems", provided jointly by Bryan McDonald and Kelsey Meagher from University of California Irvine, USA. The lecture provides an introduction to the major issues impacting global food security and links food security to sustainability and global environmental change. The lecture highlights the needs for sustainable management of agriculture and food availability and then moves on to discuss some of the near-term and long-term strategies for improving sustainability of food. Note how the lecture makes the point several times, that water security is an important driver of sustainability of food produce, and how this links with Session 2 and Session 3 that you studied earlier in this module.

The lecture also discusses some interesting results from a recent survey of the University of California Irvine's community about food and sustainability and provides an overview of efforts underway to promote sustainable food at University of California Irvine.

The lecture can be viewed here: http://ocw.uci.edu/lectures/lecture.aspx?id=183

How you can enhance sustainable food and agriculture

Activity

Now having viewed the lecture, think back to the two slides towards the end that were titled "What Can You Do" (the slides are discussed from time 54:00 to 62:24 in the video). Open up the blog (or other document) that you started in Session 1 and have been updating since, and create a new title and date entry called "Food security – local-scale options for encouraging sustainability". In this section of your blog, provide a summary of no more than 400 words that describes what steps you can take to encourage sustainability of food produce. For example, you might like to consider:

• How you can recognise that your choices matter

• How you can reduce food waste

• How you might strategically decouple from the global food network (eat locally and seasonally)

• How you can learn more about your food and where it comes from.

Spend no longer than 20 minutes on this activity.

Note how the options that you have just described here represent local efforts to improving sustainability of global food supplies. Indeed, to address all concerns of sustainability requires efforts from the local to global scale. This is reiterated in the following short interview (3-4 minutes) with Mike Hamm, Professor of Sustainable Agriculture at Michigan State University:

http://youtu.be/uHvafmsvZFM

In the next section we will explore some larger-scale case studies of projects that are aimed towards sustainability of food supplies.

Local and national-scale projects aimed at sustainable food and agriculture

In this section, we will explore a number of case studies from developing and developed countries that demonstrate projects aimed at sustainable food and agriculture, and also which seek to increase awareness of agricultural and food sustainability issues.

Encouraging sustainable food in Greater Manchester, UK

The Kindling Trust (http://kindling.org.uk/) is a fledgling not-for-profit social enterprise with charitable aims. Kindling is working to establish a radical and pioneering social change centre and enterprise zone in the rural Northwest of England, to practice and demonstrate sustainable production, living and activism, and to support others working towards an ecological and just society. Kindling is also working on a number of exciting projects in Greater Manchester, UK.

One of these projects is the “Greater Manchester Land Army”

(http://kindling.org.uk/projects/greater-manchester-land-army). Kindling in partnership with Moss Brook Growers, Glebelands City Growers, Dig Food, Unicorn Grocery, Abundance Manchester, MERCi, Hulme Community Garden Centre and Debdale Eco-Centre have secured some initial funding to establish a “Land Army” of volunteers, placements and trainees to help increase the production of sustainable food for Greater Manchester. The project aims to establish a financially resilient 'land army', which:

• Has the capacity to involve a larger 'unskilled' pool of individuals, resulting in potential increases in yields and income for growers.

• Nurtures a small number of committed and trained individuals that growers are able to call upon in times of need.

• Offers progression for potential new growers to meet increased demand.

The idea was inspired by the women's land armies of the First and Second World Wars, and offers a solution to a number of challenges faced by local organic growers including:

• Labour issues and costs for local growers at busy periods e.g. harvest time.

• Lack of skilled labour for illness and holiday cover.

• More growers are needed to meet future demand.

• Lack of a way into growing commercially for individuals.

• Lack of opportunity for practical involvement in sustainable food systems.

Another project developed by the Kindling Trust is “Sustainable Fayre”. This project explores opportunities to increase 'low-carbon' food in Manchester via school meals, complimenting the city's Climate Change Action Plan, Manchester; A Certain Future. It also encourages the purchase of local organic (hence sustainable) food. In March 2010 Kindling secured Carbon Innovation Funding to look at the viability and possible methods for supplying fairly-priced local and organic produce to Manchester’s public sector. The initial project consisted of two elements: a pilot seasonal soup project in Brookburn Primary school in partnership with local authority caterers Manchester Fayre and funded by Food Futures, and a piece of research resulting in a report entitled 'Sustainable Fayre' (Walsh and Woodcock, 2011). The Sustainable Fayre report explores ways Manchester Fayre could purchase local organic (hence sustainable) food, offering economic, social and environmental benefits to the region. The study looked at inspiring examples across the UK and in Europe and the solutions that they have found to commonly cited obstacles to sourcing sustainable food. It investigates the feasibility of supplying significant quantities of sustainable food to Manchester Fayre and the wider public sector with the aims of:

• Offering a replicable and financially sustainable solution.

• Reducing the CO2 emissions of our city’s food.

• Nurturing behavioural change in favour of low-carbon food choices.

• Identifying solutions which offer greater economic security for both farmers and Manchester Fayre.

The report (Walsh and Woodcock, 2011) can be downloaded from the following link, if you wish to read it:

http://www.kindling.org.uk/sites/kindling.org.uk/files/Sustainable_Fayre_Study_0.pdf.

The project put a low carbon soup on the menu five times a day throughout the year. To ensure that the soup is as low in carbon as possible - as well as nutritious and tasty:

• The soups are made with top quality fresh seasonal veg (all meat free and mainly dairy free too - also making them inclusive to most dietary needs)

• All ingredients are organic; the veg is sourced from farms as close as possible to the school (where possible within 30 miles)

• The dry ingredients (pulses, pasta and dry herbs) come from within Europe and are transported overland (not air freighted).

The soup recipes were developed in partnership with Manchester Fayre nutritionists and the school chef, with taster sessions and feedback from the children before the menu was set. The project was a success, with soup uptake doubling in term two and practically no waste from left overs. Following publication of the Manchester Fayre report, funds have been secured for two of the priority recommendations of the report: a full carbon

audit of Manchester Fayre's food purchases, and the development of a seasonal menu that is low carbon, fair, high animal welfare, value for money and crucially child friendly

Niger: water stress and sustainability of food production

A component unit of the United Nations Food and Agricultural Organisation (FAO) is the Water Development and Management Unit (NRLW). In the face of increasing water scarcity, and the dominance of agricultural water use, the NRLW is in the forefront to enhance global agricultural performance while promoting the sustainability of water use for food production. The following short video (8 minutes) shows how water stress in Niger is affecting the annual harvest, and how the FAO NRLW is helping to channel water in from nearby villages to help irrigate the crops. The overall aim of the project is to improve agricultural productivity to meet the increasing demands of an increasing population while at the same time without using more water. Once again, in this case study we will see how important sustainability of water resources is, for maintaining sustainability of food produce (this point was made several times in the lecture by Bryan McDonald and Kelsey Meagher that you listened to earlier this session) and is also directly linked with Session 2 and Session 3 on this module. Indeed, one of the farmers (who is a widowed mother of 9 and grandmother of 20) in the video you are about to watch makes the point that "Water is the foundation for agriculture and for family life. Without water, there is nothing". Please view the video here:

http://youtu.be/JLHnefVZa94

Vietnam: new directions for ensuring food sustainability

The following short documentary (4 minutes), compiled by the UN, shows that despite Vietnam's agricultural success since the 1980s, the country will have to take new directions in the coming years in order to maintain sustainability of food supplies. These include, for instance diversification of the types of crops grown. The video can be viewed here: http://www.fao.org/nr/water/art/2007/flash/video/fromdvd/7/gallery1.html .

The Andhra Pradesh (southern India) Water Monitoring Project

Droughts are becoming more common in southern India and the climate is increasingly unpredictable. Indiscriminate pumping from shallow aquifers shared by many farmers has caused abnormal drops in water levels. When a well goes dry, a farmer loses his crop. Six thousand farmers have been trained in groundwater management by a project run by Indian NGOs and guided by the UN's Food and Agriculture Organization (FAO). The farmers have learned to monitor how much water is available underground at the start of the growing season. Then they only plant crops that need that much water, which encourages sustainability of water and food supply. The video shows the results of empowering farmers to manage their own resources scientifically and in cooperation with other farmers. Please view the short documentary (4 minutes) here:

http://youtu.be/a6LT3Gt8N38

Summing up

Despite record cereal harvests in 2008 and 2009, over 1 billion people – mostly in developing countries – did not have enough food to meet their daily needs in 2009 (DFID and DEFRA, 2010). Climate change and population increases in the future will exacerbate this, although international trade and targeted agricultural productivity investments will play essential roles in compensating for the various negative effects of climate change (Nelson et al., 2010). With this in mind, we explored various options for enhancing sustainable food and agriculture at local and national scales, with examples of projects from Manchester, The Andhra Pradesh, Niger and Vietnam. We also looked at the options you have, personally, for enhancing sustainable food, and recorded these in your blog. In the next session, we will learn about Fairtrade, which is a strategy for poverty alleviation and sustainable development, and an example of a global-scale project aimed at enhancing sustainable food and agriculture.

Extra reading

The Soil Association is the UK's leading environmental charity campaigning for a global shift to sustainable, organic food and farming practices. They have produced a report, "An inconvenient truth about food – Neither secure nor resilient" (Maynard, 2008), which discuses the importance of food security and food sustainability, within a UK and global context. The report can be downloaded here:

http://www.soilassociation.org/LinkClick.aspx?fileticket=EttWlupviYA%3D&tabid=387.

The DFID/DEFRA Policy Narrative on Global Food Security and Sustainable Agriculture (DFID and DEFRA, 2010) is a report that assesses the current stresses on global food security and explains the UK initiatives which seek to address them. The document provides quick and easy access to the UK's approach to sustainable food. The report can be downloaded from here http://archive.defra.gov.uk/foodfarm/food/pdf/defra-dfid1003.pdf .

The International Food Policy Research Institute (IFPRI) have published a major report that assesses changes in food security by the year 2050, in response to population change, economic development, and climate change (Nelson et al., 2010). The report includes a very useful summary on pages xv-xxi, which you may like to read if you are interested in reading more; the report can be downloaded from here:
http://www.ifpri.org/climatechange/casemaps.html

(Wait for the page to load (this could take over 1 minute), then click on the "Start" button in the middle of the page (again, you may need to wait for over 1 minute for the page to load.

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Chapter 5: Sustainable food and agriculture: part 2, Fairtrade – a global-scale strategy to encourage sustainability

In this Session, we will explore a single global-scale case study of a strategy aimed at sustainable agriculture and food security; Fairtrade. Fairtrade is an excellent example of a strategy that aims to address all three pillars of sustainability; economic viability, social equity and environmental protection (see **Figure 1.1 in chapter 1.4**).

In this Session, we will learn what Fairtrade is, and how it has developed, and whether it is achieving its goals. This will be achieved by considering your awareness of Fairtrade, drawing upon a case study of the Fairtrade cotton industry, and by listening to two podcasts that include talks and discussions between people directly involved with Fairtrade.

What is Fairtrade?

You may well have noticed the FAIRTRADE Mark (see Figure 5.1) on products that you have purchased, e.g. on the packaging of chocolate bars, bananas or coffee. The FAIRTRADE Mark is a registered certification label which ensures that the farmers and workers in developing countries have been paid a fair price for their produce. The UK adopted this version of the Mark 2002.

Fairtrade labelling started in the Netherlands in the late 1980s. Following this, the Max Havelaar Foundation launched the first Fairtrade Certification Label in 1988 on coffee sourced from Mexico. In the UK, the Fairtrade Foundation was established in 1992, with the first products to carry the Fairtrade Mark launched in 1994. A historical chronology of how Fairtrade labelling has developed since 1988 is available here:

http://www.fairtrade.org.uk/what_is_fairtrade/history.aspx

The Fairtrade Foundation is the independent non-profit organisation that licenses use of the FAIRTRADE Mark on products in the UK in accordance with internationally agreed Fairtrade standards. The Fairtrade Foundation was established in 1992 by several campaigns, charities and groups, including:

- CAFOD
- Christian Aid
- Oxfam
- Traidcraft
- The World Development Movement
- The National Federation of Women's Institutes.

The Fairtrade Foundation is the UK member of the larger Fairtrade Labelling Organisations International (FLO; www.fairtrade.net), which unites 21 labelling initiatives across Europe, Japan, North America, Mexico and Australia/New Zealand as well as networks of producer organisations from Asia, Africa, Latin America and the Caribbean. The FAIRTRADE Mark certifies that international Fairtrade standards have been met. According to FLO, "The FAIRTRADE Mark offers consumers a positive way to buy products in solidarity with those who produced them. Buying Fairtrade products helps producers struggling to improve their lives" (Fairtrade International, 2012). The FAIRTRADE Mark is now available on thousands of products in around 50 countries.

According to the Fairtrade Foundation, "Fairtrade is a strategy for poverty alleviation and sustainable development. Its purpose is to create opportunities for producers and workers who have been economically disadvantaged or marginalised by the conventional trading system. If fair access to markets under better trade conditions would help them to overcome barriers to development, they can join Fairtrade. Fairtrade is a tool for development that ensures disadvantaged farmers and workers in

developing countries get a better deal through the use of the international FAIRTRADE Mark" (The Fairtrade Foundation, 2012b).

FLO argue that Fairtrade offers four important benefits for producers (The Fairtrade Foundation, 2012a):

1. Stable prices

For most products, prices that at least cover the costs of sustainable production, even when world market prices fall.

2. A Fairtrade Premium

A premium price is paid on top of the agreed Fairtrade price, and producers decide democratically how to use it. The Premium helps producers to improve the quality of their lives. The producers tend to invest the premium in education, healthcare, farm improvements or processing facilities to increase income.

3. Partnership

Fairtrade certified producers jointly own and manage Fairtrade International. Through the Fairtrade International's Board, its Committees and consultation processes producers can influence prices, premiums, standards and overall strategy.

4. Empowerment of farmers and workers

Small farmer groups must have a democratic structure and transparent administration in order to be certified. Workers must be allowed to have representatives on a committee that decides on the use of the Fairtrade Premium.

If you are interested in learning more about the aims and goals of the Fairtrade Foundation and the work they do, then spend 10-15 minutes looking around their website: http://www.fairtrade.org.uk

Please now watch the following two short films (less than 3 minutes each), which summarise what we have covered in this section. The first film describes the overall mission and goals of Fairtrade and the second film is one of Fairtrade's latest promotional videos that introduces a program aimed at increasing peoples' awareness of Fairtrade and sustainability, "Take a Step for Fairtrade":

- Film 1: http://youtu.be/h_bxTe5R9Hc
- Film 2: http://youtu.be/J60mvcp_Q_E

A case study from Fairtrade producers – the cotton industry

While Fairtrade operates for numerous agricultural and food products, including bananas, coffee, and chocolate, in this section we will focus on the cotton industry. As mentioned earlier, Fairtrade is an excellent example of a strategy that aims to address all three pillars of sustainability; economic viability, social equity and environmental protection. This is highlighted in the benefits that Fairtrade's involvement with the cotton industry has had in a number of countries across the globe. Here will focus on two examples; the cotton industry in India and in Cameroon.

Generally in India, Fairtrade certified cotton farmers can receive up to 20% more in payment for their produce through Fairtrade, than they would at market, which is an important step towards economic viability. Furthermore, precise Fairtrade standards have ensured that the cotton industry in India has had lower environmental impact, no genetic modification, and use of no harmful pesticides – all indicative of environmental protection. The following short film (less than 4 minutes), produced by the Fairtrade Foundation, demonstrates the overall benefits that Fairtrade has had for sustainability in Gujarat, India, with reference to the cotton industry:
http://youtu.be/8Ev7YTPIKJU

In 2005 and 2006, cotton farmers in Cameroon received over £420,000 in Fairtrade premium to spend on development projects. The Fairtrade Foundation have produced a short film (9 minutes) that shows how Fairtrade and the premium is changing lives for cotton farmers in Cameroon. There have been a number of improvements, particularly in terms of social equity (one of the three pillars of sustainability); including; an increased motivation for farmers to produce cotton – largely as a result of the precise quality controls enforced by Fairtrade, empowering women, construction of new and clean wells closer to the communities that use them – in some cases, people have had to walk between 5-10km to access clean water in the past, and planning construction of new schools. However, the film also highlights that there are concerns over whether:

Nearby non-Fairtrade villages involved with the cotton industry will also be able to become Fairtrade certified – and if they cannot – whether this will result in inter-village tensions.

Whether current Fairtrade certified producers will be able to maintain their certified status in the future.

Whether there will always be future demand for cotton, and so a market for all the increasing number of Fairtrade cotton producers in Cameroon.

Please view the video here: http://youtu.be/zufkw6xiskE

Everyday Fairtrade products and consumer choice

Activity

Open up the blog (or other document) that you started in Session 1 and have been updating since, and create a new title and date entry called "Food security – everyday Fairtrade products". Take a look around where you are right now, think about what products you have at home, or in your office, or that you own, and in your blog record what these are. If you can't remember what Fairtrade products you have at home, wait till you get back and update your blog later. If you don't own any then leave this section of your blog blank.

After this, please consider discussing some of the following questions and write your thoughts in your blog (or offline document) – there is no need to write more than 400 words and it should not take more than 20 minutes.

• Were you aware of Fairtrade before starting this Session of the module?

• Do you regularly buy Fairtrade products?

• If you don't currently buy Fairtrade products, would you consider trying some, such as Fairtrade tea or coffee?

• Would you consider encouraging your workplace to buy Fairtrade products? For example, Loughborough University is "a Fairtrade University".

Switching over to buying Fairtrade products requires a conscious decision; i.e. a behavioural change needs to occur. However, simply put, people in general do not like change. However, in many ways, to implement a more sustainable way of living requires behavioural change. The importance of encouraging behavioural change and the psychology of sustainability is covered in detail in **Session 9.**

Home businesses and institutions can now brand themselves as "Fairtrade", if they are accredited by Fairtrade. For example, Loughborough University in the UK was one of the first universities to become a Fairtrade university in April 2005. Both the students' union and the University catering section continue to work to renew the accreditation every year. To this end, Loughborough University is committed to (Loughborough University, 2012):

• Ensuring Fairtrade is sold by catering services and the Loughborough Students Union as an option in all campus shops, restaurants, bars and cafes as well as some vending machines wherever possible (e.g. see **Figure 5.3**). The University and catering services will continue to expand its product range when it is able.

• Ensuring Fairtrade refreshments are served at all conferences, meetings and events.

• Promoting the Fairtrade mark in all appropriate publications and company leaflets including all promotional leaflets.

• Fairtrade storyboards / notices and posters will remain placed in all halls of residences and where products are being sold.

• Articles in student and staff newsletters on Fairtrade developments and on the university, catering and students union website.

• Promotion of Fairtrade through continued events, particularly during the annual Fairtrade fortnight and the students union ethical and environmental week.

• Developing and maintaining a steering group to regulate Fairtrade activities both at the university and students union.

Fighting the banana wars

In February 2009, a very interesting talk and discussion on Fairtrade took place at the London School of Economics and Political Science (LSE). The talk has been recorded as a podcast and it provides an excellent overview of how Fairtrade has developed.

The talk is titled "Fighting the Banana Wars". The first speaker is Harriet Lamb, who speaks for around 30 minutes. Harriet Lamb has been executive director of the Fairtrade Foundation since 2001. She has guided the Foundation through a period of staggering growth, which has seen estimated sales of Fairtrade products in the UK increase from £30m to more than £493m in 2007 with more than 4500 products carrying the FAIRTRADE Mark. Harriet was awarded a CBE in the New Year's Honours List 2006. In 2007 she was voted the second most influential eco foodie in the UK after Hugh Fearnley-Whittingstall in the Observer Food Monthly magazine.

After Harriet's talk, there is a short talk, just under 20 minutes, by Adam Brett, who is a Fairtrade entrepreneur, director of Tropical Wholefoods and Fullwell Mill Ltd. Adam's talk gives a flavour of what it is like to work at the heart of Fairtrade.

It is necessary for this module to only listen to the first 49 minutes of the podcast.. However, if you are interested in hearing the question and answer session, which includes a critique of the two talks, by Dr Teddy Brett (associate programme director, Development Management MSc in the Development Studies Institute at LSE), then feel free to listen beyond 49:00 of the podcast.

The podcast can be downloaded from here:

http://richmedia.lse.ac.uk/publicLecturesAndEvents/20090217_1830_fightingTheBananaWars.mp3

Is Fairtrade successful?

The Guardian newspaper has recorded a very interesting discussion between:

• John Vidal, the Guardian's environment editor.

• Harriet Lamb, executive director of the Fairtrade Foundation.

• David Croft, director of food technology at Waitrose.

• Felicity Lawrence, the Guardian's special correspondent on food.

• Steve Muchiri, head of the East African federation of farmers.

The podcast goes beyond the introduction to Fairtrade that was presented in the “Fighting the Banana Wars” podcast earlier. The 27 minute discussion explores issues such as:

• What difference has Fairtrade made?

• Does it go far enough?

• Is the movement still relevant?

• Where does Fairtrade need to go next?

Activity

While listening to the podcast, consider whether you think Fairtrade has been successful? Do you agree with everything the speakers say? After you have listened to the podcast, open up the blog (or other document) again and create a new title entry under today's date called "Is Fairtrade successful?" Record here in the blog, in less than 300 words, whether you agree with the speakers, whether you think Fairtrade is successful, and

what improvements to Fairtrade you think could be made. Spend no longer than 25 minutes on this activity.

The podcast is available here:

http://audio.theguardian.tv/audio/kip/global-development/series/global-development-podcast/1329240584203/2037/gnl.dev.120226.vp.development_fairtrade.mp3

Summing up

The UK market has doubled every two years since the Fairtrade label was introduced and now around 20% of all bananas and coffee sold in the UK bear the label. Fairtrade has grown from a small, grassroots movement to becoming fully mainstream. Fairtrade products are all around us. However, switching to buying and using Fairtrade products still requires a social and behavioural change, which as we shall see later in this module (**Session 9**), is not always straightforward.

Extra Reading

There is no specific extra reading for this Session. However, if you are interested in learning more about Fairtrade in much greater detail, then it is worth reading the book, "Fighting the Banana Wars and Other Fairtrade Battles" by Lamb (2008), who spoke in both the podcasts in this Session.

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Chapter 6: Sustainable forest management

This session is divided into two main sections. First, we will investigate why there is a growing need to manage the Earth's forests sustainably. This is discussed largely within the context of global climate change because forests provide an important ecosystem service: the absorption and storage of CO2 from the atmosphere, which helps to limit global warming. Destruction of the Earth's forests therefore has a very real potential to negatively affect the global climate system, if they are not managed sustainably.

