UNIVERSITY OF LONDON | INTERNATIONAL PROGRAMMES

Centre for Development, Environment and Policy

P568

Sustainable Land Management

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This module draws on materials from the previous modules:
Land Resource Conservation (2003) prepared by Paul Burnham
Land Degradation and Sustainability (1995) prepared by Paul Burnham with Richard Bowles, John Boardman and Stuart McRae
Environmental Management in Agricultural Development prepared by Piers Blaikie, with Nick Abel, Yvan Biot and Michael Stocking.

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MODULE INTRODUCTION

ABOUT THIS MODULE

This module explores the problem of ensuring the continued productivity of the world's land resources. This is a key issue for sustainable development affecting both the developed and developing world.

Developing nations face the challenge of transforming traditional agricultural systems as they become less viable in the face of land scarcity. Demand for land also threatens natural environments subject to encroachment for agriculture.

Intensified, modern systems also face sustainability challenges such as excessive nutrient loading associated with the use of inorganic fertilisers, toxicity problems caused by pesticides, and the salinisation of soils in irrigated systems.

It has long been recognised that environmental management is not simply a technical problem requiring technical solutions, in fact, on the contrary, experience has shown that land-use decisions are based on social and economic criteria and it is here that governments potentially have most influence. Therefore, in addition to considering technical measures for sustainable land management in a variety of agroecological contexts, we consider the policy options open to governments to encourage the sustainable use of land resources.

STRUCTURE OF THE MODULE

Part I

Unit 1 introduces the concept of sustainable land management (SLM) and discusses what we mean by land degradation. The challenge of assessing the degradation of land resources is reviewed and the findings of major land degradation assessments are presented.

The history of policy in SLM, from colonial soil and water conservation (SWC) to climate change mitigation is briefly outlined.

Part II

In order to understand the nature of land degradation and the measures proposed to counter it, some basic understanding of soils is necessary. Units 2 and 3 seek to provide a grounding in basic soil science and the processes that can lead to the degradation of soils. These units provide technical details that are important in understanding the issues and solutions proposed in the units that follow.

Part III

Here we consider the use of forests, steeplands, and drylands for agriculture in the developing world and the challenges for land management that arise from their intensification. Each unit considers first the nature and extent of the problem followed by an examination of some potential alternatives or land-use practices that offer increased sustainability. Certain themes are repeated across modules, such as the basic principles of soil management and the challenges of identifying appropriate alternatives in smallholder farming systems. There is therefore some crossover between issues addressed in these units and students should expect to draw lessons for the development of smallholder systems in developing countries from all four units in Part III.

Part IV

Intensive farming systems generate additional problems for agricultural sustainability. In Part IV we consider management problems facing irrigated cropland, and intensive, mechanised, rainfed agriculture.

Part V

Previous units have focused primarily on the technical aspects of improved land management. In Unit 10 we further explore the theme initially raised in Unit 1 concerning the causes of land degradation and discuss how this understanding can be used as an entry point for intervention by governments to reduce land degradation and to encourage sustainable land management by land users.

WHAT YOU WILL LEARN

Module Aims

This module aims to provide the student with a thorough understanding of the challenges of sustainable land use based on knowledge of the key biophysical processes in soil and informed by an appreciation of the social and economic factors that cause land degradation and influence the success or failure of measures to counter land degradation.

The specific aims of the module are

- To provide a grounding in basic soil science, describing the nature of the soil resources and the processes that can lead to its degradation.
- To present challenges of sustainable land management in three areas that are prone to degradation in the tropics: forest lands, steeplands, and drylands.
- To examine the causes of land degradation and the policy responses by government that can be used to encourage sustainable land management.