Then in the second section, we will explore a number of multi-scale case studies that show efforts aimed at managing forests sustainably. Similar to the previous session that covered Fairtrade, we will see how evidence of sustainable forest management is apparent in our everyday lives; e.g., through the products we use and purchase regularly. Moreover, we will increase our awareness of how principles of sustainability – specifically sustainable forest management – are something that we can support through our everyday choices as a consumer.

Why is sustainability of the world's forests important?

Forests across the globe are important for three broad reasons:

1. They support numerous indigenous communities who rely upon the ecosystem services that forests supply; e.g. medicine, food and timber. For many communities, forests also hold significant cultural and spiritual values.

2. Forests are some of the richest areas for biodiversity on the globe. They provide a variety of habitats for plants, animals and micro-organisms. For example, the Amazon forest is home to around 25% of the world's terrestrial species (Dirzo and Raven, 2003).

3. Forests provide an important regulating ecosystem service; i.e. they absorb and store carbon from the atmosphere (this process is known as sequestration), which helps to mitigate (i.e. reduce the effects of) global warming. Deforestation causes some of this carbon to be released back to the atmosphere, which can exacerbate global warming.

The United Nations Food and Agricultural Organisation (FAO) and the Forestry Commission of the UK have produced a 17 minute film that shows how much forests can contribute to the mitigation of climate change. This stresses the importance of reversing forest loss that can occur as a result of 1) climate change, and 2) clearing of forests for conversion to pasture land and logging for timber. The presentation explains how society can combat climate change by conserving and managing existing forests, by tackling causes of deforestation and by planting new forests. It stresses the use of wood as a renewable energy source and as a raw material, pointing out that wood products store carbon for their entire lifetime, until they decay or are burned. A section on adaptation notes how the world's changing climate will affect the health and composition of forests and stresses the importance of adapting and planning ahead for the changes. Please view the video here:

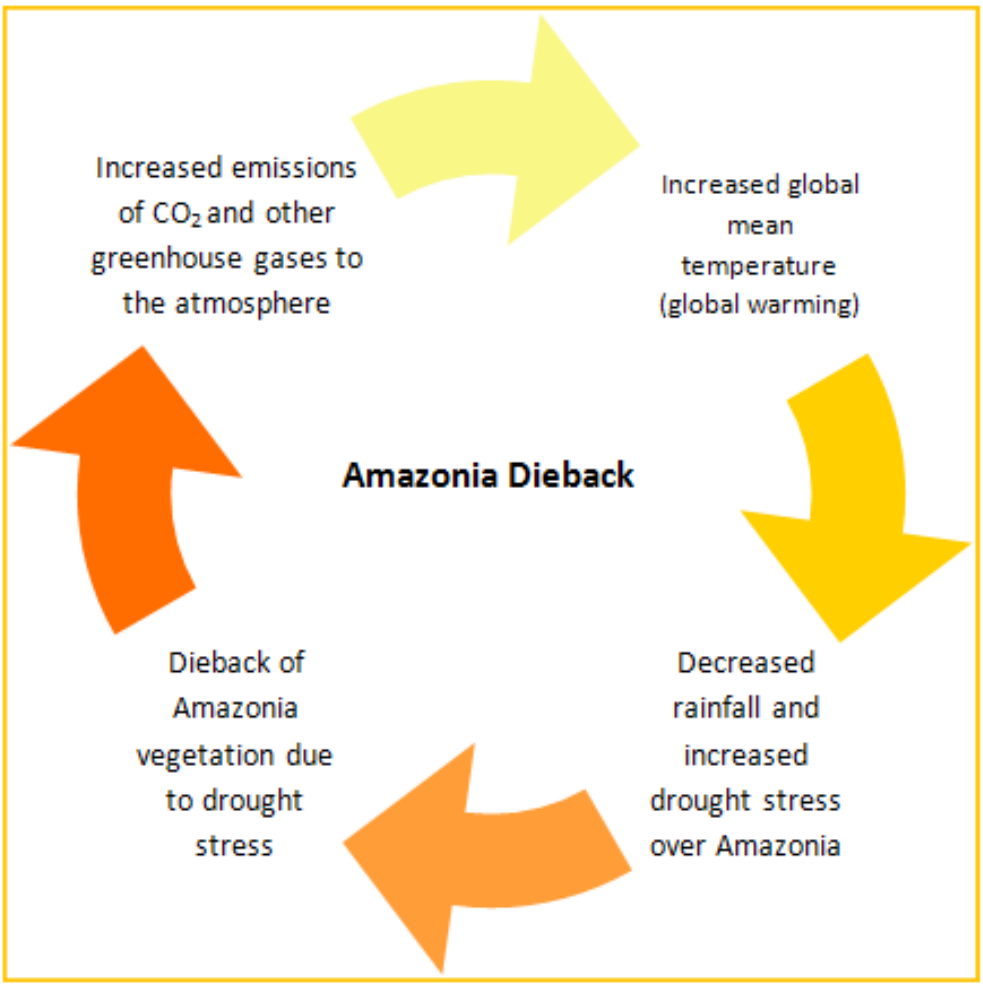
http://www.forestry.gov.uk/multimedia/aConvenientTruth_256K_640_001.wmv/$FILE/aConvenientTruth_256K_640_001.wmv/

The concept of "Amazonia dieback"

As we have seen, climate change could act as a major debilitating stressor – in combination with human deforestation – on maintaining the sustainability of forests across the globe. The Amazon and the concept of "Amazonia dieback" highlights this, specifically. This section explores this important issue – which is of high international concern – in more detail.

Global climate modelling experiments indicate that if climate change occurs under a "business as usual scenario" – i.e. without any attempts to reduce future emissions of greenhouse gases like CO2, there could be major loss of the Amazon rainforest from the year 2050 onwards. This would be as a result from decreased rainfall over the region and subsequent droughts, which impose a stress on the vegetation that currently covers much of the region. In turn, this could induce a positive feedback on global climate, whereby additional CO2 is released back into the atmosphere as a result of the death of vegetation and reduced photosynthesis and carbon storage. This release of CO2 would then further exacerbate global warming, leading to further Amazonia forest loss, and then further release of CO2; i.e. positive feedback. A simplified diagram of this positive feedback mechanism is displayed in **Figure 6.1**

Figure 6.1. Simplified diagram of positive feedback with respect to Amazonia dieback.

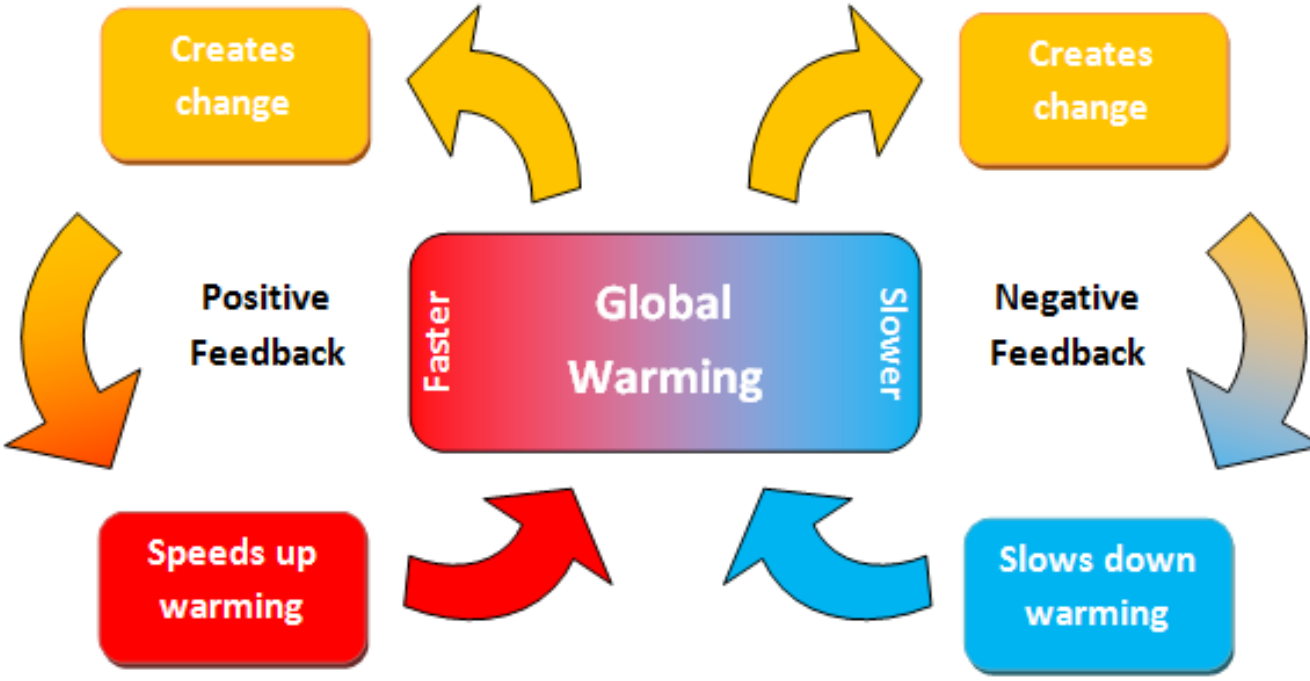


Above image sourced from the Met Office. Contains public sector information licensed under the Open Government Licence v1.0.
http://www.metoffice.gov.uk/climate-change/guide/science/explained/feedbacks/

This feedback mechanism is just one of many feedback mechanisms that occur in the climate system and which can speed up or slow down global warming. For example, there is ice albedo feedback, and water vapour feedback. While the Amazonia dieback feedback mechanism is a positive feedback mechanism, because it speeds up warming of the atmosphere, there are also negative feedbacks, which can slow down warming.

Figure 6.2 shows how positive and negative feedback mechanisms affect global warming. If you are interested in learning more about feedbacks in the earth climate system, please take a look at the Met Office website on climate feedbacks: http://www.metoffice.gov.uk/climate-change/guide/science/explained/feedbacks and/or watch the following 10 minute video that provides further details and examples: http://youtu.be/363HhzYzJlA .

Figure 6.2 Positive and negative feedbacks that affect global warming (adapted from Booth (2012))



Above image sourced from the Met Office. Contains public sector information licensed under the Open Government Licence v1.0.
http://www.metoffice.gov.uk/climate-change/guide/science/explained/feedbacks/

Positive feedback mechanisms such as Amazonia dieback in climate change highlight an important issue with respect to sustainability. As the positive feedback loop develops and becomes stronger and speeds up global warming, it may become more difficult to slow down global warming, thus making sustainability more challenging in the process. With the example of the Amazonia dieback feedback mechanism for instance, counteracting CO2 emissions from dieback by planting more trees would become more difficult as the feedback loop becomes stronger – more trees would need to be planted to counteract higher CO2 emissions from increased dieback. This implies that early intervention and sustainable management strategies are paramount at an early stage of the development of a positive feedback cycle.

Recent observations (Phillips et al., 2009) of Amazonia response to a severe drought that occurred in 2005 have demonstrated that Amazonia displays a high vulnerability to drying and that there is indeed a potential for large carbon losses to exert positive feedback on climate change, such as shown in **Figure 6.1**. It has been estimated that the Amazon forest has been absorbing around 2 billion tons of CO2 each year, on average, since the 1980s but during the 2005 drought, 3 billion tons of CO2 were lost as a result of the death of trees and slowed growth. The total impact was an extra 5 billion tons of CO2in the atmosphere, which equates to more than the annual emissions of Europe and Japan combined (Phillips et al., 2009). Recent work has also highlighted that large amounts of CO2 were released during a more recent drought in 2010 too (Lewis et al., 2011). Importantly, Whilst initial resistance to drought has been observed, this resistance appears to break down following droughts that last 3 years or longer (Da Costa et al., 2010).

Amazonia is home to around 25% of the world's terrestrial species (Dirzo and Raven, 2003) and comprises a total biomass (the mass of living biological organisms in a given area at a given time) that is equivalent to over 10 times the current annual global CO2 emissions to the atmosphere (Saatchi et al., 2007). We have already seen how important the world's forests are for photosynthesis and carbon storage, but Amazonia is especially important – the region performs around 15% of global terrestrial photosynthesis (Field et al., 1998) and it is increasing the amount of carbon stored annually (sequestration) as a result of climate change (Phillips et al., 2009) rather than being carbon neutral (Luyssaert et al., 2008). Therefore dieback of Amazonian forests would compromise an important regulating ecosystem service and could have severe secondary impacts on biodiversity as well as impact regional and global climate as a result of CO2 release (Marengo, 2006).

Please now watch the following short video (less than 3 minutes), which gives a brief overview of the 2005 and 2010 droughts and the research that we have just explored: http://youtu.be/z9foQjNVc6w –

While observations of past droughts in 2005 and 2010 indicate that there is potential for Amazonia dieback to occur and cause a positive feedback loop (see **Figure 6.1** and **Figure 6.2**), the latest climate change modelling studies indicate that there is high uncertainty in knowing how Amazonia might respond under climate change scenarios in the future. Please watch the

following short video animation (2 minutes), which shows how the UK Met Office Hadley Centre climate model simulates Amazonia vegetation cover to change from the year 1860 to 2100. The animation may look simple, but it is based upon a very complex climate model computer program – the program that produced these simulations would have taken several weeks or months to run on a powerful supercomputer. Note how the simulation shows that by the end of the century a large fraction of the forested area is converted to desert as a result of climate change. The video can be viewed here: http://youtu.be/yjUp_cXgjp8 –

The simulation you just viewed, however, is just one possible future and there are many uncertainties; i.e. the simulated fate of the Amazon in the video is not a 100% certainty. For example, other climate modeling experiments for Amazonia indicate that there is a 26% probability of a transition to a rainfall regime more appropriate for savannah grasslands, by the end of the century under climate change (Malhi et al., 2009). Other experiments have suggested that there is a 75% probability that Amazonia forest area could decrease by 3% for the period 2020–2029 and by 18% by the end of the century (Salazar et al., 2007).

Some studies show that projections of Amazonia dieback in the future under climate change are highly dependent on assumptions about something called the "CO2 fertilisation effect". The notion of the CO2 fertilisation effect revolves around the idea that the earth's biosphere may have the capacity to sequester (i.e. absorb and then store) much of the increased carbon dioxide (CO2) in the atmosphere associated with human emissions (e.g. from fossil fuel burning). This effect is known as "CO2 fertilisation" because higher CO2 concentrations in the atmosphere "fertilise" plant growth. Evidence shows that increased CO2 in the atmosphere can encourage more and faster plant growth. Since plants, through photosynthesis, convert CO2 into oxygen, it has been argued that CO2 fertilisation could potentially provide a strong negative feedback on changing CO2 concentrations; i.e. have a beneficial effect of reducing atmospheric CO2 concentrations and slowing down global warming. Please refer back to Figure 6.2 for what negative feedback in the climate system is.

However, an important question – and one that has not yet been answered definitively – is; to what extent and magnitude would CO2 fertilisation in a world with higher atmospheric CO2 concentrations actually provide a negative feedback mechanism for slowing down global warming? For instance, would it help lower global-mean temperature rise by a significant amount, or only slightly? This presents a major uncertainty in projecting whether Amazonia dieback will definitely occur under climate change. Climate and earth scientists often test this by performing experiments that on the one hand assume there will be a strong CO2 fertilisation effect under climate change, and then a second separate experiment that assumes there will be little or no CO2 fertilisation effect in the future. This allows them to compare the two experiments, and so quantify the magnitude to which CO2 fertilisation affects vegetation growth and slows down global warming. Such experiments indicate high uncertainty in projections of future Amazonia dieback, to the point where inclusion/exclusion of the effect yields decreases/increases in

Amazonia forest loss under climate change scenarios (Lapola et al., 2009; Rammig et al., 2010). Importantly, there is evidence to suggest that the benefits of the CO2 fertilisation effect may not persist for more than a few years (Leakey et al., 2009) and that the benefit may be significantly reduced by concurrent fertilisation of vines, which can shorten the lifespan of trees (Phillips et al., 2002).

While there are uncertainties in understanding exactly whether Amazonia will be converted to desert due to climate change by the end of the century, there is evidence to suggest that destruction and deforestation of the Amazon forest by humans will further exacerbate any effect of climate change. For example, modeling experiments have shown that further anthropogenic deforestation of the Amazon basin for conversion to pasture and cropland coupled with climate change, has the potential to increase the basin-average temperature by up to around 3.5°C (Costa and Foley, 2000). Also, possible increases in human migration push factors from urban areas in Brazil (Carr, 2009) pose a contributing risk factor towards further destruction of Amazonia with climate change. Climate change may also increase vulnerability to fire damage in Amazonia, which suggests that regional sustainable forest management may be critical in determining the Amazon forest fate (Malhi et al., 2009; Golding and Betts, 2008). Owing to the long-term decrease in carbon storage that results from vegetation death and removal, fires could act as a positive feedback on climate change (Gough et al., 2008). The implementation of "Protected Areas" are important for managing the Amazon forest sustainably (Soares-Filho et al., 2010) – we will explore this later in this session.

Multi-scale case studies of sustainable forest management

In this section, we will examine three specific case studies of sustainable forest management. First, we will look at a regional-scale initiative; the Amazon Region Protected Areas Project (ARPA). This example has been chosen specifically, since it is directly linked with the issue of Amazonia dieback that was introduced earlier in this session. Then we will explore two global-scale initiatives aimed at sustainable forest management: the Plant for the Planet "Billion Tree Campaign" and the Forest Stewardship Council. These initiatives are unique in that they maintain a global overview perspective of sustainability but promote national- and local-scale projects – examples of "thinking globally, acting locally".

The Amazon Rainforest – the Amazon Region Protected Areas Project (ARPA) – a regional-scale initiative

We have already seen how the Amazon forest is susceptible to drought and that there is the possibility of large parts of the Amazon turning into desert as a result of climate change, by the end of this century. Moreover, human activities such as illegal deforestation and mining clear the forest, exacerbating some of the potential impacts of climate change. To this end, sustainable forest management is paramount in the Amazon.

The Amazon Region Protected Areas Project (ARPA) is a program with strong sustainability-focussed goals. It is a partnership with the Brazilian Government, the Brazilian Biodiversity Fund (FUNBIO), the German Development Bank (KFW), the Global Environmental Facility, the World Bank, Greenspan, WWF, Conservation International, and many others. ARPA was initiated in 2002. The project aims to secure the protection of the Amazon's extraordinary natural wealth and enable future development to meet pressing social needs to proceed on a sound and sustainable footing (WWF, 2003a). ARPA has created a system of well-managed parks and other protected areas encompassing around 193,000 square miles, which is larger than the entire U.S. National Park System. The project received funding for around $370 million.

ARPA sets out to achieve clear and bold objectives (WWF, 2003b):

• Establish 70 million acres of new protected areas for strict conservation use.

• Transform 31 million acres of pre-existing but neglected parks by bringing them up to effective management standards.

• Establish 22 million acres of sustainable use reserves in which local communities will have a stake and will benefit from effective stewardship.

• Set up a long-term Protected Areas Trust Fund to ensure the financial viability and integrity of the park system in perpetuity.

Tumucumaque Mountains National Park (too-moo-koo-MAH-kay) was the first national park formally established by the Government of Brazil under the

ARPA program (WWF, 2003c). Tumucumaque is the world's largest tropical forest national park and the second largest national park in the world overall. The park is located in Brazil's north-eastern border and it covers an area of 9.5 million acres. Tumucumaque Park is located within a region known as the Guianan Moist Forests – one of the world's largest continuous tracts of pristine lowland tropical rain forest. The WWF identified this area as one of the "Earth's most outstanding and diverse habitats" and one of the "Global 200 ecoregions", where the Earth's biological wealth is most distinctive and rich, where its loss will be most severely felt, and where there is a heightened need for conservation (WWF, 2003c).

A useful example of some of the improvements to sustainability in the Tumucumaque Park that has resulted from the project is provided through the work of the Amazon Conservation Team (ACT). ACT is an interdisciplinary team of conservation professionals that was founded in 1996. ACT is a non-profit organization supported by individuals, private foundations, and government grants. They work in partnership with indigenous peoples of the Amazon to protect both their cultures and their ancestral lands. They work specifically with indigenous peoples because (ACT, 2012a):

• A significant portion of the remaining Amazon rainforest is on indigenous lands.

• Indigenous lands are often protected as well – or better – than national parks.

• Sustainable indigenous communities protect vital headwaters and other natural resources.

• Indigenous peoples have extensive local geographical and ecological knowledge.

ACT have worked with the indigenous communities of both the Tumucumaque Indigenous Reserve and the adjoining Rio Parú D'Este Reserve. Here, ACT observed how escalating encroachment in the form of illegal mining and logging threatened the lands of indigenous peoples and endangered their communities. In the past, forested areas have been harmed by unregulated gold mining, logging, and wildlife exportation. The indigenous communities requested that ACT assist them in mapping their lands and developing their administrative and institutional capacities. By 2004, ACT had finished an extensive ethnographic map (a map that incorporate and represents the cultural and ecological knowledge of a traditional population) of the reserve, which was the first of its kind for the region. As a result, the Tumucumaque chiefs gave ACT a mandate to continue to train their community members and build the capacity of their organisations to manage and protect their land. This partnership led to the development of a training course for indigenous park guards and in 2006, ACT created a parallel course for representatives of regional state and NGO institutions. ACT's efforts have increased the ability of both indigenous partners and government agencies in the region to judiciously manage the resources of this corner of the Amazon. Achievements of the ACT's work have included (ACT, 2012b):

• Site of the first certified indigenous park guard training courses in the Amazon.

• Completion of ethnographic maps for the entire Tumucumaque Indigenous Reserve totalling 10 million acres in direct partnership with the area's 4 indigenous groups.

• Confirmed abandonment of the Santa Clara mining site, the only active mine in the Park, due to the pressure applied by over-flights, legal actions guided by ACT, and an ACT-coordinated meeting by indigenous representatives with government officials.

More generally, ACT's existing conservation projects with indigenous communities in the Amazon are ideally suited not only to prevent deforestation on indigenous lands but to enable well-prepared indigenous communities to directly benefit from these new incentive programs, which may in turn allow them to continue to live sustainably in these forests. This highlights that sustainable forests includes both:

1. sustainability of vegetation and animals, and

2. sustainability of indigenous populations, their culture, values and livelihoods

Further details on other projects that show how ACT are promoting sustainability in the Amazon is available on their website: http://www.amazonteam.org/ Please take 5-10 minutes to look around the website and learn about their work.

Now please watch the following video (8 minutes) produced by the World Bank, which is a funder of the ARPA project: http://youtu.be/fJ2Bblc0Fw8. The video includes English subtitles and it provides an overview of the ARPA project.

Importantly, recent climate model experiments have suggested that the creation of Protected Areas in Amazonia will help to prevent Amazonia dieback (Walker et al., 2009). Climate model simulation experiments have been conducted where it is assumed that all forested areas outside of the Protected Areas are deforested in the future. The climate system is then allowed to develop into the future under this scenario. Results show that dry ecosystems in the southern and southeastern parts of the Amazon basin do not desiccate appreciably and that extensive areas experience an increase in precipitation (Walker et al., 2009). Nor do the moist forests dry out to an excessive amount (Walker et al., 2009). This suggests that Amazonia dieback could be prevented by the ARPA project. The authors of this research conclude that evidently, Brazilian environmental policy has created a sustainable core of protected areas in the Amazon that buffers against potential Amazonia dieback and protects the drier ecosystems of the basin, and that all efforts should be made to manage them effectively, accordingly (Walker et al., 2009).

The Plant for the Planet "Billion Tree Campaign" – a global-scale initiative with local-scale influence

The Billion Tree Campaign encourages people, communities, organisations, business and industry, civil society and governments to plant trees and enter their tree planting pledges on the Billion Tree Campaign website: http://www.plant-for-the-planet-billiontreecampaign.org/ . The objective is to plant at least one billion trees worldwide each year.

The campaign was inspired by Professor Wangari Maathai, Nobel Peace Prize laureate for 2004 and founder of Kenya's Green Belt Movement, which has planted more than 30 million trees in 12 African countries since 1977. The Billion Tree Campaign was launched on 8th November 2006 during the 12th meeting of the Conference of the Parties (COP12) to the United Nations Framework Convention on Climate Change (UNFCC) held in Nairobi, Kenya.

Up until December 2011, the United Nations Environment Programme (UNEP) managed the Billion Tree Campaign, which has overseen the planting of more than 12 billion trees worldwide. The campaign has since been formally handed over by UNEP to the Plant for the Planet Foundation; a youth-led environmental organisation based in Germany:

http://www.plant-for-the-planet.org/en/.

When the campaign was conceived in 2006, there were already numerous tree planting schemes across the globe, so UNEP in conjunction with the World Agroforestry Centre, federated these efforts in rural and urban areas by encouraging any person or organisation to enter pledges through the Billion Tree Campaign website . Each pledge could be anything from a single tree to several million trees. The responsibility lied with the person/organisation making the pledge to arrange for the tree planting. All contributing participants received a certificate of involvement and they were encouraged to follow up via the website so UNEP could verify that the trees have survived, in partnership with certification mechanisms, such as the Forest Stewardship Council (FSC; discussed in the next section).

Since the campaign's inception in 2006, thousands of individuals, schools, governments, corporations and other organisations around the world have planted trees in the name of sustainability. The billionth tree, an African Olive, was planted in Ethiopia in November 2007 – just a few months after the campaign was launched. In May 2008, the second billionth tree took root as part of the United Nations World Food Programme's agroforestry initiative. Growing to reach 193 countries, the campaign achieved the 12 billion landmark in October 2011, following a tree planting campaign by a community organisation in Kenya.

UNEP had always considered the Billion Tree Campaign to have a finite lifespan and, after running the campaign for four years, the organization had a choice between bringing the campaign to a close or transferring it to a partner. The decision was taken to transfer management of the campaign to the Plant for the Planet Foundation (http://www.plant-for-the-planet.org/en/). Just as when UNEP managed the campaign, a website

(http://www.plant-for-the-planet-billiontreecampaign.org) records the ongoing tally of pledges, and also publishes photos and accounts from registered campaign members of what they have achieved. An important aspect, with regards to sustainability, is that the campaign strongly encourages the planting of indigenous trees and trees that are appropriate to the local environment.

While the Campaign is global, it is organised in cyberspace. A small number of staff with few resources coordinate the campaign through the internet. The Campaign website is essentially the Campaign Headquarters. Partners enter the site to record their pledges and plantings, to obtain guidance, to share ideas and resources, and to post pictures.

The Billion Tree Campaign is a method of empowering the global public to face the challenge of maintaining sustainable forestry. Many of the Campaign partners are schools and related organisations and the children that attend them. For instance, Scout organisations are heavily involved with the campaign. The World Organization of the Scout Movement now offers a badge for tree stewardship with the Plant for the Planet logo. The Scout Associations of Ethiopia, France, Hungary, Kenya, Mauritania, Morocco, UK and the U.S. have each pledged over one million trees (UNEP, 2008). Senegal have launched the "un élève, un arbre" (one child, one tree) project, to foster a tree aware generation that is familiar with notion of sustainability. Senegal's Minister of Environment announced plans to encourage every student, from pre-school through university, to plant a tree and care for it (UNEP, 2008), with the idea that each student and his or her tree will "grow up" together for the wellbeing of both. Please now watch the following short video (4 minutes), produced by Plant for the Planet, which shows how influential the role of Schools and children have been in this global campaign: http://youtu.be/ZzksgMrS_7o

Corporations also play an important role in the Campaign. The first corporation to join the Campaign as an inaugural corporate partner was Toyota Monaco. The corporation pledged to plant 21 trees for every hybrid car purchased in Monaco. 21 was chosen because we are currently in the 21st century and also because of Agenda 21, which set out the policy framework for sustainable development (see Session 1). Kenya Airways joined the Campaign by planting 130,000 trees in the deforested Ngong Hills near Nairobi. Also, Accor has enrolled its hotels in the Plant for the Planet – this includes hotel chains such as Ibis, Novotel, Etap and Formula 1. Importantly, not only do Accor pledge to plant trees but an additional benefit of their enrolment with Plant for the Planet is that they increase public awareness of sustainability issues.

The Campaign has been extremely successful, with over 12 billion trees pledged in total since the Campaign started (data correct as of November 2011). The top 10 countries, in terms of number of trees pledged are:

Figure 6.3.3 The Forest Stewardship Council (FSC) – a global-scale initiative with national and local-scale influence

1. China: 2.8 billion

2. India: 2.1 billion

3. Ethiopia: 1.6 billion

4. Mexico: 785 million

5. Turkey: 716 million

6. Nigeria: 612 million

7. Kenya: 455 million

8. Peru: 246 million

9. Myanmar: 191 million

10. Cuba: 137 million

What is the FSC?

Conversations at the 1992 Earth Summit in Rio (see Session 1) contributed to the formation of the Forest Stewardship Council (FSC) (FSC, 2012a). The formation of the FSC was largely in response to the failure of an intergovernmental process to agree on a global forest compact at Rio. Furthermore, it was formed in response to the compelling question at Rio, of what is sustainable forestry?

The FSC is an independent, non-governmental, not-for-profit organisation established to promote the responsible management of the world's forests.

Before we learn about the mission, vision and achievements of the FSC, please first watch the following short film (< 2 minutes), which introduces the FSC. You may well recognise the FSC "tick tree" logo that appears in the video, from products you have bought that contain paper or card. The video can be viewed here:

http://youtu.be/iaziDpSXF84

The FSC is a multi-stakeholder organisation and through its membership, develops forest management and chain of custody standards, delivers trademark assurance and provides accreditation services to a global network of committed businesses, organisations and communities (FSC, 2012a).

The FSC and sustainability

The Forest Stewardship Council was created" to change the dialogue about and the practice of sustainable forestry worldwide" and the FSC believe that this impressive goal has in many ways been achieved (FSC-US, 2012). The

FSC sets forth principles, criteria, and standards that are central to addressing sustainability issues; they span economic, social, and environmental concerns. The FSC standards represent the world's strongest system for guiding forest management toward sustainable outcomes.

Sustainability is central to the overall vision of the FSC, which is that:

"The world's forests meet the social, ecological, and economic rights and needs of the present generation without compromising those of future generations" (FSC, 2012a).

Note the striking similarity of this vision, to one of the definitions of sustainability, which we learnt in Session 1 of this module. Specifically, the definition stated by the Brundtland Commission in its report 'Our Common Future' in 1987 (World Commission on Environment and Development (WCED), 1987):

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The overall mission of the FSC is that they:

"Shall promote environmentally appropriate, socially beneficial, and economically viable management of the world's forests" (FSC, 2012a).

Once again, note how central this is to sustainability; in particular, how it includes the three pillars of sustainability – environmental protection, social equity and economic viability (see Figure 1.1. in Session 1 of this module). The FSC expand this mission, focussing on each of these pillars of sustainability as follows:

• "Environmentally appropriate forest management ensures that the production of timber, non-timber products and ecosystem services maintains the forest's biodiversity, productivity, and ecological processes.

• Socially beneficial forest management helps both local people and society at large to enjoy long term benefits and also provides strong incentives to local people to sustain the forest resources and adhere to long-term management plans.

• Economically viable forest management means that forest operations are structured and managed so as to be sufficiently profitable, without generating financial profit at the expense of the forest resource, the ecosystem, or affected communities. The tension between the need to generate adequate financial returns and the principles of responsible forest operations can be reduced through efforts to market the full range of forest products and services for their best value" (FSC, 2012a).

FSC certification

The FSC standards for forest management have now been applied in over 57 countries around the world, where the FSC is represented at the national

level. For example, in 1995, FSC-US, was established as the national "chapter" of FSC in the United States. The purpose of FSC-US is to coordinate the development of forest management standards throughout the different bio-geographic regions of the U.S., to provide public information about certification and FSC, and to work with certification organisations to promote FSC certification in the U.S (FSC-US, 2012). FSC UK sets forest management standards for the UK, promotes the system and provides an information service (FSC UK, 2012a).

The FSC "tick tree" logo is used on product labels to indicate whether products are certified under the FSC system. When you see the FSC logo on a label you can buy timber and other wood products, such as paper, with the confidence that you are not contributing to the destruction of the world's forests.

Forests are inspected and certified against strict standards based on FSC's 10 Principles of Forest Stewardship. These ten principles (FSC UK, 2012b) are listed in **Figure 6.7** Forest inspections are undertaken by independent organisations, such as the Soil Association, that are accredited by the FSC. In order to be given FSC certification a forest must be managed in an environmentally appropriate, socially beneficial and economically viable manner. Forests that meet these strict standards are given FSC certification and the timber allowed to carry the FSC label (see **Figure 6.8**). The FSC logo on a wood or wood based product is as assurance that it is made with, or contains, wood that comes from FSC certified forests or from post-consumer waste. The FSC label is currently found on over 10,000 product lines in the UK alone (e.g. see **Figure 6.9**). It can appear on garden furniture, decking, sheds, conservatories, tools, kitchen, bathroom and general housewares, brushes, wall paper, flooring, doors, shelves, furniture, toilet tissue, paper, pencils etc. It can also be found on less obvious items such as charcoal, and there are now also coffins available.

Figure 6.7 The FSC's 10 Principles of Forest Stewardship (FSC UK, 2012b)

1.Compliance with Laws and FSC Principles

Forest management needs to respect all applicable laws of the country in which they occur.

2.Tenure and Use Rights and Responsibilities

Long-term tenure and use rights to the land and forest resources shall be clearly defined, documented and legally established.

3.Indigenous Peoples' Rights

Recognition and respect for the legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources is required.

4.Community Relations and Worker's Rights

Forest management operations need to maintain or enhance the long-term social and economic well-being of forest workers and local communities.

5.Benefits from the Forest

Forest management operations should encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.

6.Environmental Impact

Forest management should conserve biological diversity and its associated values, so as to maintain the ecological functions and the integrity of the forest.

7.Management Plan

A management plan that is appropriate to the scale and intensity of the operations should be implemented and kept up to date.

8.Monitoring And Assessment

Monitoring should be conducted to assess the condition of the forest, yields of forest products, management activities and their social and environmental impacts.

9.Maintenance of High Conservation Value Forests

Management activities in high conservation value forests should maintain or enhance the attributes which define such forests.

10.Plantations

While plantations can provide an array of social and economic benefits, and can contribute to satisfying the world's needs for forest products, they should

complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests.

Case studies of FSC work – Honduras

With the Fundación COPADE (comercio para el desarrollo), the FSC have produced a short film (7 minutes)that shows how FSC certification brings benefits to small wood processors in Honduras. Certification has helped the workshops to access new markets, brought better organization and processing techniques, and improved equipment and safety for the workers. The video presents the entire supply chain from the certified forests to wood processing by the local carpenters and the final products sold in Spain and Honduras. Please view the video here: http://www.fsc.org/1956.html

Case studies of FSC work – forest certification in the Amazon with Precious Woods

Precious Woods (http://www.preciouswoods.com/) is company that has been working with FSC to inspect tropical rain forests for FSC certification. They have operations in the Amazon, where every tree with a minimum diameter of 30 cm is identified, marked and recorded (FSC, 2012d). The information is used to help decide which trees can be harvested, which areas of forest should be preserved, and where roads may or may not be constructed. Logging is highly selective, with only 3-4 trees per hectare harvested once every 25 years. When trees are felled, it is done carefully so that neighbouring trees are not damaged and movement of the felled tree from source to saw mill is done so as to cause as little disruption to the forest floor as possible. Also, all watercourses, banks and slopes are preserved as areas of high ecological value and are marked as permanently exempt from any economic use. A large expanse of unfragmented forest has been set aside as a preservation area – this area comprises about 25% of the entire forested area that Precious Woods is involved with.

Case studies of FSC work – the 2012 Olympics and the 2014 Winter Olympics

One of the undertakings that worked in favour of London's original bid to the Olympic Committee, for London to host the 2012 games, was the emphasis on sustainability. This means that all construction materials need to meet certain criteria such as low carbon input and reusability. One requirement concerns the timber used for the construction of the Olympic Park, which must have proof of certification. The FSC are conducting a comprehensive independent auditing exercise to confirm precisely the proportion of FSC certified material that has been consumed on the London site since building began (FSC, 2012c). FSC UK believe this audit will be sufficiently robust to allow the London Olympic Park to claim accurately that a certain percentage (which has not yet been fully compiled) of the timber consumed during the project is from FSC sources.

The 2014 Winter Olympics in Sochi, on the Russian Black Sea coast, will have 'Green standards' for their Green building program, with FSC playing a major role (FSC, 2012b). FSC certified timber will be used for all construction

including buildings, transport and energy infrastructure, as well as related nature protection projects in the region. Also, the organising committee of Sochi 2014 Olympic games will use FSC certified office materials, food packaging and printing products.

Case studies of FSC work – Mexico, U.S. and The Netherlands

The FSC have produced a short film (20 minutes) that documents how the work of the FSC is promoting sustainable forest management in countries across the globe, including Mexico, the U.S. and The Netherlands. The film also provides a general overview of the mission and vision of FSC for forests across the globe, which summarises the main points we have covered in this section. Please view the video here: http://www.fsc-uk.org/?page_id=393

Other initiatives for promoting sustainable forests

There are numerous other initiatives for promoting sustainable forests and their management. This part of the session asks you to research one other initiative on your own and to record it in your blog (or offline document) that you have been developing throughout this module.

Activity

Open up the blog (or other document) that you started in Session 1 and have been updating since, and create a new title and date entry called "Promoting sustainability of forests". In this section of your blog, provide a summary of no more than 500 words of an initiative not covered in this session that seeks to promote sustainable forests and their management. The initiative you chose can be a global-, regional- or local-scale project, and even a project that you yourself may have been involved with that relates to sustainable forests.

Some examples of initiatives that you could chose are included below (pick only one), or you might like to include one not on the list:

• The Rainforest Alliance

• The Programme for the Endorsement of Forest Certification (PEFC)

• The Sustainable Forests Partnership (SFP)

You should try to include the following points in your summary:

• How does the initiative promote sustainability of forests?

• Does the initiative cover all three pillars of sustainability?

• What evidence is there of the initiative being successful?

• Does the initiative seek sustainability through public or institutional involvement, or both?

• A history of how and why the initiative was formed.

Spend no longer than 40 minutes on this activity.

Summing up

In this session, we have seen how important forests across the globe are for regulating the Earth's climate. Large-scale deforestation could release CO2 into the atmosphere and exacerbate global warming. This process was explored in detail with reference to Amazonia dieback, but it should be understood that there remain uncertainties with regard to whether Amazonia dieback will occur in the future under climate change.

Nevertheless, uncertainty in projections of the future is not a reason to doubt present-day action on managing forests sustainably. Moreover, sustainable forest management also benefits indigenous forest-dwelling communities who reply upon forests for their survival and often place significant cultural and spiritual values on them. Furthermore, forests are a major source of global biodiversity.

Various initiatives have been successful in encouraging and implementing sustainable forest management across the globe. Some of these are prime examples of "thinking globally, acting locally"; i.e. the initiatives seek to solve a global problem by implementing local-scale projects all over the globe. To this end, sustainable forest management is something that we can all contribute to, regardless of whether we live and/or work in or near a forest. For example, we can encourage our workplaces and schools to pledge to plant trees with the Plant for the Planet Campaign and we can make informed decisions on the products we buy; e.g. do they include the FSC label?

This highlights the multi-dimensional aspect of sustainability in general. In order to achieve large-scale sustainability, a range of global to local solutions are required and raising public awareness and increasing their involvement is important.

Extra reading

A range of extra case studies on sustainable forests, based upon the work of the FSC is available from http://www.fsc.org/casestudies.html. The case studies are brief and informative and they are generally on two sides of A4. They include details on FSC certification schemes in Chile, Honduras, Indonesia, Nepal, Portugal and the U.S. It is worthwhile reading through one or two of these case studies, which compliment those already covered in this Session.

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Chapter 7: Sustainable energy: part 1, where does the world's energy supply come from and how sustainable is it?

The issue of energy regularly arises in debates on sustainability. Access to safe, clean and sustainable energy supplies is one of the greatest challenges facing humanity during the twenty-first century. Over this Session and the next, we will survey the world's present energy systems and their sustainability problems, together with some of the possible solutions to those problems and how these might emerge in practice.

Throughout history, the use of energy has been central to the functioning and development of human societies. But during the nineteenth and twentieth centuries, humanity learned how to harness the highly concentrated forms of energy contained within fossil fuels. These provided the power that drove the industrial revolution, bringing unparalleled increases in affluence and productivity to millions of people throughout the world. As we enter the third millennium, however, there is a growing realisation that the world's energy systems will need to be changed radically if they are to supply our energy needs sustainably on a long-term basis.

These two Sessions serve as an introductory overview of sustainable energy. The two Sessions aim to survey, in very general terms, the world's present energy systems and their sustainability problems, together with some of the possible solutions to those problems and how these might emerge in practice during the twenty-first century. This Session explores where the world's current energy supply comes from and then describes some of the solutions for sustainable methods of energy production by exploring a range of "renewable" energy supplies. In Part II, we will explore some of the solutions to sustainable energy in terms of energy efficiency improvements.

Where does the world's current energy supply come from?

The world's current energy systems have been built around the many advantages of fossil fuels, and we now depend overwhelmingly upon them. Concerns that supplies will 'run out' in the short-to-medium term have probably been exaggerated, thanks to the continued discovery of new reserves and the application of increasingly advanced exploration technologies. Nevertheless it remains the case that fossil fuel reserves are ultimately finite. In the long term they will eventually become depleted and substitutes will have to be found.

Moreover, fossil fuels have been concentrated by natural processes in relatively few countries. Two-thirds of the world's proven oil reserves, for example, are located in the Middle East and North Africa. This concentration of scarce resources has already led to major world crises and conflicts, such as the 1970s 'oil crisis' and the Gulf War in the 1990s (see **Figure 7.1**.). It has the potential to create similar, or even more severe, problems in the future.

The exploitation of fossil fuel resources entails significant health hazards. These can occur in the course of their extraction from the earth, for example in coal mining accidents or fires on oil or gas drilling rigs (see **Figure 7.3**). They can also occur during distribution, for example in oil spillages from tankers that pollute beaches and kill wildlife; or on combustion, which generates atmospheric pollutants such as sulphur dioxide and oxides of nitrogen that are detrimental to the environment (see **Figure 7.4**) and to health.

Fossil fuel combustion also generates very large quantities of carbon dioxide (CO_2). The majority of the world's scientists now believe that anthropogenic greenhouse gas emissions are causing the earth's temperature to increase at a rate unprecedented since the ending of the last ice age. This could cause significant changes in the world's climate system, leading to disruption of agriculture and ecosystems, to sea level rises that could overwhelm some low-lying countries, and to accelerated melting of glaciers and polar ice.

Nuclear power has grown in importance since its inception after World War II and now supplies around 7% of world primary energy. A major advantage of nuclear power plants, in contrast with fossil fuelled plants, is that they do not emit greenhouse gases. Also, supplies of uranium, the principal nuclear fuel, are sufficient for many decades – and possibly centuries – of supply at current use rates. However, the use of nuclear energy – as we shall later in this Session – gives rise to problems arising from the routine emissions of radioactive substances, difficulties of radioactive waste disposal, and dangers from the proliferation of nuclear weapons material. To these must be added the possibility of major nuclear accidents which, though highly unlikely, could be catastrophic in their effects. Although some of these problems may be amenable to solution in the longer term, such solutions have not yet been fully developed.

Extracting energy from fossil or nuclear fuels, in the course of providing energy-related services to society, generates significant environmental and social impacts. These impacts are greater than they need be because of the low efficiency of our current systems for delivering energy, converting it into forms appropriate for specific tasks, and utilising it in our homes, machinery, appliances and vehicles. An important way of mitigating the environmental impacts of current fuel use is therefore to improve the efficiency of these systems. Over the past few decades, significant efficiency improvements have indeed been made, but further major improvements are feasible technologically – and are, in many cases, attractive economically.

Of course, not all energy sources are of fossil or nuclear origin. The renewable energy sources, principally solar energy and its derivatives in the form of bioenergy, hydroelectricity, wind and wave power, are increasingly considered likely to play an important role in the sustainable energy systems of the future. The 'renewables' are based on energy flows that are replenished by natural processes, and so do not become depleted with use as do fossil or nuclear fuels – although there may be other constraints on their use. The environmental impacts of renewable energy sources vary, but they are generally much lower than those of conventional fuels. However, the current costs of renewable energy sources are in many cases higher than those of conventional sources, and this has until recently retarded their deployment.

All these considerations suggest that in creating a sustainable energy future for humanity during the coming decades, it will be necessary:

1. to implement greatly improved technologies for harnessing the fossil and nuclear fuels, to ensure that their use, if continued, creates much lower environmental and social impact;

2. to develop and deploy the renewable energy sources on a much wider scale; and

3. to make major improvements in the efficiency of energy conversion, distribution and use.

These first two of these three general approaches will be explored further throughout this Session. The third will be covered in Session 8 .

Definitions: energy, sustainability and the future

The eighteenth-century poet and artist William Blake (**Figure 7.5**), probably expressed our personal experience of energy as we feel it in our day-to-day lives more accurately than any scientific definition. Indeed, the word energy, when it first appeared in English in the sixteenth century, had no scientific meaning at all. Based on a Greek word coined by Aristotle, it meant forceful or vigorous language.