Module Learning Outcomes

By the end of this module, students should be able to:

- describe the components of soil and important land degradation processes (erosion, nutrient depletion, and salinisation) and critically discuss relevance and importance to sustainable development
- explain and critically assess how multiple factors may lead to unsustainable land management practices and to identify possible points of intervention for tackling land degradation problems
- give selective examples of successful strategies for sustainable land management in different ecological zones and farming systems and identify the biophysical and socioeconomic factors related to their success with critical interpretation of importance and priority
- discuss and critically assess the complex relationship between poverty and environmental degradation
- critically examine the role of government intervention and policy in creating conditions for sustainable land management

ASSESSMENT

This module is assessed by:

- an examined assignment (EA) worth 20%
- a written examination in October worth 80%

Since the EA is an element of the formal examination process, please note the following:

(a) The EA questions and submission date will be available on the Online Learning Environment.

(b) The EA is submitted by uploading it to the Online Learning Environment.

(c) The EA is marked by the module tutor and students will receive a percentage mark and feedback.

(d) Answers submitted must be entirely the student's own work and not a product of collaboration. For this reason, the Online Learning Environment is not an appropriate forum for queries about the EA.

(e) Plagiarism is a breach of regulations. To ensure compliance with the specific University of London regulations, all students are advised to read the guidelines on referencing the work of other people. For more detailed information, see the User Resource Section of the Online Learning Environment.

STUDY MATERIALS

There is one textbook for this module.

- Liniger HP, Mekdaschi Studer R, Hauert C and M Gurtner (2011) *Sustainable Land Management in Practice – Guidelines and Best Practices for Sub-Saharan Africa*. TerrAfrica, WOCAT and FAO, Rome.

Extracts from this text feature in the Key Readings list for each unit where they have specific relevance for that unit or a particular section. Case studies are highlighted where they relate to a specific agroecological environment; you may find other relevant case studies that have not been listed. We also encourage you to read the general material contained in this book as background to your studies.

Key Readings

Key Readings are provided in bound volumes in the study pack. They are considered integral to your studies and the content is examinable. These extracts are drawn from a wide range of sources, authored by individual researchers and analysts, and also through the collective efforts of diverse national and international organisations. They aim to provide a range of perspectives and more depth on the unit subject matter.

Further Readings

The module also directs students to additional material (often with links to online material which may be of interest) which is not examinable. Students are not expected to follow up each and every Further Reading, but can follow up specific points of interest.

INDICATIVE STUDY CALENDAR

Part/unit	Unit title	Study time (hours)
PART I	**Introduction**	
Unit 1	Sustainable land management	15
PART II	**Basic soil science**	
Unit 2	The world of the soil	10
Unit 3	Degradation processes	20
PART III	**Land management in low–input and extensive farming systems**	
Unit 4	Deforestation and land use change	10
Unit 5	Farming in tropical steeplands	15
Unit 6	Dryland farming systems	15
Unit 7	Pastoralism and rangeland degradation	15
PART IV	**Land management in intensive farming systems**	
Unit 8	Irrigated agriculture	10
Unit 9	High input rainfed agriculture	10
PART V	**Conclusion**	
Unit 10	Policy and interventions for sustainable land management	15
Examined Assignment Check the online learning environment for submission deadline		15

Examination entry	July
Revision and examination preparation	September
End-of-module examination	October

ACRONYMS AND ABBREVIATIONS

(R)USLE	(Revised) Universal Soil Loss Equation
(R)WEQ (Revised)	Wind Erosion Equation
(S)OM	soil organic matter
ACIAR	Australian Centre for International Agricultural Research
AI	aridity index
ANSWERS	Areal Non-point Source Watershed Environment Response Simulation (an erosion prediction model using a GIS)
AVHRR	advanced very high resolution radiometer
AWC	Available Water Capacity
BD	bulk density
BRRI	Bangladesh Rice Research Institute
CA	Conservation Agriculture
CBA	cost–benefit analysis
CEC	cation exchange capacity
CIAT	International Centre for Tropical Agriculture
CIFOR	Center for International Forestry Research
CPR	common property resources
CREAMS	Chemicals, Runoff and Erosion from Agricultural Management Systems
CTF	Controlled Traffic Farming
DDT	dichlorodiphenyltrichoroethane (a very persistent organo-chlorine insecticide)
DEFRA	Department for Environment, Food and Rural Affairs
DPSIR	Driving forces, Pressures, State, Impact, Response
EC (EC_e)	electrical conductivity (of an extract from a saturation paste of a soil sample with deionised water)
EPIC	Erosion Productivity Impact Calculator
EPTD	Environment and Production Technology Division (a division of IFPRI)
ESA	the Agricultural Development Economics Division (of FAO)
ESP	Exchangeable Sodium Percentage (of the total cation exchange capacity of a soil sample)
FAO	Food and Agriculture Organization of the United Nations
FFS	farmer field school
FPR	farmer participatory research
g	gramme