It was not until the early 1800s that the concept of energy in the modern sense was developed by scientists to describe and compare their observations about the behaviour of such diverse phenomena as the transfer of heat, the motion of planets, the operation of machinery and the flow of electricity. Today, the standard scientific definition is that "energy is the capacity to do work"; that is, to move an object against a resisting force.

In everyday language, the word 'power' is often used as a synonym for energy – and indeed in this Session and the next, the two words may occasionally be used in this rather loose way merely as substitutes for each other. But when speaking scientifically, "power" is defined as "the rate of doing work", that is, the rate at which energy is converted from one form to another, or transmitted from one place to another. The main unit of measurement of energy is the joule (J) and the main unit of measurement of power is the watt (W), which is defined as a rate of one joule per second.

Definitions of sustainability were considered in Session 1 . In the context of energy, sustainability has come to mean the harnessing of energy sources:

• that are not substantially depleted by continued use;

• the use of which does not entail the emission of pollutants or other hazards to the environment on a substantial scale; and

• the use of which does not involve the perpetuation of substantial health hazards or social injustices.

This is, of course, a very broad ideal. Although a few energy sources can come close to fulfilling these conditions, most fall considerably short of the optimum. This means that, in practice, sustainability is a relative – rather than an absolute concept. It is not so much that some energy sources are sustainable and others not; it is more that some energy sources, in certain contexts, are more sustainable than others. Determining the relative sustainability of one energy system with respect to another is usually a complex process, involving detailed consideration of the specific processes and technologies proposed, the context in which they are being used and the differing values and interests of the various parties involved.

For example, suppose the Government of a country is proposing to construct a large hydro-electric power plant like the one shown in **Figure 7.6**. The villagers whose homes would be flooded by the associated reservoir – if the dam failed – would probably take a different view of the plant's sustainability to that taken by the city-based planners in the electricity utility proposing its

construction, whose homes would be unaffected and whose careers would probably stand to benefit from such a major capital project.

When we speak of ‘the future’ in the context of a ‘sustainable future’, what do we mean? Next year? One or two decades hence? The end of the twenty-first century? The end of the third millennium? Forever?

Ideally, in view of the Brundtland Report's injunction that humanity should not compromise the needs of future generations, we should judge the sustainability of all energy systems on an indefinite time scale – far into the very distant future. In practice, however, this might be realistically interpreted as endeavouring to ensure that energy systems become sustainable (or at the very least, much less un-sustainable) over the next century or so – with the additional proviso that, even beyond that time horizon, few substantial difficulties can presently be envisaged.

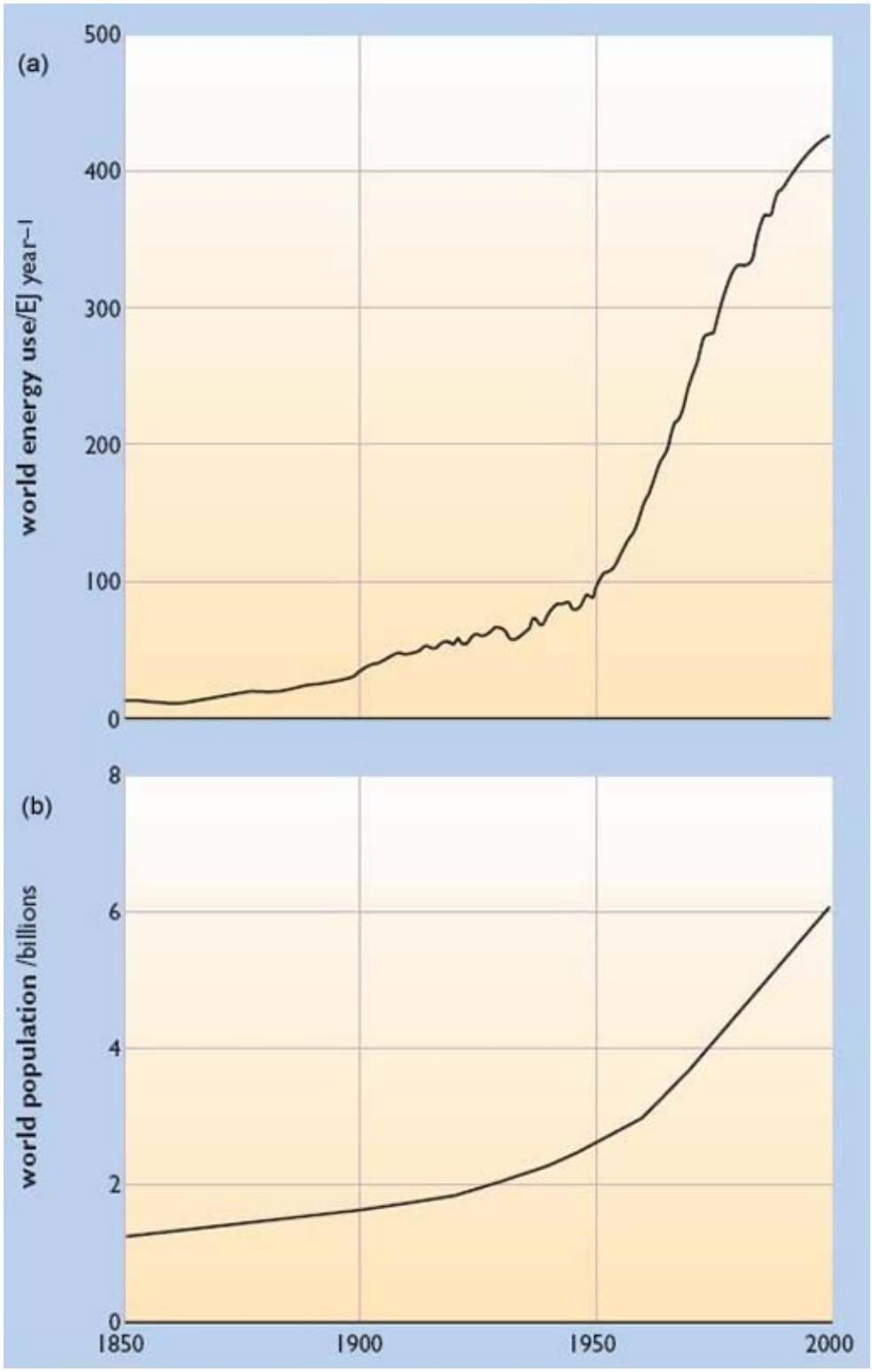
Present energy sources and sustainability

This section identifies the principal energy systems used by humanity at the turn of this century, and the extent to which they are sustainable. The years 2000 and 2001 are regularly cited as referring to “present” in this section, since these years are a baseline that are often referred to. While this gives a useful indication of the scale of use of the “current” principal energy systems across the globe, it should be noted that the very latest estimates may be slightly different.

Fossil fuels

Until quite recently, human energy requirements were modest and supplies came either from harnessing natural processes such as the growth of plants, which provided wood for heating and food to energise human or animal muscles, or from the power of water and wind, used to drive simple machinery. But the nineteenth and twentieth centuries saw a large increase in global energy use, based mainly on burning cheap and plentiful fossil fuels: first coal, then oil and natural gas. These fossil fuels now supply over 80% of the world's current energy consumption.
The population of the world rose nearly four-fold during the twentieth century, from 1.6 billion in 1900 to approximately 6.1 billion in 2000. However, world primary energy use increased at a much faster rate. Between 1900 and 2000, it rose more than 10-fold (see **Figure 7.7**).

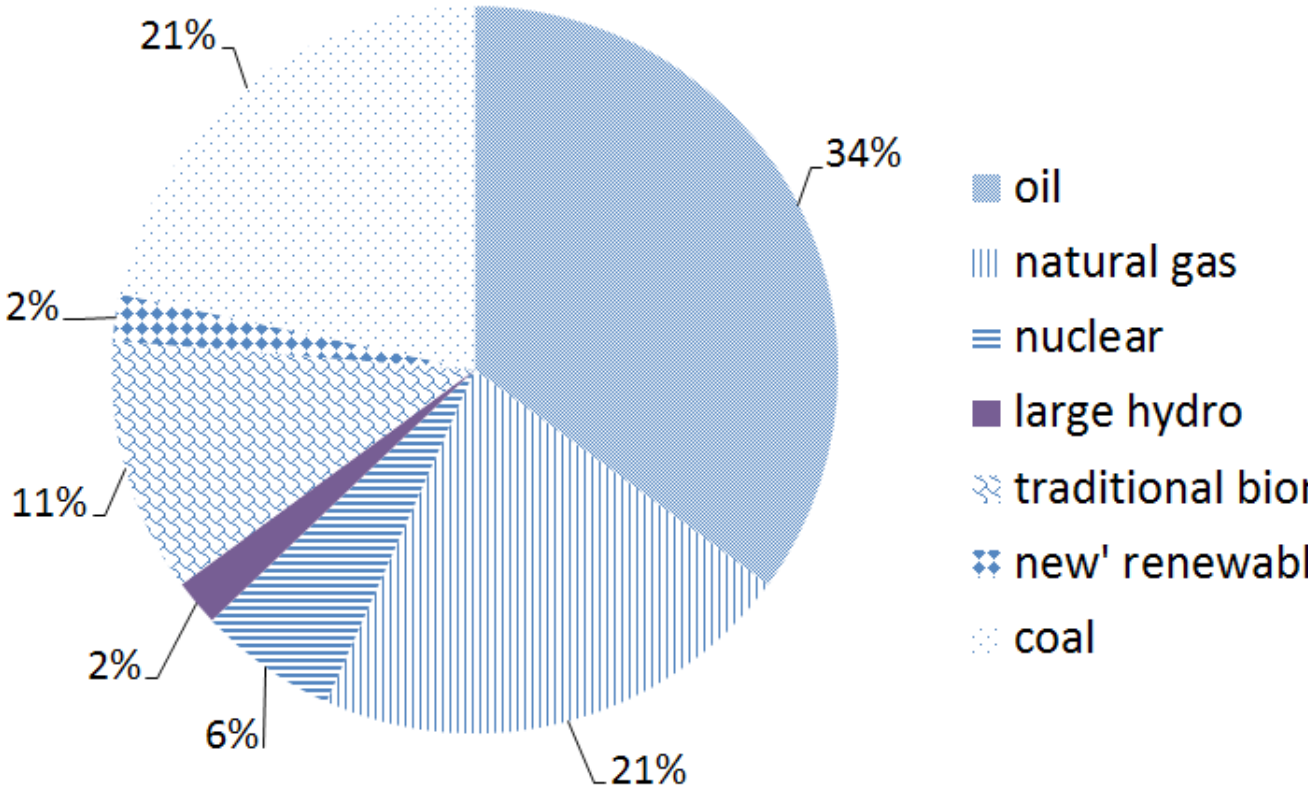
Figure 7.7 Growth in world primary energy use, 1850–2000; (b) Growth in world population, 1850–2000.



http://openlearn.open.ac.uk/mod/oucontent/view.php?id=397932&section=3.2

For most of the nineteenth century the world's principal fuel was firewood (or other forms of traditional ‘bioenergy’), but coal use was rising fast and by the beginning of the twentieth century it had replaced wood as the dominant energy source. During the 1920s, oil in turn began to challenge coal and by the 1970s had overtaken it as the leading contributor to world supplies. By then, natural gas was also making a very substantial contribution, with nuclear energy and hydro power also supplying smaller but significant amounts. As **Figure 7.8** shows, total world primary energy use in 2000 was an estimated 424 million million million joules, i.e. 424 exajoules, equivalent to around 10,000 million tonnes of oil.

Figure 7.8 Percentage contributions of various energy sources to world primary energy consumption in 2000.



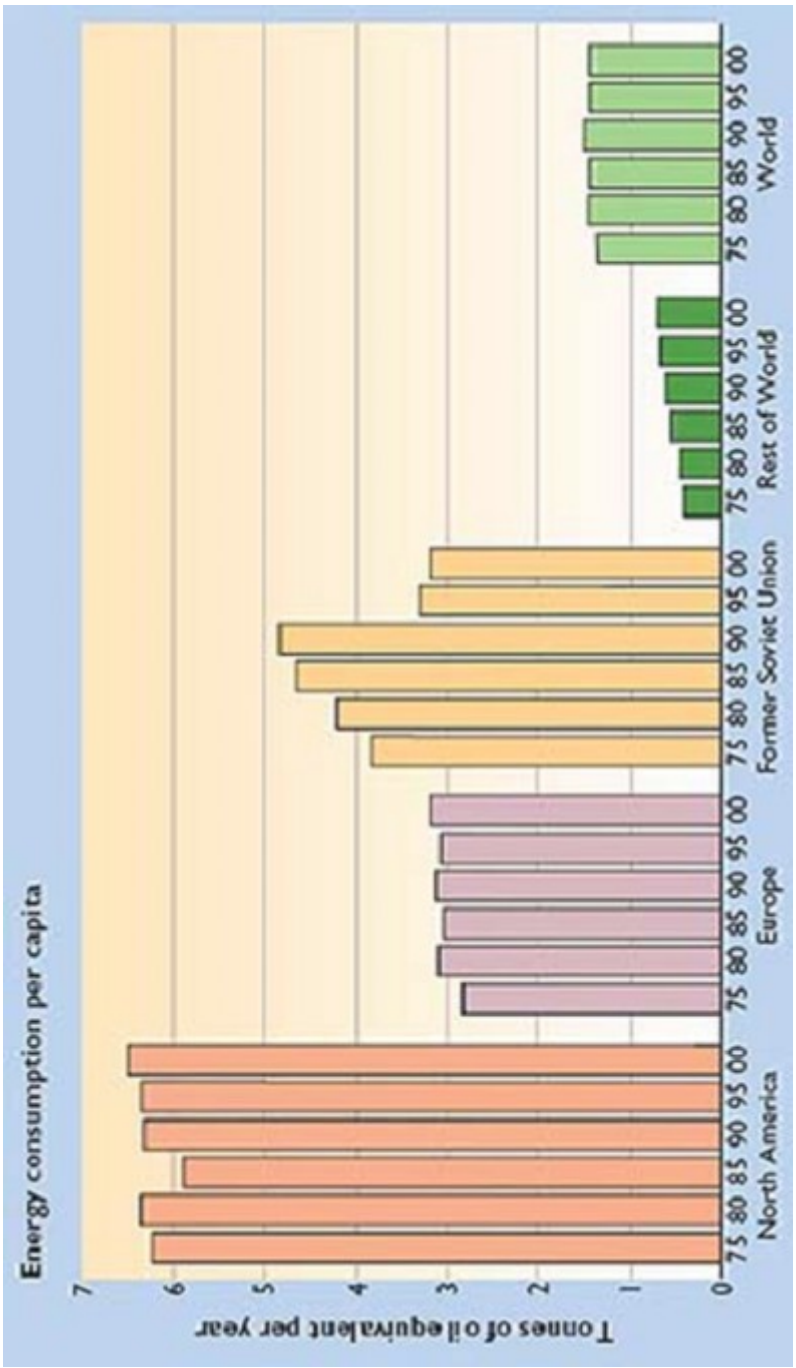
By the year 2000, oil was still the largest single contributor to world supplies, providing about 35% of primary energy, with gas and coal supplying roughly equal shares at around 21-22%, nuclear providing nearly 7%, and hydropower 2%. In 2000, traditional biofuels still supplied an estimated 11%, while more modern forms of 'bioenergy' provided around 2%, with other 'new renewables' like wind power contributing a very small (though rapidly growing) fraction of world demand.

On average, world primary energy use per person in 2000 was about 70 thousand million joules (70 gigajoules), including non-commercial bioenergy. This is equivalent to about 1.7 tonnes of oil per person per year, or about 5 litres of oil per day.

However, this average conceals major differences between the inhabitants of different regions. As **Figure 7.9** illustrates, North Americans annually consume the equivalent of about 8 tonnes of oil per head (about 20 litres per day), whereas residents of Europe and the former Soviet Union consume about half that amount, and the inhabitants of the rest of the world use only about one-tenth.

World consumption per person has shown almost no growth over the past 20 years. North American consumption per capita is more than twice that of Europe and the former Soviet Union, and almost 10 times the level in the Rest of the World. Note that these figures include only commercially traded fuels (i.e. they exclude traditional biofuels).

Figure 7.9. Per capita primary energy consumption, in tonnes of oil equivalent per year, for different regions of the world and for the world as a whole, 1975–2000.



Fossil fuels are extremely attractive as energy sources. They are highly concentrated, enabling large amounts of energy to be stored in relatively small volumes. They are relatively easy to distribute, especially oil and gas which are fluids.

During the twentieth century, these unique advantages enabled the development of increasingly sophisticated and effective technologies for transforming fossil fuel energy into useful heat, light and motion; these ranged from the oil lamp to the steam engine and the internal combustion engine. Today, at the beginning of the twenty-first century, fossil fuel-based systems reign supreme, supplying the great majority of the world's energy.

The fossil fuels we use today originated in the growth and decay of plants and marine organisms that existed on the earth millions of years ago. Coal was formed when dead trees and other vegetation became submerged under water and were subsequently compressed, in geological processes lasting millions of years, into concentrated solid layers below the earth's surface. Oil and associated natural gas originally consisted of the remains of countless billions of marine organisms that slowly accreted into layers beneath the earth's oceans and were gradually transformed, through geological forces acting over aeons of time, into the liquid and gaseous reserves we access today by drilling into the earth's crust. The fossil fuels are composed mainly of carbon and hydrogen, which is why they are called hydrocarbons.

Coal was the fuel that powered the industrial revolution. Its combustion produces relatively large amounts of carbon dioxide (CO_2) compared with other fuels. It also results in particulates (soot), and sulphur dioxide emissions. The use of coal in UK homes and industry has now been largely superseded by natural gas, but it is still used for electricity generation. Huge world-wide coal reserves remain, enough for several hundred years' use at current rates.

Oil is the world's leading energy source. Its high energy density and convenience of use are particularly advantageous in the transport sector, where it is the dominant fuel. Oil combustion produces less CO_2 per unit of energy released than burning coal, but more CO_2 than burning natural gas. Proven world oil reserves are sufficient for about 40 years of use at current rates.

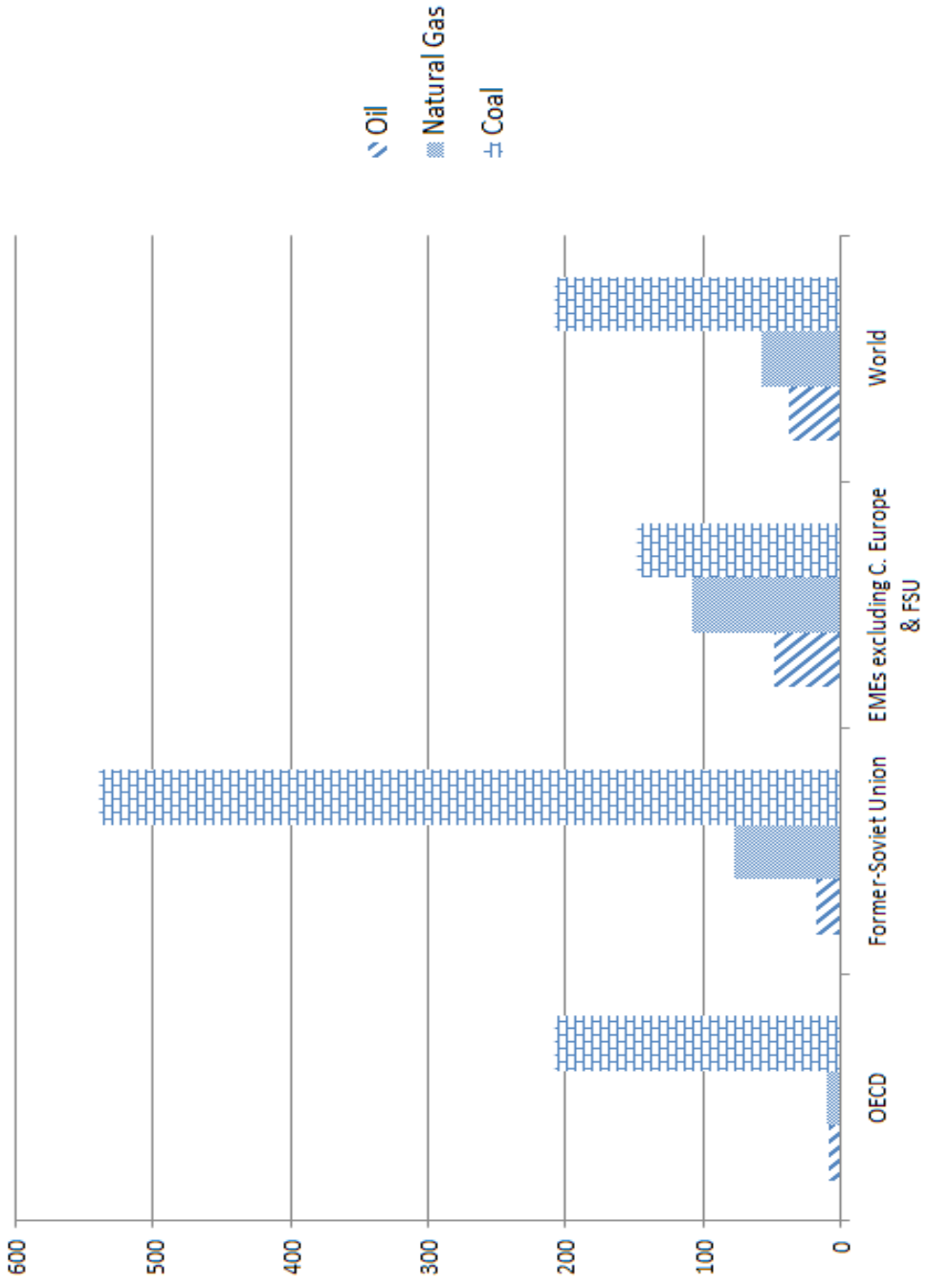
Natural gas combustion produces significantly lower CO_2 emissions per unit of energy than the combustion of other fossil fuels. Emissions are also free from sulphur dioxide or particulates. The relative cleanliness and convenience of natural gas have made it the preferred fuel for heating and, increasingly, for electricity generation in Western Europe. Proven world gas reserves are sufficient for about 60 years of use at current rates.

Since the fossil fuels were created in specific circumstances where the geological conditions were favourable, the largest deposits of oil, gas and coal tend to be concentrated in particular regions of the globe– although less appreciable deposits are remarkably widespread. The majority of the world's oil reserves are located in the Middle East and North Africa, while the majority

of our natural gas reserves are split roughly equally between the Middle East/ North Africa and the former Soviet Union. Although coal deposits are rather more evenly spread throughout the world, three-quarters of world coal reserves are concentrated in just four countries: Australia, China, South Africa and the United States of America (United Nations Development Programme, 2000).

Although human society now consumes fossil fuels at an exceptional rate, the amounts of coal, oil and gas that remain are still very large. One simple way of assessing the size of reserves is called the reserves/production (R/P) ratio – the number of years the reserves would last if use continued at the current rate. Coal has the largest R/P ratio. Present estimates suggest the world has more than 200 years' worth of coal left at current use rates. For oil, current R/P estimates suggest a lifetime of about 40 years at current rates. For gas, the R/P ratio is somewhat higher, at around 60 years.

Figure 7.11 Reserves/production (R/P) ratios (in years) for oil, natural gas and coal, in 2000, for various regions of the world and the world as a whole



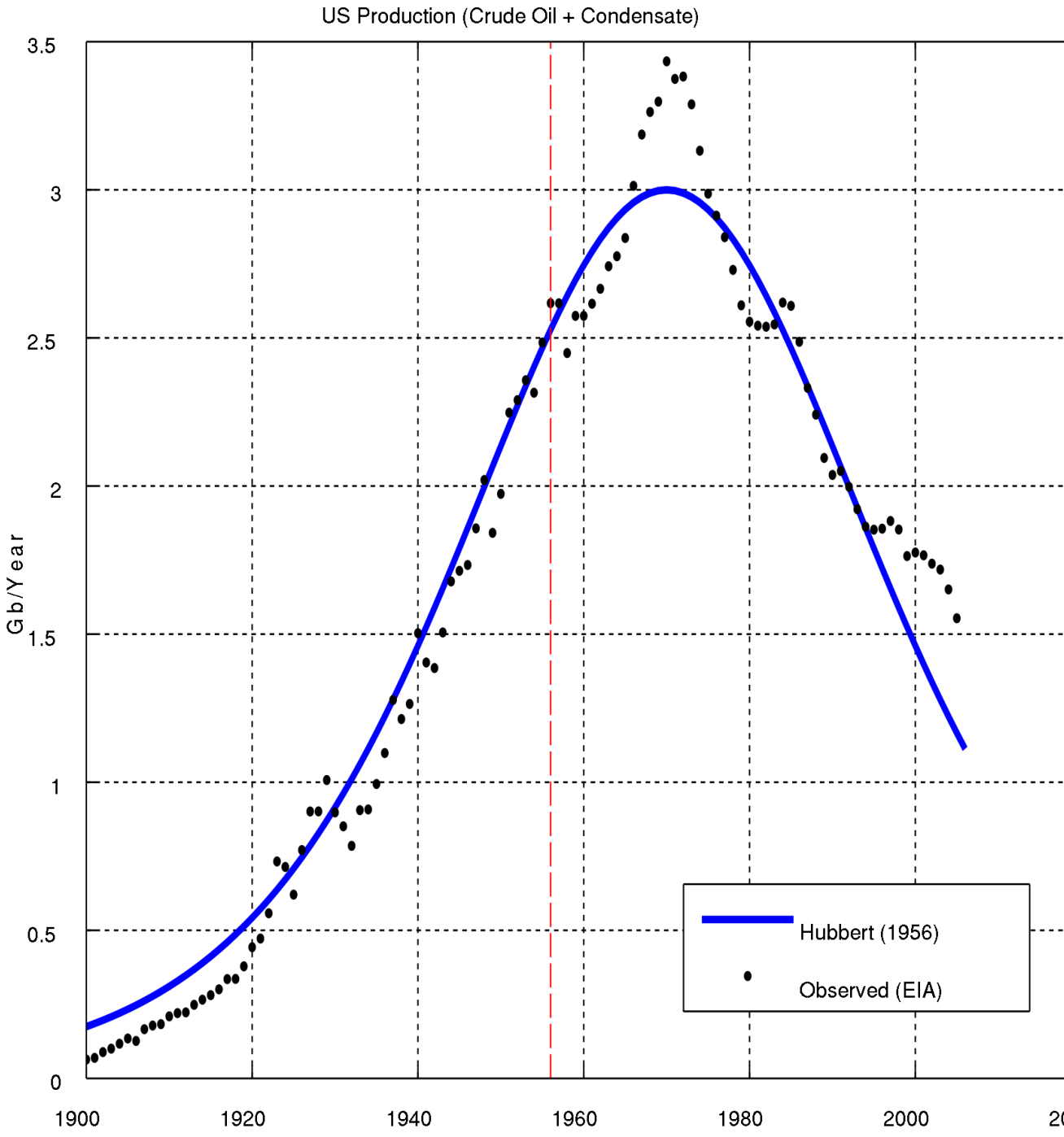
http://openlearn.open.ac.uk/mod/oucontent/view.php?id=397932&section=3.2

Fossil fuel reserves/production ratios need to be interpreted with great caution, however. They do not take into account the discovery of new proven reserves, or technological developments that enable more fuel to be extracted from deposits or improve the economic viability of 'difficult' deposits. Moreover, it should be noted that the estimates presented in this Section are for around the start of the century. The debate on resource depletion is not if, but when the resource will run out.

Dr. M. King Hubbert was a U.S. geophysicist who worked for the oil industry in the U.S. during the 1950s. He suggested that the amount of oil being discovered was reducing, and made a projection that oil production for the U.S. would slow, "peak" and then decline, following a bell-shaped curve as depicted in Figure 7.12.

Hubbert estimated that the U.S. would peak in oil production during the period 1965-70. Actual figures show that he was correct to within a few years. Hubbert's concept can be applied to world oil supply and the estimate of when we reach the top of the curve is known as "peak oil". Again it is important to remember that peak oil is a certainty at current consumption levels; the issue is only when this will happen.

Figure 7.12. Hubbert's curve - the dotted red line shows when the prediction was made.



In the future, when global consumption exceeds production there will be a shortfall between supply and demand. At this point prices in oil will increase, and there are concerns about where to secure oil from. We have already established in this Session that our current energy demands are reliant on oil and other fossil fuels. Once we reach peak oil, as well as a rise in price, energy security will become an issue.

We saw in Session 3 that when pressure is exerted on access to a natural resource (e.g. water), there is a potential for international disputes and conflict to arise. Hubbert's peak has been used specifically for oil, but all production of fossil fuels and other mined minerals of which there is a finite supply follow a similar curve, leading to peak gas, peak coal, peak uranium, peak copper etc. The subject of peak oil and the implications of our reliance on a substance that will one day run out has sparked heated debate in the last few years, especially as the price of oil has been steadily rising.

Richard Sears is a visiting scientist at MIT, after a long career as a geophysicist and executive at Shell. Please now watch the following short presentation (7 minutes) by Sears, which gives an overview of the concept of peak oil and moreover, our current reliance on fossil fuels. Sears constantly raises the importance of sustainability in his presentation. The presentation can be viewed here:

http://www.ted.com/talks/richard_sears_planning_for_the_end_of_oil.html

Nuclear energy

The development of ‘peaceful’ nuclear electricity generation after its use for military purposes in World War II was initially heralded as ushering in a new era of virtually limitless, clean power that some predicted would be ‘too cheap to meter’. In practice, however, nuclear electricity has proved to be more expensive than that from fossil fuels. Since the UK opened the world's first grid-connected nuclear power station at Calder Hall in Cumbria in 1956. Nuclear electricity generation has expanded to a point where it now accounts for nearly 7% of world primary energy, and for over 17% of the world's electricity. In some countries, it is the principal source of electricity generation. France, for example, derives around 75% of its electricity from nuclear power.

Nuclear energy is based on harnessing the very large quantities of energy that are released when the nuclei of certain atoms, notably uranium-235 and plutonium-239, are induced to split or ‘fission’. The complete fission of a kilogram of uranium-235 should produce, in principle, as much energy as the combustion of over 3000 tonnes of coal. In practice, the fission is incomplete and there are other losses, but nevertheless nuclear fuels are more highly concentrated sources of energy than fossil fuels.

The heat generated by nuclear fission in a nuclear power station is used to raise high-pressure steam which then drives steam turbines coupled to electrical generators, as in a conventional power station.

A major advantage of nuclear energy is that the operation of nuclear power plants results in no emissions of CO2 or sulphur dioxide. However, there are some emissions from the fossil fuel used in uranium mining, nuclear fuel manufacture, and the construction of nuclear power plants.

There seems little danger of the world 'running out' of nuclear fuel in the near future. Uranium reserves have been identified in many countries and are sufficient for many decades of use at current rates, and there are probably enough additional deposits to extend this to several centuries. Furthermore, advanced nuclear technologies such as the 'fast breeder reactor' (FBR) could enable uranium deposits to be used even more effectively, thus extending the lifetime of reserves. In an FBR, the plentiful but non-fissile isotope uranium-238 is transformed into fissile plutonium-239, which can then be used as reactor fuel. But the development of FBRs has been inhibited by substantial technical and safety problems, and by the low price of uranium which currently makes the technology un-competitive economically.

Although the majority of nuclear reactors in most countries have operated without serious safety problems, a number of major accidents, like those at Windscale in the UK in 1957, Three Mile Island in the USA in 1979, Chernobyl in the Ukraine in 1986 and the Fukushima I Nuclear Power Plant in Japan in 2011 have created widespread public unease about nuclear technology in general – despite the opinion of nuclear-industry experts who argue that such anxieties are irrational.

There is also an issue regarding how, ultimately, to dispose of nuclear waste products, some of which remain hazardous for many thousands of years; and the problem of proliferation of nuclear materials such as plutonium-239 and uranium-235, which could fall into the hands of 'rogue states' or 'terrorists' capable of creating crude but devastating atomic weapons from them. Nuclear power stations and reprocessing facilities may themselves be vulnerable to terrorist attacks, which could result in the release of very large quantities of radioactive substances into the environment.

Despite these difficulties, the nuclear industry is attempting to develop more advanced types of nuclear reactor which, it claims, will be cheaper to build and operate, and inherently safer, than existing designs. These are being promoted as an improved technological option for generating the carbon-free electricity that will be required later in the twenty-first century if global climate change is to be mitigated and we are to move towards a more sustainable form of energy production.

Another potentially important nuclear technology is that of nuclear fusion. This involves the fusing together of atomic nuclei, in this case those of deuterium (more commonly known as 'heavy' hydrogen). This process, similar to that underlying the generation of energy within the sun, also results in the release of very large amounts of energy. However, in order to

create fusion on earth it is necessary to create conditions in which the nuclei of special forms (called isotopes) of hydrogen interact in an extremely confined space at extremely high temperatures, and so far scientists have only been able to make this happen for a few seconds. The leading designs for controlled fusion research use magnetic or laser confinement of a plasma, with heat from the fusion reactions used to operate a steam turbine which in turn drives electrical generators. As of July 2010, the largest experiment by means of magnetic confinement has been the Joint European Torus. Presently, the energy required to power the process currently greatly exceeds the energy generated. Research into fusion power continues, with substantial funding, but most experts consider that the technology, even if eventually it can be demonstrated successfully, is very unlikely to become commercially available for many decades.

Bioenergy

Wood is created by photosynthesis in the leaves of plants. Photosynthesis is a process powered by solar energy in which atmospheric CO2 and water are converted into carbohydrates (compounds of carbon, oxygen and hydrogen) in the plant's leaves and stems. These, in the form of wood or other 'biomass', can be used as fuels – called biofuels, which are sources of bioenergy.

Wood is very widely used as a fuel in many parts of the developing world. In some countries, other biofuels such as animal dung are also used. As shown in **Figure 7.8**, such traditional biofuels are estimated to supply around 11% of world primary energy.

If the forests that provide wood fuel are re-planted at the same rate as they are cut down, then such fuel use should in principle be sustainable – sustainable forest management is covered in detail in Session 6 . When forests are managed sustainably in this way, the CO2 absorbed in growing replacement trees should equal the CO2 emitted when the original trees are burned. However, this is only true when complete combustion of the wood occurs and all the carbon in the wood is released as CO2. Although near-complete combustion can be achieved in the best available wood stoves and furnaces, most open fires and stoves are not so efficient. This means that not only is CO2 released (albeit in somewhat smaller quantities if the combustion is incomplete) but other combustion products are also emitted, some of which are more powerful greenhouse gases than CO2. In particular, these can include methane, which on a molecule-for-molecule basis has 20 times the global warming potential of CO2 over a 20-year-period. The incomplete combustion of wood can therefore release a mixture of greenhouse gases with a greater overall global warming effect than can be offset by the CO2 absorbed in growing replacement trees. This suggests an urgent need to improve the efficiency of traditional wood-burning processes (Smith et al., 2000). However, it should be stressed that the overall global effect of greenhouse gas emissions arising from incomplete biomass combustion in developing countries is probably much less than that of emissions from burning fossil fuels, which occurs mostly in developed countries.

A further issue is that in many developing countries, wood fuel is being used at a rate that exceeds its re-growth, which is not only unsustainable but also results in villagers having to travel ever-increasing distances, often involving great hardship, to gather sufficient firewood for their daily needs. Also, when it has been gathered, firewood is often burned very inefficiently in open fires. This not only results in excess greenhouse gas emissions, as we have seen, but also gives much less effective warmth than if an efficient stove were used. Moreover, it usually results in high levels of smoke pollution, with very detrimental health effects.

Not all bioenergy use is in the form of traditional biofuels. A significant contribution to world supplies now comes from bioenergy power plants. These feature the clean, high-efficiency combustion of straw, forestry wastes or wood chips from trees grown in special plantations. The heat produced is either used directly or for electricity generation, or sometimes for both purposes.

Municipal wastes, a large proportion of which are biological in origin, are also widely used for heat or electricity production. However, there is considerable controversy over whether or not energy from waste should be regarded as 'sustainable'. Waste-to-energy plants have been opposed by some environmental groups on the grounds that, in order to be economically viable, they need to be fed with a steady stream of waste over many years, which discourages better solutions to the waste problem, such as material re-use or recycling. There are further concerns over possible emissions of dioxins, which are carcinogenic, from the combustion of chlorine compounds present in municipal waste.

Another modern source of bioenergy is alcohol (ethanol) produced by fermenting sugar cane or maize, which is quite widely used in vehicles in Brazil and some states of the USA. The alcohol is often blended with conventional petroleum to form a mixture known as 'Gasohol'.

Similar to municipal wastes, there is debate over whether ethanol should be regarded as sustainable. For example, in a study reported by Lapola et al. (2010), the relationship between the planned expansion of biofuel plantations in Brazil and direct and indirect land-use changes (e.g., biofuel plantations replace rangelands, which replace forests) was investigated. Recall how in Session 6 we learnt how important forests are for regulating carbon emissions from the land to the atmosphere. The researchers assumed that ethanol and biodiesel production would increase during the period 2003-2020. Based upon this assumption, Lapola et al. (2010) found that indirect land-use changes, especially those pushing the rangeland frontier into the Amazonian forests, could offset the carbon savings from the use of biofuels instead of fossil fuels. Moreover, Lapola et al. (2010) estimated that sugarcane ethanol and soybean biodiesel could each contribute to nearly half of the projected indirect deforestation of 121,970 km2 that is estimated to occur by 2020. This was seen to create a carbon debt that could take around 250 years to be repaid using biofuels instead of fossil fuels. The study concludes that a closer collaboration or strengthened institutional link between the biofuel and cattle-ranching sectors in the coming years is crucial

for effective carbon savings from biofuels – and hence sustainability too – in Brazil.

Hydroelectricity

Another energy source that has been harnessed by humanity for many centuries is the power of flowing water, which has been used for milling corn, pumping and driving machinery. During the twentieth century, its main use has been in the generation of hydroelectricity, and hydropower has grown to become one of the world's principal electricity sources. It currently provides around 2.3% of world primary energy.

The original source of hydroelectric power is solar energy, which warms the world's oceans, causing water to evaporate from them. In the atmosphere, this forms clouds of moisture which eventually falls back to earth in the form of rain (or snow). The rain flows down through mountains into streams and rivers, where its flow can be harnessed using water wheels or turbines to generate power. When harnessed on a small scale, hydropower creates few, if any, adverse environmental impacts. However, many modern hydro installations have been built on a very large scale, involving the creation of massive dams and the flooding of extremely large areas. This often entails the re-location of many thousands of indigenous residents who are usually, to say the least, reluctant to move from their homes. Other impacts include adverse effects on fish and other wildlife, reductions in water-borne nutrients used in agriculture downstream, increases in water-borne diseases – and not least, the rare but catastrophic effects of dam failures. A further problem with large dams is that in certain circumstances trees and other vegetation trapped below water when a reservoir is flooded can decay ‘anaerobically’ (i.e. in the absence of oxygen). This produces methane, which is a more powerful greenhouse gas than the CO2. Methane would not have been produced if the tree had decayed normally in the presence of oxygen from the atmosphere. However, the current consensus is that greenhouse gas emissions from hydropower generation are likely to be at least an order of magnitude lower than those from fossil-fuel-generated electricity (United Nations Development Programme, 2000).

This section has described how fossil fuels provide the majority of the world's energy requirements, with bioenergy, nuclear energy and hydropower also making major contributions. The other ‘renewable’ energy sources currently supply only a small fraction of world demand, although the contribution of these ‘renewables’ seems likely to grow rapidly in coming decades, as we shall see in the following section.

Renewable energy sources

What are renewable energy sources?

Fossil and nuclear fuels are often termed non-renewable energy sources. This is because, although the quantities in which they are available may be extremely large, they are nevertheless finite and so will in principle 'run out' at some time in the future. By contrast, hydropower and bioenergy (from biofuels grown sustainably) are two examples of renewable energy sources – that is, sources that are continuously replenished by natural processes. Renewable energy sources are essentially flows of energy, whereas the fossil and nuclear fuels are, in essence, stocks of energy.

World-wide, there has been a rapid rise in the development and deployment of renewable energy sources during the past few decades, not only because, unlike fossil or nuclear fuels, there is no danger of their 'running out', but also because their use normally entails no (or few) greenhouse gas emissions and therefore does not contribute to global climate change.

Renewable energy sources range from solar power in its various forms, through bioenergy and hydro to wind, wave, tidal and geothermal energy (see **Figure 7.23**).

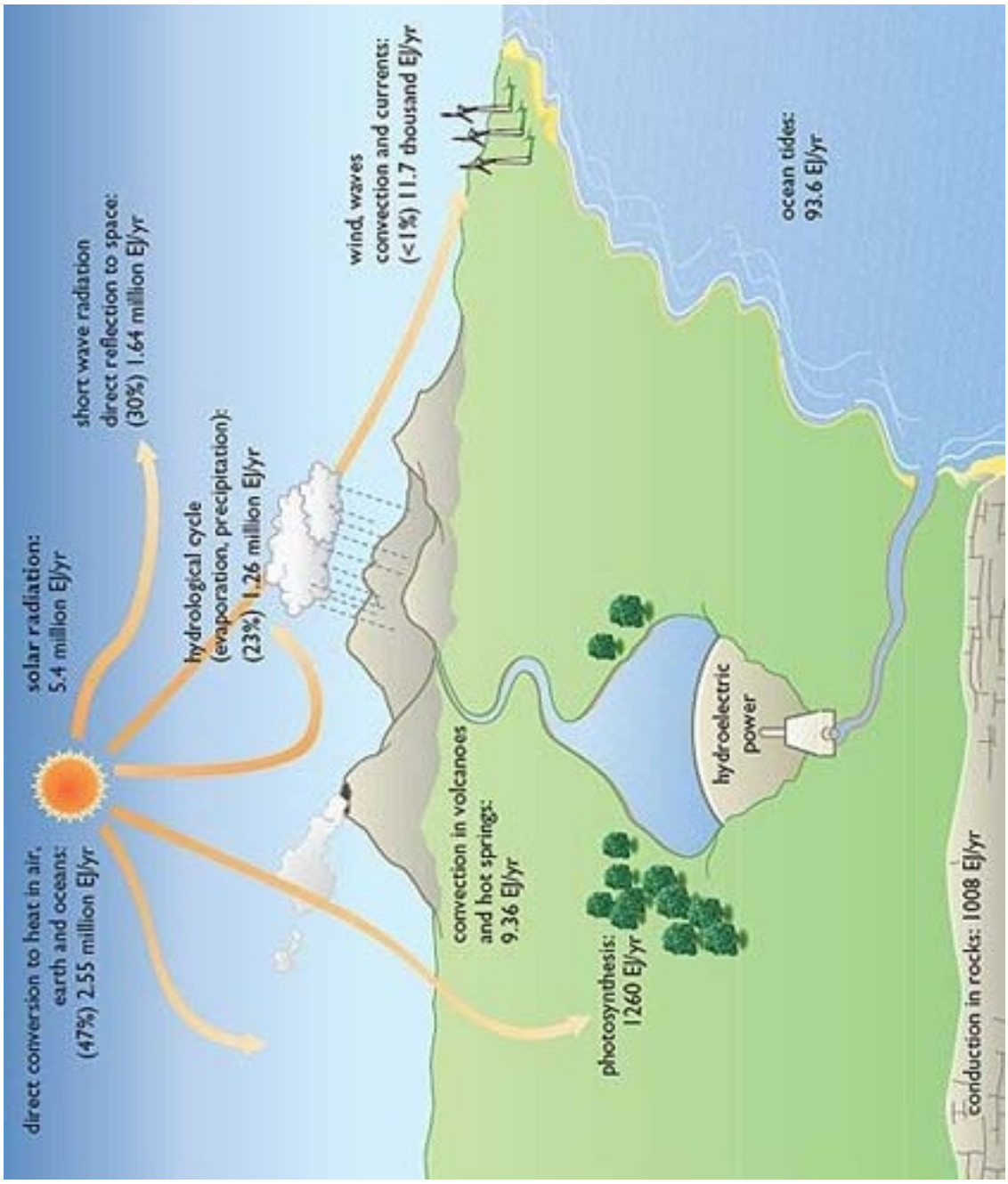


Figure 7.23 (above). The various forms of renewable energy depend primarily on incoming solar radiation, which totals around 5.4 million Exajoules (EJ) per year. Of this, approximately 30% is reflected back into space. The remaining 70% is in principle available for use on Earth, as shown, and amounts to approximately 3.8 million EJ. This is around 10,000 times the current rate of consumption of fossil and nuclear fuels, which in the year 2000 amounted to around 360 EJ. Two other, non-solar, renewable energy sources are shown in the figure. These are the motion of the ocean tides, caused principally by the moon's gravitational pull (with a small contribution from the sun's gravity); and geothermal heat from the earth's interior, which manifests itself in convection in volcanoes and hot springs, and in conduction in rocks.

The general nature and scope of the various 'renewables' are briefly summarised in this section.

Solar energy

The sun has a surface temperature of around 6000°C, maintained by continuous nuclear fusion reactions between hydrogen atoms within its interior. These nuclear reactions will gradually convert all of the hydrogen into heavier elements, but this is a relatively slow process and the sun should continue to supply power for another 5 billion years.