GIS	Geographic Information System
GLASOD	Global Assessment of Soil Degradation
GMU	grassland management units
ha	hectare
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRAF	International Center for Research in Agroforestry
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IIED	International Institute for Environment and Development
IIRR	International Institute of Rural Reconstruction
IITA	International Institute for Tropical Agriculture
ILCA	International Livestock Commission for Africa
ILEIA	Centre for Information in Low External Input and Sustainable Agriculture
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IUSS	International Union of Soil Sciences
IWMI	International Water Management Institute
km	kilometre
l	litre
LADA	Land Degradation Assessment in Drylands project UNEP/FAO
LFA	less favoured area
LGP	length of growing period
LUCC	Land-Use and Land–Cover Change
m	metre
MA	Millennium Ecosystem Assessment
NRCS	Natural Resources Conservation Service (part of USDA)
NUTMON	Nutrient Monitoring for Tropical Farming Systems
NVDI	normalised difference vegetation index
ODI	Overseas Development Institute
OECD	Organisation for Economic Co-operation and Development
PES	payment for environmental services

PI	Productivity Index. (A multiplier assigned to soil series, which is used in the USA to convert soil loss into percentage productivity loss. The results are extremely arbitrary!)
PTD	participatory technology development
PVA	polyvinyl acetate (used as a soil stabiliser to check erosion)
SALT	sloping agricultural land technology
SLCP	Sloping lands Conservation Programme
SLEMSA	Soil Loss Estimator for Southern Africa
SLM	Sustainable Land Management
SOM	soil organic matter
SOTER	Soils and Terrain Digital Data Base Project
SWC	soil and water conservation
T&V	training and visit
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture
VAMA	a modified vinyl acetate maleic acid compound
WCED	World Commission on Environment and Development
WEPP	Water Erosion Prediction Project
WHO	World Health Organization
WOCAT	World Overview of Conservation Approaches and Technologies
WRB	World Reference Base for Soil Resources
WRI	World Resources Institute
WUE	water use efficiency

Unit One: Sustainable Land Management

Unit Information

Unit Overview

This unit seeks to provide an introduction to the subject of sustainable land management. It outlines why sustainable land management is important for development and environmental protection. The main processes of land degradation are listed and the land management practices that may cause them are described. We consider the global assessment of land resources and consider some of the reasons why estimating the degree and extent of land degradation presents a challenge.

Unit Aims

- To introduce the concept of sustainable land management.
- To outline the principal degradation processes affecting land and the land use practices that may promote them.
- To examine the global incidence of land degradation.

Unit Learning Outcomes

By the end of this unit, students should be able to:

- define what is meant by sustainable land management
- list the principal degradation processes affecting land and suggest some of the activities that may cause them
- recognise land degradation ‘narratives’ and view them cautiously

Unit Interdependencies

This unit provides an introduction to the themes and content of the module. Therefore many of the issues raised will be covered in more depth in later units. An introduction to basic soil science (including soil formation and classification) and the basis of soil fertility is presented in Unit 2; mechanisms of land degradation and the difficulties of assessment are considered in Unit 3; the policy options for sustainable land management and the relationship between poverty and environmental degradation will be considered in Unit 10.

Causes of land degradation in different agroecological contexts (drylands, steeplands etc) will be considered in more depth in the relevant unit.

KEY READINGS

Section 1

- UNCCD Secretariat (2012) *Zero Net Land Degradation, A Sustainable Development Goal for Rio+20*. UNCCD Secretariat Policy Brief, pp. 1–21.

This paper provides an overview of the Zero Net Land Degradation Sustainable Development Goal agreed at Rio+20. It presents an argument for global action on controlling and reversing land degradation and an overview of current knowledge on the state of the world's land resources.