The sun radiates huge quantities of energy into space, and the tiny fraction intercepted by the Earth's atmosphere, 150 million km away, is nonetheless equivalent to about 15,000 times humanity's present rate of use of fossil and nuclear fuels. Even though approximately one-third of the intercepted energy is reflected away by the atmosphere before reaching the earth's surface, this still means that a continuous and virtually inexhaustible flow of power amounting to 10,000 times our current rate of consumption of conventional fuels is available in principle to human civilisation.

Solar energy, when it enters our buildings, warms and illuminates them to a significant extent. When buildings are specifically designed to take full advantage of the sun's radiation, their needs for additional heating and for artificial lighting can be further reduced. Solar power can also be harnessed by using solar collectors to produce hot water for washing or space heating in buildings.

Such collectors are in widespread use in sunny countries such as Israel and Greece, but are also quite widely used in less sunny places such as Great Britain. For example, there are more than 40,000 roof-top solar water heating systems in Great Britain.

Harnessing solar energy to provide electricity directly involves the use of a different and more sophisticated technology called solar photovoltaics (PV). PV 'modules' are made of specially-prepared layers of semi-conducting materials (usually silicon) that generate electricity when photons of sunlight fall upon them. Arrays of PV modules are normally mounted on the roofs or facades of buildings, providing some or all of their electricity needs. PV technology is growing very rapidly and several countries have initiated major

development and demonstration programmes as well as offering subsidy payments for households that install PV panels.

Wind energy

When solar radiation enters the earth's atmosphere, because of the curvature of the earth it warms different regions of the atmosphere to differing extents – most at the equator and least at the poles. Since air tends to flow from warmer to cooler regions, this causes winds, and it is these air flows that are harnessed in windmills and wind turbines to produce power.

Wind power, in the form of traditional windmills used for grinding corn or pumping water, has been in use for centuries. But in the second half of the twentieth century, and particularly in the past few decades, the use of modern wind turbines for electricity generation has been growing very rapidly. Installed wind generating capacity has doubled every two and a half years since 1991, and at the end of 2001 the world total was over 23,000 MW. Denmark derives more than 15% of its electricity from wind, and in other countries such as Germany, Spain and the US, turbines have in recent years been installed at a rate of more than a thousand megawatts per year. Wind turbines can be placed on the land or at sea where they are referred to as "offshore wind farms".

Wave power

When winds blow over the world's oceans, they cause waves. Various technologies for harnessing the power of waves have been developed over the past few decades, of which the 'oscillating water column' (OWC) is perhaps the most widely used. In an OWC, the rise and fall of the waves inside an enclosed chamber alternately blows and sucks air through a special kind of air turbine, which is coupled to a generator to produce electricity. Wave energy technology is not as fully developed as wind power or PV, but advances in developing and demonstrating the technology can be expected over the coming decade.

Tidal energy

The energy that causes the slow but regular rise and fall of the tides around our coastlines is not the same as that which creates waves. It is caused principally by the gravitational pull of the moon on the world's oceans. The sun also plays a minor role, not through its radiant energy but in the form of its gravitational pull, which exerts a small additional effect on tidal rhythms.

The principal technology for harnessing tidal energy essentially involves building a low dam, or barrage, across the estuary of a suitable river. The barrage has inlets that allow the rising sea levels to build up behind it. When the tide has reached maximum height, the inlets are closed and the impounded water is allowed to flow back to the sea in a controlled manner, via a turbine-generator system similar to that used in hydroelectric schemes.

Geothermal energy

The source of geothermal energy is the earth's internal heat, which originates mainly from the decay of long-lived radioactive elements. The most useful geothermal resources occur where underground bodies of water called aquifers can collect this heat, especially in those areas where volcanic or tectonic activity brings the heat close to the surface. The resulting hot water, or in some cases steam, is used for electricity generation where possible, for example in Italy, New Zealand and the Philippines, and for direct heating use in more than 60 other countries. Geothermal energy is already making a minor but locally useful contribution to world energy supplies. If geothermal heat is extracted in a particular location at a rate that does not exceed the rate at which it is being replenished from deep within the earth, it is a renewable energy source. But in many cases this is not so; the geothermal heat is in effect being ‘mined’ and will ‘run out’ locally in perhaps a few years or decades.

Summing up

Renewable energy sources are generally sustainable in the sense that they cannot 'run out' – although, as noted earlier in this Session, both biomass and geothermal energy need wise management if they are to be used sustainably. For all of the other renewables, almost any realistic rate of exploitation by humans would be unlikely to approach their rate of replenishment by nature, though of course the use of all renewables is subject to various practical constraints.

Renewable energies are also relatively 'sustainable' in the additional sense that their environmental and social impacts are generally more benign than those of fossil or nuclear fuels. However, the deployment of renewables in some cases entails significant environmental and social impacts.

Renewable energy sources are generally much less concentrated than fossil or nuclear fuels, so large areas of land (or building surfaces) are often required if substantial quantities of energy are to be collected. This can lead to a significant visual impact, as in the case of wind turbines.

Also, the monetary costs of many renewable sources are at present considerably higher than those of conventional fuels. Until this imbalance is reduced, either by reducing the costs of renewables or through increases in the costs of conventional sources, renewables may be unable to succeed in capturing a substantial fraction of the world market.

Renewables may seem attractive in many ways, but how large a contribution might they make to world energy needs in the future?

Extra reading

POST note 315, "Renewable energy in a changing climate" (POST, 2008), published by the Parliamentary Office of Science and Technology provides an excellent overview of the main sources of renewable energy in the UK. Moreover it highlights the importance of renewbale energy with respect to UK legislation. The document can be viewed here: http://www.parliament.uk/business/publications/research/briefing-papers/POST-PN-315

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Chapter 8: Sustainable energy: part 2, achieving sustainable energy through supply and demand efficiency mechanisms

Renewables may seem attractive in many ways, but as we have just seen, their implementation is not straightforward or a guaranteed solution to sustainable energy. A further drive towards sustainable energy use can be achieved by carefully monitoring and adjusting the supply-and-demand energy relationship. Moreover, improvements in the efficiency of energy usage and demand can be achieved respectively.

This is explored in detail in this Session with reference to a number of case studies.

Energy services and supply and demand

Energy services

Except in the form of food, no one needs or wants energy as such. That is to say, no one wants to eat coal or uranium, drink oil, breathe natural gas or be directly connected to an electricity supply. What people want is energy services – those services which energy uniquely can provide. Principally, these are: heat, for warming rooms, for washing and for processing materials; lighting, both interior and exterior; motive power, for a myriad of uses from pumping fluids to lifting elevators to driving vehicles; and power for electronic communications and computing.

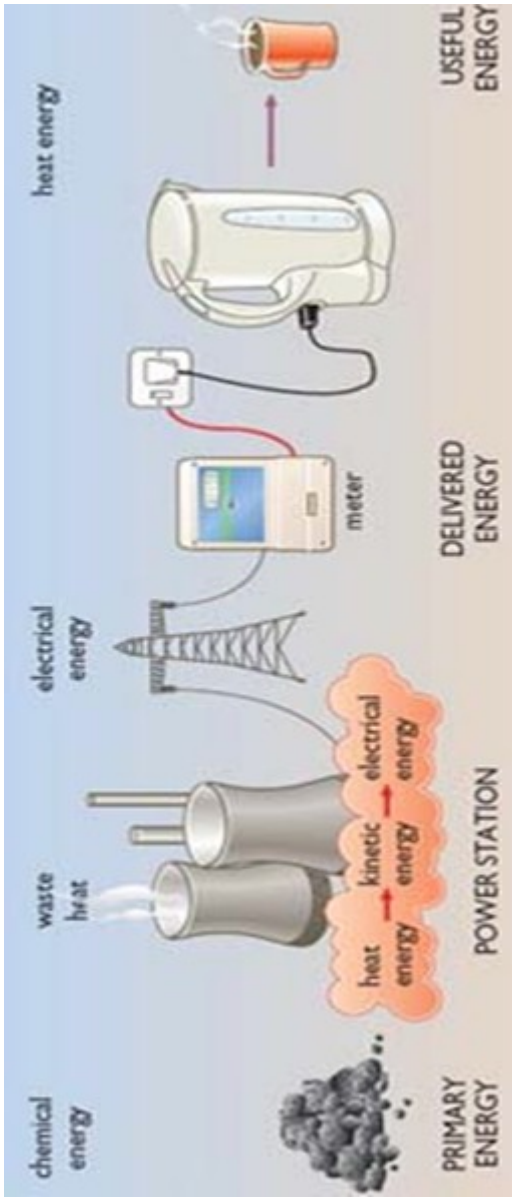
When Thomas Edison set up the world's first electric power station in New York in 1882, it was not electricity he sold, but light. He provided the electricity and light bulbs, and charged his customers for the service of illumination. This meant he had a strong incentive to generate and distribute electricity as efficiently as possible, and to install light bulbs that were as efficient and long-lasting as possible.

Unfortunately, the early Edison approach did not survive, and the regulatory regime under which most utilities operate today simply rewards them for selling as much energy as possible, irrespective of the efficiency with which it is used or the longevity of the appliances using it. In a few countries, however, governments have changed the way energy utilities are regulated by setting up mechanisms to reward them for providing energy services rather than mere energy. In this case, customers benefit by having lower overall costs, the utility makes as much profit as before, and the environment benefits through reduced energy wastage and the emission of fewer pollutants.

Linking supply and demand

Apart from the aforementioned relatively few enlightened examples, the efficiency with which humanity currently uses its energy sources is generally very low. At present, only about one-third of the energy content of the fuel the world uses emerges as 'useful' energy, at the end of the long supply chains we have established to connect our coal and uranium mines, our oil and gas wells, with our energy-related needs for warmth, light, motion, communication, etc. (see **Figure 8.1**). The remaining two-thirds usually disappears into the environment in the form of 'waste' heat. One of the reasons for our continuing inefficiency in energy use is that energy has been steadily reducing in price, in real terms, over the past 100 years (see **Figure 8.2**).

Figure 8.1. An example of one of the energy 'chains' linking primary energy with delivered energy and useful energy, via various energy transformations.



Energy's decreasing cost means that our society has only a relatively weak financial incentive to use it more wisely. The chains that link energy supplies with users' demands are lengthy and complex, as **Figure 8.1** illustrates. Each link in the chain involves converting energy from one form or another, for example in the burning of coal to generate electricity; or distributing energy via some kind of transmission link or network, such as a national electricity grid or gas pipeline infrastructure.

Figure 8.2. Average household rates for US electricity, 1900–2000, expressed in real terms, i.e. taking into account the effects of inflation. Source: Smil (2000).

Energy efficiency improvements

Supply side measures

On the supply side of our energy systems, there is a very large potential for improving the efficiency of electricity generation by introducing new technologies that are more efficient than older power plants. The efficiency of a power plant is defined as the percentage of the energy content of the fuel input that is converted into electricity output over a given time period. Since the early days of electricity production, power plant efficiency has been improving steadily. The most advanced form of fossil-fuelled power plant now available is the Combined Cycle Gas Turbine (CCGT).

CCGTs are more than 50% efficient, compared with the older steam turbine power plants that are still in widespread use, where the efficiency is only about 30% and thus about 70% of the energy content of the input fuel is wasted in the form of heat, usually dumped to the atmosphere via cooling towers.

CCGTs are more "climate friendly" than older, coal-fired steam turbine plants, not only because they are more efficient but also because they burn natural gas, which on combustion emits about 40% less CO2 than coal per unit of energy generated. Overall, taking into account both the higher efficiency and natural gas's lower CO2 emissions, when compared with traditional coal-fired plant CCGT-based power plants release about half as much CO2 per unit of electricity produced. Most of the reductions that occurred in Britain's CO2 emissions during the 1990s were due to the so-called "dash for gas" as a substitute for coal in power generation.

In some countries, the "waste" heat from power stations is widely used in district heating schemes to heat buildings. In 2000, around 72% of Denmark's electricity was produced in such 'Combined Heat and Power' systems.

After fuels have been converted to electricity, whether in CCGTs or steam turbine-only plants, further losses occur in the wires of the transmission and distribution systems that convey the electricity to customers. In the UK, these amount to around 8%. Overall, this means that even when a modern, high-efficiency CCGT is the electricity generator, less than half the energy in its input fuel emerges as electricity at the customers' power sockets. In the case of older power stations the figure is around 25%.

Clearly, there is room for further improvements in the supply-side efficiency of our electricity systems, by further increasing the efficiency of generating plant and by ensuring that whatever "waste" heat remains is piped to where it can be used.

Coal, oil and gas, when they are used directly rather than for electricity generation, are also subjected to processing, refining and cleaning before being distributed to customers. Some energy is also lost in their distribution, for example in the fuel used by road tankers or the electricity used to pump gas or oil through pipelines. However, these losses are much lower, typically

less than 10% overall. This means that over 90% of the energy content of coal, oil and gas, if used directly, is available to customers at the end of the processing and distribution chain. The scope for further supply-side efficiency improvements is obviously much more limited here than in the case of electricity.

Demand-side efficiency improvements

Now we will examine briefly what can be done to improve the efficiency of energy use at the demand side – that is, in our buildings, industries and vehicles.

Improving the sustainability of energy use by applying demand-side measures involves two distinct approaches:

1) Technological

2) Social

The technological approach involves installing improved energy conversion (or distribution) technologies that require less input energy to achieve a given level of useful energy output or energy service.

The social approach involves re-arranging our lifestyles, individually and collectively, in minor or perhaps major ways, in order to ensure that the energy required to perform a given service is reduced in comparison with other ways of supplying that service.

For example, you may live in a densely populated town with shops, offices, schools and other amenities scattered evenly around. You may be able to do your shopping, or go to work or university, without using a car, simply by walking relatively short distances. Or you may find it convenient to catch a bus, as bus services are usually more frequent and efficient in higher-density settlements.

On the other hand, you may live in a town with a similar population, but one that has been designed (as have many new towns) to have a low population density (i.e. fewer residents per area land), with shops and offices concentrated in the town centre. In this case, you may well use a car for many of your local journeys, consuming fossil fuels and generating emissions of greenhouse gases and other pollutants.

In both towns, the residents receive exactly the same levels of service: shopping, working, schooling, etc. But in the high-density town the residents can use energy services more sustainably than in the low-density town – all other things being equal.

In government energy statistics, energy demand is usually broken down into four main sectors:

1) The domestic sector

2) The commercial and institutional sector (often termed the services sector)

3) The Industrial Sector

4) The Transport Sector

The domestic sector

This consists of individual households, within which the main categories of energy use are for space heating, water heating, cooking, lighting and other electrical appliances.

Within the UK, Energy Performance Certificates (EPCs) give information on how to make homes more energy efficient and reduce energy costs. All homes bought, sold or rented within the UK require an EPC. EPCs contain information such as a home's energy use and typical energy costs as well as a recommendation report with suggestions to reduce energy use and save money. An example EPC can be downloaded from here:

http://www.communities.gov.uk/documents/planningandbuilding/pdf/2116821.pdf

People within the domestic sector also have the choice as consumers to purchase energy efficient products for their homes. For example, the EU Directive 92/75/EC established an energy consumption labelling scheme for home appliances like washing machines, dishwashers and refrigerators. The energy efficiency of the appliance is rated in terms of a set of energy efficiency classes from A to G on the label. Where A is the most energy efficient and G the least efficient. The labels allow consumers to compare different products. A+, A++ and A+++ grades have recently been introduced for refrigeration products. Directive 92/75/EC was replaced by Directive 2010/30/EU on 31 July 2011.

The services sector

This consists of offices, shops, schools, hospitals, banks, etc. The energy requirements of this sector are very similar to those of the domestic sector: space heating, water heating, cooking, lights and appliances. Air conditioning, however, is more prevalent in this sector than in the domestic sector – at least in countries with temperate climates, like the UK. In this sector, as in the domestic sector, most of consumption is within buildings.

The main technological measures that can be taken to conserve energy and use it more efficiently within buildings include:

• improved levels of insulation in walls, roofs and floors, to reduce heat losses through these elements;

• Energy-efficient windows, designed to allow less heat to escape whilst still admitting large amounts of sunlight;

• Draught-proofing and heat recovery systems to reduce heat lost through ventilation whilst retaining sufficient fresh air within the building;

• More efficient boilers that require a smaller fuel input to achieve a given level of space or water heating, together with improved insulation of pipes to reduce heat losses;

• Energy-efficient lights that require much smaller amounts of power to provide a given level of illumination;

• Energy-efficient appliances, such as refrigerators, cookers, washing machines, dishwashers, TV sets and hi-fi equipment in the domestic sector;

• More efficient computers, copiers and other business equipment in the commercial and institutional sector. These consume less energy whilst delivering the same level of service as their inefficient predecessors;

• Improved control systems, to ensure that energy-consuming equipment is not switched on when not needed, and that power output levels match the requirements of users.

Buildings can incorporate several of these initiatives to help reduce energy demand and so become more sustainable.

It is now common for businesses and institutions in the service sector to publish sustainability plans. These documents outline the measures and policies that the business/institution has adopted to encourage sustainability. Policies on energy efficiency are typically included in these plans. For example, Marks and Spencer (M&S), a major UK high street retailer, has published “Plan A” (M&S, 2011). Plan A is the M&S sustainability plan. It was launched in January 2007 and it originally set out 100 commitments to achieve in 5 years. M&S have now extended Plan A to 180 commitments to achieve by 2015, with the ultimate goal of becoming “the world's most sustainable major retailer” (M&S, 2011). Through Plan A, M&S are working with their customers and suppliers to combat climate change, reduce waste, use sustainable raw materials, trade ethically, and help customers to lead healthier lifestyles. In 2011, M&S had achieved 95 of the 180 Plan A commitments they set themselves in 2007 and 2010 (M&S, 2011). In terms of energy efficiency, M&S have improved energy efficiency in their stores by 23% and their warehouses by 24%, relative to 2007 (M&S, 2011). M&S have also met their target to improve the fuel efficiency of their delivery fleets by 20% (M&S, 2011). Their total carbon emissions reduced by 13% from 2007 whilst their sales floor footage continued to grow (M&S, 2011). This

demonstrates that M&S have been able to develop their business while at the same time incorporate a range of sustainability policies, including improvements in energy efficiency.

The University of Nottingham has invested heavily to ensure their buildings have as little impact as possible on the environment, across their campuses in the UK, Malaysia and China. For example, the University's Jubilee Campus in Nottingham, UK is a model of sustainability and low-energy design, deriving heating and cooling from energy produced by the on-site lake and 450m2 of solar PV cells. Furthermore, new buildings at the Jubilee Campus Extension – such as International House and the Sir Colin Campbell Building– exceed stringent building regulations and have a carbon footprint that is 55% lower than average; thanks to innovations such as clever insulation and solar-controlled glass.

Activity

Please now open your blog (or offline document) that you have been developing throughout this module. Create a new title and date entry called "Energy efficiency in the service sector: a case study". Go online to search for an example of a specific institution or business of your choice that has engaged in energy efficiency improvements. Hint: try searching on Google with key words for well known businesses and/or institutions and words like "energy efficiency" and "sustainability". In this section of your blog, include 5-6 bullet points of the steps taken by your chosen business or institution to improve energy efficiency, including any evidence of the steps being successful. The blog should be fewer than 400 words and take no longer than 25 minutes to complete.

The industrial sector

Much of industrial energy use also occurs within buildings, and consists of requirements for space heating, water heating, cooking, lights and appliances, as in the domestic and commercial and institutional sectors. But in addition, many industries, such as the steel industry, use substantial quantities of high-temperature heat and large amounts of electricity to power various specialised processes. These demands in many cases exceed those of the buildings where the activities are housed and of the people within them.

So apart from improving the energy efficiency of the buildings and appliances in the industrial sector, where the approaches are similar to those in the domestic and services sectors, there are other measures that apply specifically to industry. In particular, these include "cascading" of energy uses, where "waste" heat from a high-temperature process is used to provide energy for lower temperature processes; and the use of high-efficiency electric motors, pumps, fans and drive systems, with accurate matching of motors to the tasks they are required to perform, and accurate sizing of pipes and their associated pumps.

The measures that can be adopted by industry also include reductions in the material content of products, for example in car bodies or drinks cans, where thinner metals can be used without any reduction in the required strength; or

the substitution of less energy-intensive materials, as in the use of plastics instead of steel for car bumpers.

These measures are one form of what has been termed "dematerialisation" – a reduction in the material-intensity (and hence the energy-intensity) of production.

Another form of dematerialisation involves changes that are more social than technological. It occurs when the structure of a country's entire economy shifts towards less energy- and materials-intensive activities. For example, in the UK the steel industry today accounts for a much smaller share of the country's gross domestic product (GDP) than it did 20 years ago. By contrast, the UK services sector now constitutes a much bigger fraction of GDP than two decades ago. Since the service sector usually requires less energy than the steel industry for every pound's worth of production, Britain's overall energy demands have been less than they would otherwise have been. However, if the steel that was formerly manufactured in Britain is now manufactured abroad but still imported to the UK in similar quantities, all that has happened is that the energy input, with its associated CO2 emissions and their implications for global warming, has been transferred to another country.

The transport sector

Motor vehicles (cars, vans, buses, trucks, motor cycles) dominate the transport sector in developed countries. But this sector also encompasses many other modes of transport, including rail, air and shipping, and non-motorised transport forms such as cycling and walking.

In most developed countries there has been an enormous increase in transportation, measured in passenger-kilometres travelled annually, over the past few decades. Most of this has involved motorised transport, mainly fuelled by oil, and so energy use has also increased greatly, as have the associated CO2 emissions.

Transport energy demand can be reduced by implementing social measures and technological measures.

An obvious social way of reducing the energy required by the transport sector is to shift a proportion of people's journeys away from the energy-intensive modes and towards the more energy-frugal modes. This process is sometimes termed 'modal shift'. This could be achieved without reducing the total number of journeys, or the overall distance travelled, so that the amenity or service enjoyed by the traveller would remain the same. If, for example, a greater proportion of long-distance journeys within Europe were made by inter-city train rather than by air, the overall energy demand involved could be reduced substantially. Or if urban commuters made more

journeys to work by rail, bicycle or bus instead of using their cars, the effects would be similar. For example, more and more businesses are now encouraging their staff to participate in car-sharing schemes. Also, a number cities across the globe have now introduced pay-as-you-go bicycle rental docking stations in an effort to encourage people to travel by bicycle across cities, instead of by car; for example, London and Melbourne. In London, more than 4,000 new cycle-hire docking points were installed and 2,000 new bikes provided, in the run-up to the 2012 Olympics, in a drive towards sustainability.

Of course, if people are to undertake transport modal shifts of these kinds, they will need to be encouraged by fast, comfortable, efficient services – or penalised into switching by such measures as congestion charging, which is being implemented in central London and other major cities. For example, please now watch the following short video (4 minutes), which attempts to describe in an accessible and concise way, how to use the pay-as-you-go bicycles in London: http://youtu.be/DVCF2MXH31I.

How successful do you think this video is? Would you be willing to try using one of these bicycles instead of public transport or driving? Do you think this is a good step towards sustainable energy? Please now open your blog (or offline document) that you have been developing throughout this module. Create a new title under today's date entry called "Energy efficiency in the transport sector: pay-as-you-go bikes". In this section of your blog, record your answers to these questions in no more than 400 words. Spend no longer than 20 minutes on this activity.

In addition to such social measures, there are numerous technological options for improving the energy efficiency of transport energy use. Improving vehicle fuel economy is one obvious measure, and the average fuel economy (in miles per gallon, or litres per 100 km) of vehicles has indeed improved very substantially in most developed countries over the past few decades. However, this improvement has been largely offset (in the UK at least) by an increase in the total number of vehicle-miles travelled, and by increases in the average speeds of vehicles, both of which result in increased fuel consumption. Nevertheless, manufacturers continue to introduce new models with steadily improving fuel economy, partially spurred by legislation requiring them to do so. New approaches include 'hybrid' petrol-electric cars such as the Toyota Prius (www.toyota.co.uk/Prius) and the Tesla Roadster (http://www.teslamotors.com/goelectric)

Please now watch the following short video (4 minutes), which is aimed at encouraging energy efficiency. Note how the video aims to address three of the four energy sectors we have just covered. The video can be viewed here:

http://www.youtube.com/watch?v=QG3HNQiEaTM

The rebound effect

When individuals or organisations implement energy efficiency improvements, they usually save money as well as energy. However, if the money saved is then spent on higher standards of service, or additional energy-consuming activities that would not have otherwise been undertaken, then some or all of the energy savings may be eliminated. This tendency is sometimes known as the "rebound effect".

For example, if householders install improved insulation or a more efficient heating boiler, they should in principle reduce their heating bills. However, if they instead maintain their homes at a higher temperature than before, or heat them for longer periods, the savings may be wholly or partly negated. Alternatively, they may decide to spend the money saved through lower heating bills by taking a holiday involving air travel. Since air travel is quite energy-intensive (see Figure 8.8) once again the energy savings will be offset by increased consumption, albeit of a different kind.

In devising national policies to encourage energy efficiency improvement, governments need to take the rebound effect into consideration. In some cases, it may mean that the energy savings actually achieved when energy efficiency measures are implemented are less than expected. Another policy implication is that citizens should be given incentives to spend any savings they make through implementing energy efficiency measures in ways that are energy-frugal rather than energy-intensive.

Public opinion on renewable energy and energy efficiency

Renewable energy sources are generally sustainable in the sense that they cannot "run out" – although, as noted in Session 7 , both biomass and geothermal energy need wise management if they are to be used sustainably. For all of the other renewables, almost any realistic rate of exploitation by humans would be unlikely to approach their rate of replenishment by nature, though of course the use of all renewables is subject to various practical constraints.

Renewable energies are also relatively sustainable in the additional sense that their environmental and social impacts are generally more benign than those of fossil or nuclear fuels. However, the monetary costs of many renewable sources are at present considerably higher than those of conventional fuels. Until this imbalance is reduced, either by reducing the costs of renewables or through increases in the costs of conventional sources, renewables may be unable to succeed in capturing a substantial fraction of the world market.

Moreover, the deployment of renewables in some cases entails significant environmental and social impacts. Renewable energy sources are generally much less concentrated than fossil or nuclear fuels, so large areas of land (or building surfaces) are often required if substantial quantities of energy are to be collected. This can lead to a significant visual impact, as in the case of wind turbines. For example, see the following news article, published in The Telegraph in April 2012, which reports on public opinion of a planned wind farm on Thornton Moor at Howarth in Yorkshire (the "wild and wonderful" moorland that inspired the book Wuthering Heights):

http://www.telegraph.co.uk/earth/earthnews/9189105/Fears-over-wind-turbine-plans-in-Bronte-country.html

Note how in The Telegraph news article, the Chair of the Thornton Moor Wind farm Action Group is reported as saying: "The damage to the landscape is going to be irreparable. Our whole way of life is going to suffer". This strikes important nuances with ecological and social sustainability. So, while wind energy is a relatively sustainable form of energy production, in some cases, it can be in conflict with other sustainable issues.

Activity

Having read The Telegraph news article above, please now open your blog (or offline document) that you have been developing throughout this module. Create a new title under the date entry you started earlier, called "Sustainable energy and conflicts of interest". In this section of your blog, record your opinion in fewer than 500 words, of The Telegraph article. You may wish to consider whether you think the wind farm should be built, or not? Do you think that the development of a renewable energy wind source at the expense of the loss of a piece of beautiful and historically important piece of land is a justifiable trade-off? Spend no longer than 20 minutes on this activity.

The Yorkshire wind farm case study shows how the public may not necessarily simply accept renewable energy, as a means to achieving sustainable energy usage. Indeed, recent research (POST, 2007) has highlighted this issue of NIMBY-ism (Not-In-My-BackYard) in renewable energy. This suggests that people will support the abstract concept of renewable energy but tend to oppose it when it would affect them or their lifestyles (for example if a wind farm was proposed on land near their home). On the other hand, there is evidence to suggest that people living close to or having direct experience of wind power developments tend to view them positively.

What is more clear from research, is that the public feels that attention should be focussed on demand reduction and energy efficiency, rather than energy production, in terms of achieving sustainable energy (POST, 2007). Moreover, the public is generally aware that meaningful long term changes, especially in terms of lifestyle and behaviour are required to achieve sustainability of energy. We have considered several of these already in this Session.

Summing Up

Mechanisms and schemes aimed at improving energy efficiency are an additional means to renewable energy, for encouraging sustainable energy.

•On the supply side of energy, efficiency improvements can be made in the methods used to generate energy.

•On the demand side, efficiency improvements can be achieved in the domestic, industrial, services and transport sectors.

•While energy efficiency improvements are achievable, in order to achieve an improvement in sustainability it is important that the benefits of these achievements are not offset by increased energy usage elsewhere, which occur as a result of the savings; i.e. the "rebound effect".

•The public feels that attention should be focussed on demand reduction and energy efficiency, rather than renewable energy production, in terms of achieving sustainable energy.

Extra Reading

The Parliamentary Office of Science and Technology have compiled a brief report (POST, 2007) which assesses the opinion of the UK public on whether they prefer that sustainable energy should be achieved through renewable energy or energy efficiency changes. The report can be downloaded from here: http://www.parliament.uk/briefing-papers/POST-PN-294

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Chapter 9: Changing Attitudes Towards Sustainability

Throughout this module, we have learnt about numerous incentives aimed at encouraging sustainability. A lot of these incentives are aimed at educating or encouraging the public to make social changes in their normal daily lives towards acting in a more sustainable way. Some examples we have seen are:

• The Water Footprint – aimed at encouraging people to use water more sustainably (Session 3).

• Fairtrade labelling – aimed at encouraging people to buy products that promote sustainable agriculture and food security (Session 5).

• The Plant for the Planet "Billion Tree Campaign" – aimed at encouraging sustainable forestry (Session 6).

• Forest Stewardship Council (FSC) labelling – aimed at encouraging sustainable forestry (Session 6).

• EU energy efficiency labels on "white goods" (e.g. refrigerators, washing machines, dishwashers) – aimed at encouraging people to buy energy efficient products (Session 8).

However, for initiatives such as these to be wholly successful in achieving sustainability, they need to be adopted by the people they are aimed at. In the examples above, public engagement with the initiatives is required. Moreover, while progress is being made in the natural and physical sciences towards technological solutions and in political circles towards more sustainable policies, an understanding of individuals is vital for these new technologies to be adopted and policies supported.

This Session explores the importance of the psychology of sustainability and public perceptions of sustainability, as well as the relevance of promoting sustainable behaviour in the right way. This is important because an understanding of these issues will facilitate the formulation of successful initiatives and policies that are adopted by the public and businesses.

This is achieved by focussing on an exploration of how the UK government is promoting sustainable behaviour. The UK government has made a number of attempts to develop an under-standing of British pro-environmental attitudes and behaviours. For example, there have been periodic surveys of public perceptions of sustainable behaviours conducted by the Department for Transport, e.g. DfT (2010), while Defra (the Department for Environment, Food and Rural Affairs) has developed a "framework for sustainable behaviours" which identifies different "segments" and top level "groups" of the population based on their attitudes and behaviours (Defra, 2008). This framework will be explored in this Session first. Then, recent research on the relationship between human behaviour and sustainability, conducted by the UK Cabinet Office Behavioural Insight Team, will be presented. Finally, the Session concludes with an online lecture on the psychology of sustainability.

The Defra (2008) Framework for Sustaunable Behaviours Report

The Defra (2008) study concentrated on the main public consumption clusters of food and drink, personal travel, homes and household products, and travel tourism. Environmental behaviours across all the environmental sectors, including climate change, air quality, water quality, waste, biodiversity and protection of natural resources, taking account of our "global footprint", were considered by Defra (2008). Specifically, the study investigated 12 headline behaviour goals, selected after a process of stakeholder engagement, to identify a range of low/high impact and easy/hard behaviours, some of which could potentially engage large numbers of people and others which would be more appropriate for targeting particular population groups. The 12 goals, across five sectors were:

• Personal transport

1. Use more efficient vehicles

2. Use car less for short trips

3. Avoid unnecessary flights (short haul)

• Homes: waste

4. Increase recycling

5. Waste less food

• Homes: energy

6. Install insulation

7. Better energy management

8. Install microgeneration (the small-scale generation of electric power by individuals, small businesses and communities to meet their own needs)

• Homes: water

9. More responsible water usage

• Eco-products

10. Buy energy efficient products

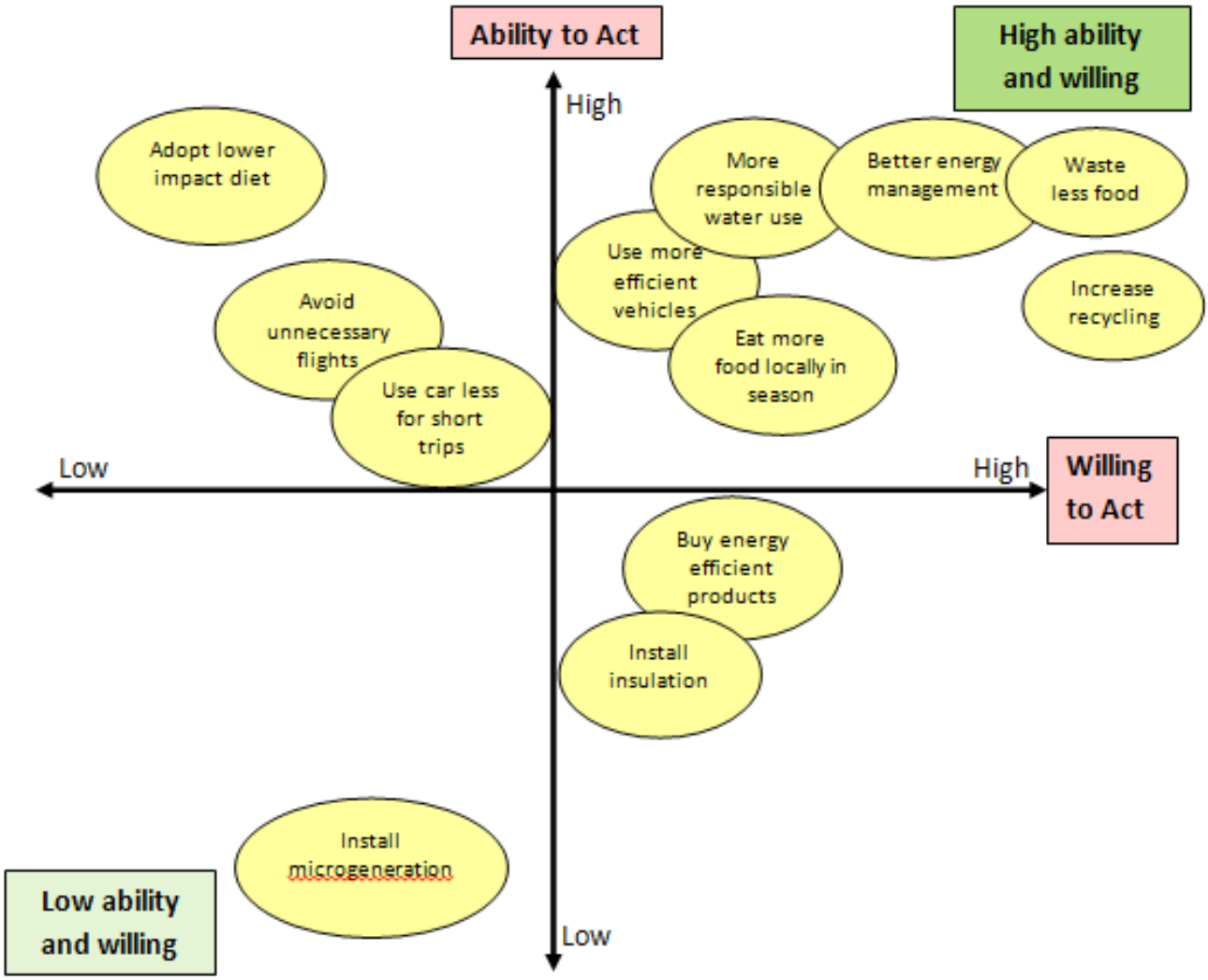
11. Eat more food that is locally in season

12. Adopt a lower impact diet.

The Defra (2008) study looked at people's willingness and ability to act on these 12 headline goals in the UK. The results showed that there are some behaviour goals to which the door is relatively open, as most people are already willing to act and have a high ability to do so. For example, to waste less food, adopt better energy management in the home, and engage in more

responsible water usage. Goals that were found to be more challenging were either those where there is low ability and low willingness to act (e.g. install micro-generation) or those where willingness is low although people acknowledge that they could act (e.g. avoiding unnecessary flights). These are summarised in **Figure 9.1**.

Figure 9.1 People's willingness and ability to act on 12 headline goals of sustainability, as found in a study by Defra (2008).

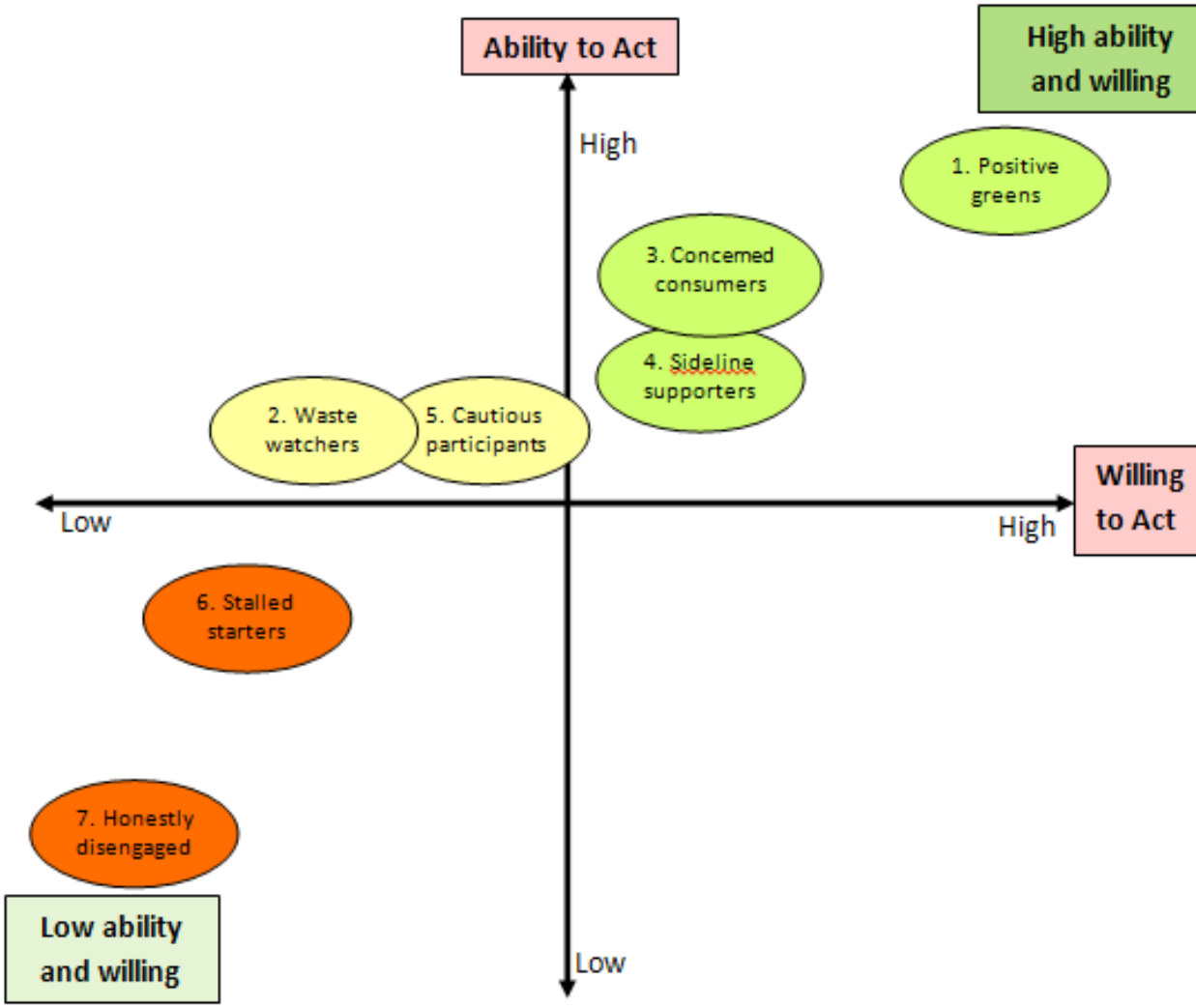


Based upon the results that Defra (2008) found, and which are presented in **Figure 9.1,** they then divided the UK population into seven broad segments. Each segment was defined upon a person's ability and willingness to act on the 12 sustainability goals together. The seven segments were:

1. Positive greens
2. Waste watchers
3. Concerned consumers
4. Sideline supporters
5. Cautious participants
6. Stalled starters
7. Honestly disengaged

The seven segments are shown diagrammatically in **Figure 9.2**

Figure 9.2. The seven segments of the UK population based upon a person's ability and willingness to act on the 12 sustainability goals together, as defined by Defra (2008)



Above graph sourced from Defra (2008) under the Open Government License (Crown Copyright).
http://www.defra.gov.uk/publications/files/pb13574-behaviours-report-080110.pdf

Defra (2008) then divided the seven segments into three top-level groups (these are identified by the different coloured ellipses in **Figure 9.2**).

• Group 1

This group included segments 1, 3 and 4. This group is typified by people who are relatively willing to act and have relatively high potential to do more. Segment 1 are already active, but, because of their commitment and strong pro-environmental beliefs, are prepared to do more. People in segment 3 have less conviction in their environmental views and are less active than segment 1 but being environmentally friendly fits with their self-identity and they are willing to do more. People in segment 4 have similar pro-environmental beliefs to segment 1 but they are relative beginners with environmental behaviours and very willing to do more, in at least some areas of their lives. Defra (2008) argued that best way to engage people in this group with sustainability is to tackle external barriers such as information, facilities and infrastructure and to engage people through communications, community action, and targeting of individual opinion leaders.

• Group 2

This group included segments 2 and 5. These segments need different approaches to encourage people to be more environmentally friendly and to act in sustainable ways. People included in segment 2 are already active, though driven by a motivation to avoid waste, high concerns about changes to the UK countryside and have concerns about other countries not acting. People in segment 5 tend to be more dependent on behaviours becoming the norm before they will act and more embarrassed to be green. However, they are willing to do more to achieve sustainability than people in segment 2. Defra (2008) argued that the best way to encourage people in this group to act sustainably is to provide fiscal incentives or for businesses and government to lead by example.

• Group 3

This group included segments 6 and 7. People here are generally less willing to act and are less likely to be open to voluntary engagement or exemplification by others. Defra (2008) argued that the best way to encourage people in this group to act sustainably is to implement interventions of choice editing in product availability or, where necessary, regulation.

Please now open your blog (or offline document) that you have been developing throughout this module. Create a new title and date entry called "Willingness and ability to act sustainably". In this section of your blog, write a couple of paragraphs about where you would fit into **Figure 9.1**. This blog post should not exceed 500 words and it should take less than 30 minutes to prepare.

Activity

Please now open your blog (or offline document) that you have been developing throughout this module. Create a new title and date entry called "Willingness and ability to act sustainably". First, edit the interactive flash graph below, which is a replication of **Figure 9.1**, to reflect your own willingness and ability to act on the 12 headline goals of sustainability outlined by Defra. You can move the 12 balloons around to reflect your own views. When you are happy with where you have placed the balloons, please press the "Print Screen" button on your keyboard to copy the image. Then paste this into your blog by pressing "Control" and "V" on your keyboard simultaneously.

Then in your blog write a paragraph or two about why you placed the balloons where you did. For example, you could consider whether you think that you are more willing to avoid unnecessary flights than the general result for the UK that is presented in **Figure 9.1**? Do you feel as able and willing to recycle and reduce food waste as the general UK population presented in **Figure 9.1**?

Finally, please include a sentence that states whether you willingness and ability to act on any of these seven goals of sustainability outlined by Defra (2008) have changed since undertaking this module. This is important to think about, because it demonstrates the degree to which peoples' attitudes towards sustainability change. Throughout this module, you have essentially engaged in education on some aspects of sustainability. If your attitude towards sustainability has not been influenced by this module, then this demonstrates precisely how challenging it can be for governments to influence peoples' attitudes towards sustainability – it is not something that can be changed very quickly or easily.

This blog post should not exceed 500 words and it should take less than 30 minutes to prepare.

Research by the Behavioural Insight Team

the UK government has produced comes from the Cabinet Office, which contains a group known as the Behavioural Insight Team:

http://www.cabinetoffice.gov.uk/content/applying-behavioural-insights. The Behavioural Insight Team was announced in 2010 to provide an evidence base for government programmes that aimed to influence individual behaviour.

Many of the most pressing public policy issues we face today are influenced by how we, as individuals, behave. For example, we can all cite instances in which we know that we should act differently in our own self interest or in the wider interest, but for one reason or another do not. The Behavioural Insight Team acknowledges that the traditional tools of Government have proven to be less successful in addressing these behavioural problems (O'Donnell, 2012). To this end, it is necessary to think about ways of supplementing the more traditional tools of government, with policy that helps to encourage behaviour change of this kind. This is what the Behavioural Insights Team seeks to achieve and it supports Government departments in designing policy that better reflects how people really behave, not how they are assumed to behave.