Section 3

- Blaikie (1995) Changing environments or changing views? A political ecology for developing countries. *Geography* 80(3) 203–214.

This paper describes how landscapes and environments may be perceived differently by different groups. It also goes on to discuss why this process (of defining and prioritising environmental problems) is political.

(a) What do we mean when we say that land degradation is 'socially constructed'?

(b) What are the implications of this for sustainable land management policy?

Section 4

- Branca G, Lipper L, McCarthy N, Jolejole MC (2013) Food security, climate change, and sustainable land management. A review. *Agronomy for Sustainable Development* 33 635–650.

This paper considers both how sustainable land management may contribute to meeting food security goals and reduced carbon emissions. As a review of the literature it contains a lot of detail — but in addition to the key points about productivity and carbon emissions provides an introduction to the range of technologies that might be considered under 'sustainable land management'.

- de Graaff J, Aklilu A, Ouessar M, Asins-Velis S, Kessler A (2012) The development of soil and water conservation policies and practices in five selected countries from 1960 to 2010. *Land Use Policy* 32 165–174.

This paper reviews patterns in soils and water conservation policies in five countries. This reveals how strategies to combat degradation are subject to wider trends or fashions and local social economic conditions.

Further Readings

Bai ZG, Dent DL, Olsson L, Schaepman ME (2008) *Global Assessment of Land Degradation and Improvement 1: Identification by Remote Sensing.* Report 2008/01 FAO/ISRIC, Rome/Wageningen.

Available from: http://www.fao.org/nr/lada/

DeFriesa R, Rosenzweigvol C (2010) Toward a whole-landscape approach for sustainable land use in the tropics. *Proceedings of the National Academy of Sciences of the United States of America* 107(46)19627–19632.

Jones A, Panagos P, Barcelo S *et al* (2012) *The State of Soil in Europe. A contribution of the JRC to the European Environment Agency's Environment State and Outlook Report–SOER 2010.* European Environment Agency.

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Bai ZG, Dent DL, Olsson L, Schaepman ME (2008) *Global Assessment of Land Degradation and Improvement 1: Identification by Remote Sensing.* Report 2008/01 FAO/ISRIC, Rome/Wageningen.

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Barnett T, Blaikie P (1992) *AIDS in Africa: its Present and Future Impact*. Belhaven Press, London.

Barrow CJ (1991) *Land degradation: Development and Breakdown of Terrestrial Environments*. Cambridge University Press, Cambridge.

Blaikie P (1985) *The Political Economy of Soil Erosion in Developing countries.* Longman, London.

Blaikie P, Brookfield H (1987) *Land Degradation and Society.* Methuen, London.

Clay D, Reardon T, Kangasniemi J (1998) Sustainable intensification in the highland tropics: Rwandan farmers' investments in land conservation and soil fertility. *Economic Development and Cultural Change* 46 351–377.

EJF (2003) *Desert in the Delta; a Report on the environmental, Human Rights and Social Impacts of Shrimp Production in Bangladesh*. Environmental Justice Foundation (EJF), London.

FAO/Geonetwork (1989) *Bailey's Global Map of Ecoregions*.

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Available from: http://geonetwork3.fao.org/fggd/ [Accessed 11 December 2013]

Geist HJ, Lambin EF (2002) Proximate causes and underlying driving forces of tropical deforestation. *BioScience* 52(2) 143–150.

Henao J, Baanante (2006) *Agricultural Production and Soil Nutrient Mining in Africa; Implications for Resource Conservation and Policy Development*. International Center for Soil Fertility & Agricultural Development (IFDC), Alabama.

Available from: http://www.ifdc.org/Documents/T-72-Agricultural_Production_and_Soil_Nutrient/ [Accessed 12 December 2013]

Iskandar T, Rachman A, Nur M, McLeod M, Subagyono K, Moore N, Slavich P (2006) *Crop Production and Soil Salinity in the Tsunami Affected Areas of the Eastern Coast of Aceh Province, Indonesia*. 18th World Congress of Soil Science, Philadelphia, USA.