Governments are often reluctant to openly attempt to influence people's values, and the Behavioural Insight Team draws heavily on work by two behavioural economists (Thaler and Sunstein, 2008), which is seen as offering a 'value-neutral' approach to behavioural change. Indeed, the team is often referred to colloquially as the 'Nudge' team (after the title of the book by Thaler and Sunstein (2008)). Thaler and Sunstein (2008) describe their approach as focusing on 'decision architecture', but it shares a great deal of common ground with the principles of social marketing the systematic application of marketing concepts and techniques to achieve specific behavioural goals relevant to the social good.

There are two reports that show most clearly how the UK government is seeking to influence sustainable behaviours. The first introduces an approach called 'MINDSPACE' (Dolan et al., 2010), which is an acronym for the nine principles that the Cabinet Office considers to be critical for influencing individual behaviour. The nine principles are:

1. Messenger (people are heavily influenced by who communicates information).

2. Incentives (our responses to incentives are shaped by 'heuristics' such as strongly avoiding losses).

3. Norms (we are strongly influenced by what others do).

4. Defaults (we "go with the flow" of pre-set options).

5. Salience (our attention is drawn to what is novel and seems relevant to us).

6. Priming (our acts are often influenced by sub-conscious cues).

7. Affect (our emotional associations can powerfully shape our actions).

8. Commitments (we seek to be consistent with our public promises, and reciprocate acts).

9. Ego (we act in ways that make us feel better about ourselves).

These nine principles are designed to be applicable to a range of domains – not just sustainable behaviours. Although the nine principles remain within the boundaries of social marketing, the MINDSPACE approach is quite a sophisticated and evidence-based strategy for impacting sustainable behaviours.

Using these principles, the Behavioural Insight Team produced a second report looking specifically at household energy behaviours, and has applied a wide range of behavioural economic evidence to the design of the "Green Deal" (http://www.decc.gov.uk/en/content/cms/tackling/green_deal/green_deal.aspx).

The Green Deal is a flagship policy aimed at improving the energy efficiency of up to 14 million homes in the UK. For example, drawing on the "Incentives" principle of MINDSPACE, low-interest loans are being offered to households to remove the barrier of paying "up-front" for things like home insulation. Also, in collaboration with the energy company Opower, information about neighbours' energy usage will be made available on people's energy bills (based on the 'Social Norms' principle of MINDSPACE). Please take a look around the Opower website, here: http://www.opower.com/

Social Norms and Social Networks

Rather than exploring in detail each of the nine principles of MINDSPACE, in this section, we focus on the "N" of MINDSPACE – "Social Norms." If you are interested in learning more about the other principles of MINDSPACE, then you are encouraged to read the full report by Dolan et al. (2010), which can be accessed here:

http://www.instituteforgovernment.org.uk/sites/default/files/publications/MINDSPACE.pdf

It is very rarely that people act purely as individuals. Most of our behaviour is social – with family, friends, colleagues or even strangers on the commute to work. Many strategies for promoting sustainable behaviour seem to forget this, and focus exclusively on people as individuals.

Too often, communications on sustainability are directed to the individual as a single unit in the larger social system. This can make the problems feel too overwhelming, but through an enhanced awareness of what other people are doing, a stronger sense of collective purpose can be developed.

One of the most well-supported bodies of research on sustainable behaviour starts from the position that changing individuals' actions is best achieved by highlighting and influencing the behaviour of others around them: focusing on social norms to promote sustainable behaviour. Social norms are simply the standards that we use to judge the appropriateness of our own behaviour. People tend to act in a way that is socially acceptable, and so if a particular behaviour (littering, for example, or driving a car with a large engine) can be cast in a socially unacceptable light, then people should be less likely to engage in it.

Pictures and videos of ordinary people ("like me") engaging in sustainable behaviours are a simple and effective way of generating a sense of social normality around saving energy (Schultz et al., 2007). There are different reasons that people adopt social norms, and encouraging people to adopt a positive norm simply to "conform", to avoid a feeling of guilt, or for fear of not "fitting in" is likely to produce a relatively shallow level of motivation for behaviour change. Where social norms can be combined with "intrinsic" motivations (e.g. a sense of social belonging), they are likely to be more effective and persistent (Climate Change Communication Advisory Group (CCCAG), 2010).

However, while social norms are a powerful and effective way of influencing sustainable behaviours, there are some pitfalls to avoid. As Cialdini (2003) demonstrated, the problem with campaigns and appeals based on social norms is that they often contain a hidden message. So, for example, a campaign that focuses on the fact that too many people take internal flights actually contains two messages – that taking internal flights is bad for the environment, and that lots of people are taking internal flights. This second message can make the campaign counterproductive; by conveying how common

the undesirable behaviour is, it can give those who do not currently engage in that behaviour a perverse incentive to do so.

In an experiment by Schultz et al. (2007), researchers examined the influence of social norms on the household energy consumption of residents of California. The researchers picked houses at random and then divided them into groups depending on whether their energy consumption was higher or lower than the average for that area. Some low-energy-use households received only information about average energy usage — thereby setting the social norm. A second group of low-energy households had a positive "emoticon" (happy face; J) positioned next to their personal energy figure, conveying approval of their energy footprint. A third group of over-consuming households were shown their energy usage coupled with a negative emoticon (sad face; L), intended to convey disapproval of their higher-than-average footprint.

The researchers then measured energy consumption in the following months. As one might expect, the over-consuming households used the social norm as a motivation to reduce their energy use, but under-consuming households that had received only the social norm information increased their energy use. Crucially, though, the under-consuming households that had received positive feedback did not show this "rebound effect" (recall how we discussed this notion in Session 8; the addition of a smiley face next to their energy usage made all the difference J. Despite the simplicity of the feedback, households that felt their under-consumption was socially approved (rather than a reason to relax), maintained their small energy footprint. This suggests that using social norms can be effective — but only if they are used in the right way.

As we saw earlier in this Session, academic research like this is now being put into practice by the energy company Opower, who have used simple social norm strategies like this to achieve consistent savings on average energy use with their US customers (Allcott, 2011). Working with the UK government's Behavioural Insight Team, Opower are now trialling similar techniques in the UK. But the strategy of focussing on the "social" rather than the "individual" level can be taken much further than cleverly designed energy bills: there are few influences more powerful than an individual's social network, and if positive norms for sustainable behaviour are incorporated at this level, they will have even more of an impact.

Social networks are everywhere. Friends, colleagues, neighbours and family make up most people's network of social contacts, and they have a powerful effect on our behaviour. The idea that information and innovation can spread through social networks is not a new one – in the field of commercial marketing, advertising campaigns targeting "opinion leaders" and influential individuals is commonplace. In other fields – health behaviour for example – campaigns often target peer groups and existing social networks, in the hope that the spreading of positive health behaviours will be more likely within groups of individuals who trust each other and pay attention to each others' behaviour.

Can social networks be used to spread pro-environmental behaviour? Unfortunately, there is not much in the way of direct evidence to answer this question. Olli et al. (2001) have suggested that whether or not people are in an "environmental network" is one of the biggest determinants of engaging in pro-environmental behaviour. This does not tell us whether social networks diffuse pro-environmental behaviour among their members, or whether people with a pre-existing interest in pro-environmental behaviour join these sorts of social networks. But the evidence that does exist about social networks and the diffusion of behaviour in general suggests that sustainable behaviours will be enhanced by targeting social networks rather than individuals.

Social networks are important for creating a social identity that incorporates sustainability as a guiding principle (Rabinovich et al., 2010), rather than simply passing on a series of disjointed behaviours that may benefit the environment. If sustainable behaviour is incorporated at this level (and becomes defining for a social group) more significant behavioural changes (reinforced through peer pressure) are likely to be facilitated. Targeting social networks also helps to enhance "social capital' – something that is critical for building the resilience to cope with and adapt to changes brought about by adapting to climate change (Rowson et al., 2010). Moreover, the efficacy of group based programmes at promoting pro-environmental behaviour change has been demonstrated on numerous occasions – participants in these projects consistently point to a sense of mutual learning and support as a key reason for making and maintaining changes in behaviour (Nye and Burgess, 2008).

By means of example, one programme in North Carolina (DuRant et al., 2006), aimed at preventing teenage pregnancy, used parent-child relationships to get the message across, with the tagline:

"Talk to Your Kids About Sex. Everyone else is". It targeted its messages to take advantage of existing social network relations – good friends, parents, spouses and siblings. This campaign tried to create a social norm for talking to children about sex, and used an existing powerful social relationship to get the message across. A phone survey established that parents exposed to the campaign were more likely to talk to their kids about sex the next month. The trick was to use mass communication to encourage inter-personal communication – so that the actual work of persuasion was done by peers.

For the majority of people, their social network is unlikely to be one that has sustainability at its core. But social networks – Trade Unions, Rugby Clubs, Mother and Toddler groups – still perform a critical role in spreading change through society. Encouraging and supporting pre-existing social networks to take ownership of sustainability (rather than approach it as a problem for "green groups") is a critical task.

More recently, online social networks have grown rapidly in popularity. If you are a member, just try searching for Sustainability on Facebook or #Sustainability on Twitter, and see what comes up

The Psychology of Sustainability

There is growing concern that sustainability is not possible given current trends and that understanding human interactions with the environment is a key aspect of ameliorating many of these issues. Psychology, as the science of human behaviour, is in a prime position to assist with this task. Human interactions with sustainability include human drivers of un-sustainability (e.g. over-use of limited resources), human consequences of instability (e.g. natural and technological disasters), and human responses to a changing environment (e.g. mitigation and adaptation).

Although progress is being made in the natural and physical sciences towards technological solutions and in political circles towards more sustainable policies, as we have just seen, an understanding of individuals is vital for these new technologies to be adopted and policies supported.

Please now watch and make notes on the following lecture (68 minutes). The lecture includes a discussion of current and pressing issues in the psychology of sustainability and provides further details on social norms. The lecture also discusses issues around risk perception, message framing, and positive psychology that highlight some of the ways that psychology is contributing to the debate on sustainability.

The lecture can be viewed here: http://ocw.uci.edu/lectures/lecture.aspx?id=440

Summing Up

It is important to understand human behaviour if policies and initiatives aimed at encouraging sustainability are to be effective.

•In this Session, we have explored some of the ways that the UK government is promoting sustainable behaviour.

•Defra have noted that it is possible – at a general level for the UK population – to group peoples' attitudes towards sustainability.

•The UK Cabinet Office has introduced an approach called 'MINDSPACE', which is an acronym for nine principles that are considered to be critical for influencing individual behaviour.

•With examples, we considered the importance of one of these principles in detail – social norms.

Extra Reading

• The 9 pages of the Executive Summary of the Defra (2008) report "A Framework for Pro-Environmental Behaviours" is worthwhile reading. The report can be downloaded from here:

http://archive.defra.gov.uk/evidence/social/behaviour/documents/behaviours-jan08-report.pdf .

• If you are interested in learning more about MINDSPACE and influencing public behaviour towards sustainability, then you are encouraged to read the report by Dolan et al. (2010), which can be accessed here:

http://www.instituteforgovernment.org.uk/sites/default/files/publications/MINDSPACE.pdf It is a long report, so in the first instance it is worth reading the Executive Summary.

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Chapter 10: Synthesising Sustainability and Setting of the Module Assessment Exercise

This Session draws together everything that we have covered in the previous nine Sessions. In part, this will be achieved by you. For instance, you will be asked to redefine sustainability, in your own words, now that you have taken this module. This may well be very different from your initial ideas on sustainability that you wrote about in Session 1 . You will also be asked to summarise how initiatives like “Plant for the Planet” or Fairtrade address the three pillars of sustainability.

Following this, we will take a detailed look at two sustainability plans. These are documents that outline the sustainability strategy of a business or institution. They typically aim to cover all three pillars of sustainability, and various issues, including water, energy and agriculture, for instance. They are an excellent example of showing how all the aspects of sustainability that we have considered in this module can be synthesised together.

At the end of this Session, the module assessment exercise is set.

Revisiting Your Thoughts on Sustainability

Recall how in Session 1, you were asked to write your first blog entry (or section in your offline document). This blog described your understanding of sustainability, before studying this module. We will now repeat this exercise, but this time you will be able to reflect upon of all the issues we have covered in this module.

Activity

Please now open your blog (or offline document) that you have been developing throughout this module. Create a new title and date entry called "My thoughts on sustainability: Part II".

In this blog entry, please write one or two paragraphs – of no more than 400 words that describe what you think sustainability is. More importantly, please state whether your understanding and awareness of sustainability has changed since taking this module. If it has, what has changed? Has existing knowledge on sustainability issues been reinforced? Have you learnt new things about sustainability? Or maybe you are now more critical about sustainability issues? And you may even have made small or big behavioural changes as a result of learning about limits on the environment and sustainability – if you have, do blog about them! Feel free to refer back to things you mentioned in your first blog entry ("My thoughts on sustainability: Part I"), to help comparison with how your opinions on sustainability have changed since starting this module. Spend no longer than 30 minutes on this activity.

The Three Pillars of Sustainability

Once again, think back to Session 1 and recall how Figure 1.1 showed that sustainability can be represented as including environmental protection, social equity and economic viability. Several of the case study projects and initiatives (e.g. Fairtrade , Water Footprint , Plant for the Planet) we have explored in this module address these three pillars of sustainability. It is not always immediately obvious how they are addressing each of the three pillars, but they do.

Activity

Please now return to your blog (or offline document) that you have been developing throughout this module. Create a new entry under today's date called "Addressing the three pillars of sustainability". Choose any of the sustainability initiatives/movements that we have covered in this module (e.g. Fairtrade , Water Footprint , Plant for the Planet), or one that we may not have covered (e.g. The Rainforest Alliance, The Cement Sustainability Initiative (CSI)). For your selection, write one paragraph in your blog for each pillar of sustainability, which states how that initiative/movement addresses each pillar, respectively. This will result in three paragraphs; one for environmental protection, one for social equity, and one for economic viability. If you select a movement/initiative that we did not cover, then please provide a brief introduction about what the initiative is.

Do not spend more than 40 minutes preparing this blog and try to keep the number of words to fewer than 600.

Sustainability Plans

It is now common for businesses and institutions in the service sector to publish sustainability plans. These documents outline the measures and policies that the business/institution has adopted to encourage sustainability. Typically, a sustainability plan will aim to address the three pillars of sustainability. Furthermore, a sustainability plan will consider several social, environmental and economic issues. A sustainability plan might include sustainability goals that relate to water usage, energy efficiency, waste, social equality, paper consumption, and food production and sourcing, for instance. Essentially, a sustainability plan tries to draw together all the elements we have considered in this module (e.g. water, food, agriculture, forestry, and energy), as well as others (e.g. waste and construction).

Case study: The Marks and Spencer sustainability plan

We briefly introduced sustainability plans in Session 8 , when we explored "Plan A", which is the Marks and Spencer (M&S) sustainability plan. It was launched in January 2007 and it originally set out 100 commitments to achieve in 5 years. M&S have now extended Plan A to 180 commitments to achieve by 2015, with the ultimate goal of becoming "the world's most sustainable major retailer" (M&S, 2011). Through Plan A, M&S are working with their customers and suppliers to combat climate change, reduce waste, use sustainable raw materials, trade ethically, and help customers to lead healthier lifestyles. In 2011, M&S had achieved 95 of the 180 Plan A commitments they set themselves in 2007 and 2010 (M&S, 2011).

Examples of what M&S achieved in the year 2011 alone, through Plan A, include (M&S, 2011):

• The opening of the first Sustainable Learning Store, in Sheffield. This store sets new standards in sustainability for all M&S stores. It uses 100% LED (light emitting diode) efficient lighting and incorporates a 'green' roof and living wall to support local biodiversity. The store's environmental impact has been reduced, by appointing a project Carbon Manager and the development of a local Biodiversity Action Plan. No waste was sent to landfill during construction.

• M&S launched the Plan A Innovation Fund, which has started to support a wide range of employee instigated projects. These include ways to reduce food waste, develop more sustainable fabrics and improve energy and water efficiency.

• Nearly 38,000 M&S employees took up the offer to receive free home energy monitors, which help people to reduce energy usage by viewing what they daily energy usage and cost is.

• 4,000 M&S employees had their homes insulated free of charge, to help improve household energy demand efficiency.

• Importantly, M&S have proved that sustainability makes good business sense, by generating a net benefit of over £70m through Plan A in 2011.

• M&S is the world's largest retailer of Fairtrade cotton clothing.

• Energy efficiency of stores has increased by 23% and warehouses by 24%, relative to 2007.

• Fuel efficiency of M&S delivery fleets has been improved by 20%.

• Total carbon emissions have been reduced by 13% relative to 2007.

• M&S are now recycling 94% of all the waste they generate from stores, offices and warehouses.

• 76% of wood now meets M&S sustainable sourcing standards.

• Fairtrade sales increased by 60% relative to 2007 and M&S introduced Fairtrade green beans from Kenya, wines from Chile and an extended range of cut-flowers including lilies.

Many other sustainability achievements are outlined in the M&S 2011 Plan A report (M&S, 2011). If you are interested in learning more about Plan A, then please view the M&S Plan A website (http://plana.marksandspencer.com/) or download the M&S (2011) Plan A report from here:

http://corporate.marksandspencer.com/documents/publications/2011/how_we-do_business_report_2011.

The University of Nottingham (UK) sustainability plan

Another useful sustainability plan to consider as an example is that used by the University of Nottingham in the UK. The University has put together an "Environmental Strategy" document, which details what the University is doing to improve sustainability (University of Nottingham, 2010). The strategy is based upon 11 key areas:

1. Waste and Recycling

2. Energy and Water

3. Travel and Transport

4. Procurement

5. Campus Development

6. Awareness Raising, Training and Communication

7. Corporate Governance

8. Information Services

9. Landscape

10. Teaching and Learning

11. Research

For each key area, the University has outlined a number of strategic aims, objectives and key performance indicators. For example, on "Energy and Water", the Environmental Strategy states a strategic aim as:

"To improve the environmental performance of our buildings and the University's physical infrastructure by moving towards carbon neutral energy performance, adopting environmentally conscious procurement practice, promoting renewable energy systems, reducing water consumption and waste output" (University of Nottingham, 2010).

The objectives related to this strategic aim are:

• Reduce energy consumption whilst at the same time ensuring the University's activities continue.

• Raise the awareness of the cost of energy.

• Reduce the overall cost of energy.

• Reduce energy waste.

• Reduce dependence on carbon with a shift towards carbon neutral or low carbon energy sources.

• Ensure that energy consumption and low carbon energy are considerations in the procurement process.

• Reduce water costs and consumption.

• Minimise pollution.

The key performance indicators for these objectives are:

• Energy consumption per m2 GIA (Gross Internal Area).

• Energy Emissions per m2 GIA.

• Water Consumption per m2 GIA.

• Total emissions for energy – carbon reduction achieved.

• Percentage of renewable electricity.

Please take about 15 minutes to read through each of the strategic aims, objectives and key performance indicators highlighted in the University of Nottingham Environmental Strategy document, which can be downloaded here:

http://www.nottingham.ac.uk/about/documents/environmentalstrategy200910.pdf.

The document is divided into chapters, according to each of the 11 key areas mentioned previously. The aims, objectives and indicators are in blue text boxes at the end of each chapter.

Summing Up

Sustainability can be thought of as encompassing three pillars; social equity, economic viability and environmental protection.

•This module has considered several important elements of sustainability; water, food, agriculture, forestry and energy.

•For each of these elements, we have seen why their sustainable management is important, since we are living within finite environmental limits.

•We have also examined multi-scale case studies of projects and initiatives aimed at encouraging and improving sustainability of resources.

•All of these projects and initiatives aim to address the three pillars of sustainability.

•Initiatives and projects alone are not sufficient for achieving sustainability however. Often, a social and/or behavioural change by people is required, for them to act more sustainably.

Your blog (or offline document) that you have been developing throughout the module, provides a record of your opinions on sustainability, details on your awareness of sustainability, and specific examples of sustainability.

Module Assessment Exercise

Sustainability is a very large topic that has grown rapidly over the past 20 years. Clearly, there are other elements of sustainability that we did not have time to cover (e.g. sustainable waste management). The module assessment exercise will give you an opportunity to explore one of these, by applying your knowledge and ideas that you have gained from the module to another area of sustainability.

This module will be assessed by a poster presentation. The aims of this assessment are:

1. To develop your presentation and communication skills.

2. To widen your awareness and understanding of sustainability issues.

3. To provide you with the opportunity to meet and engage with other students at the University of Nottingham, studying on this module.

There will be a half-day mini sustainability conference held at the University of Nottingham, which will be attended by all students registered for this module. Members of University staff will also attend the conference to assess the posters. Each student will have an opportunity to stand by their poster to present it to other students and staff. Time will be strictly limited to 5 minutes for each presenter. This will be followed by a short 1-2 minute question and answer session.

Your poster should be printed in size A1 and it can be printed in either landscape or portrait format. An electronic version of the poster must also be handed in. The electronic version should be submitted as a PDF file. Posters can be created using various packages, including Microsoft PowerPoint, Adobe Illustrator, Adobe Photoshop, and Microsoft Word. Most people tend to use Microsoft PowerPoint.

Your poster should be on an element of sustainability that we have not covered in this module. Some examples of topics you could choose are:

• Sustainable tourism

• Sustainable waste management

• Sustainable transport

You are not limited to the above suggestions, however, but the topic must not be one that we have covered in this module.

Your poster should include the following information:

• Identification of the issue; i.e. why is it important that your topic is managed sustainably.

• Identification of initiatives and/or programs aimed at improving awareness of, and sustainability for your chosen topic.

• Specific case studies of such initiatives/programs should be included, which demonstrate the success (or not) of the initiatives/programs.

For example, if you chose "Sustainable water" as your topic (although you cannot because this was covered in the module), you could include information such as:

• Tables or maps of current and/or future water availability across the globe, which demonstrate where there is low/high water stress, and so a need for water to be managed sustainably.

• Some details of the situation with the Aral Sea, which is a useful case study for demonstrating why water needs to be managed sustainably.

• A description of the concept of the Water Footprint, as a means of raising awareness of water sustainability.

• A description of the "TeCSIS/TAWC" project – a useful case study for showing efforts for increasing the sustainability of the Ogallala Aquifer in the U.S.

• A few details from the M&S Plan A document, which demonstrate what M&S are doing to improve water efficiency.

The poster will be assessed by University of Nottingham academic staff, based upon the quality of the:

• 5-minute oral presentation.

• Visual presentation of the poster.

• Content of the poster, e.g. relevance of case studies and depth of coverage.

• Ability to answer questions after the 5-minute presentation.

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