Johnson DL, Lewis LA (2006) *Land Degradation: Creation and Destruction,* 2nd edn. Rowman & Littlefield, Lanham.

Lal R (2004) Soil carbon sequestration to mitigate climate change. *Geoderma* 123 1–22.

Lambin EF, Turner BL, Geist HJ *et al* (2001) The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change* 11(4) 261–269.

LADA (undated) *Preliminary Map of Land Degradation Produced.* Land Degradation Assessment in Drylands

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MEA (2003) *Ecosystems and Human Well-being: A Framework for Assessment.* Millennium Ecosystem Assessment.

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Available from: http://www.isric.org/isric/webdocs/docs/ISRIC_Report_1990_07.pdf [Accessed 12 December 2013]

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Stocking MA (2003) Tropical soils and food security: the next 50 years. *Science* 302(5649) 1356–1359.

UN Earth Summit (1992) UN Conference on Environment and Development.

UNHCR (1997) *Refugees and the Environment: Caring for the Future*. The United Nations High Commissioner for Refugees (UNHCR), Geneva.

USDA Natural Resources Conservation Society (NRCS) *Soils*.

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http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/maps/?cid=nrcs142p2_054013 and
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1.0 SUSTAINABLE LAND MANAGEMENT AND DEVELOPMENT

Section Overview

This section outlines the global importance of sustainable land management. We describe the key elements of land use change and why these pose a threat to agricultural sustainability.

Section Learning Outcomes

By the end of this section, students should be able to:

- define what is meant by sustainable land management
- describe intensification and expansion as routes to increased agricultural production and describe the problems associated with each
- define 'land degradation'
- list the principal types of land degradation experienced in agricultural systems
- list common agricultural or land use practices leading to land degradation

1.1 What do we mean by sustainable land management?

Sustainable land management is a broad concept which refers to the management of a landscape in order that the 'services' provided by the landscape are preserved and/or enhanced. This concept of sustainable land management is linked to the idea of ecosystem services which aims to capture all the functions of the ecosystem that are of benefit to people. The concept of ecosystem services has been used in the Millennium Ecosystem Assessment (1.1.1).

1.1.1 Ecosystem services

– Provisioning services that provide necessities such as food, water, timber and fibre
– Regulating services that affect climate, floods, disease, wastes and water quality
– Cultural services that provide recreational, aesthetic, and spiritual benefits
– Supporting services such as soil formation, photosynthesis and nutrient cycling

Source: MEA (undated) and MEA (2003)

Whilst this concept is useful for conceptualising and accounting for the myriad of services provided by our natural environment, in this module we will narrow our focus to the productive function of the landscape – that is the provisioning services. Within this narrower framework we will adopt the following definition:

> *SLM can be defined as 'the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions'.*
>
> *Source: UN Earth Summit (1992).*

Sustainable Land Management is therefore concerned with both:

- preserving and enhancing the productive capacities of land in cropped and grazed areas
- action to stop and reverse degradation (World Bank 2006 p. xiv)

1.2 Why is SLM an important global development issue?

The land resource is at the root of agricultural production, producing the basis for human survival and economic activity. The sustainable use of the world's land resources is therefore a key issue in the future welfare of countries in both the developed and developing world. Growing demands placed on the natural resource base arise from both increasing populations and economic development.

In addition to fulfilling basic needs and comprising an important fraction of economic activity, the development of agriculture is seen by many to be the important first step to economic development. In addition, 75% of the world's poor live in rural areas and are directly or indirectly dependent on agriculture as the basis of their livelihoods (World Bank 2007). Improving agricultural productivity is therefore seen as critical to reducing global poverty. However, agricultural development may be impeded by a declining or degrading resource base; and this in turn may impoverish the population dependent upon it.

Threats to the productive functions of landscapes

Increased agricultural production is achieved by two routes:

- areal expansion (expansion of cropped/grazed areas – **extensification**)
- **intensification** – increase levels of input per unit area

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1.2.1 Changes in cereal production in Africa and Asia due to increases in area and yield

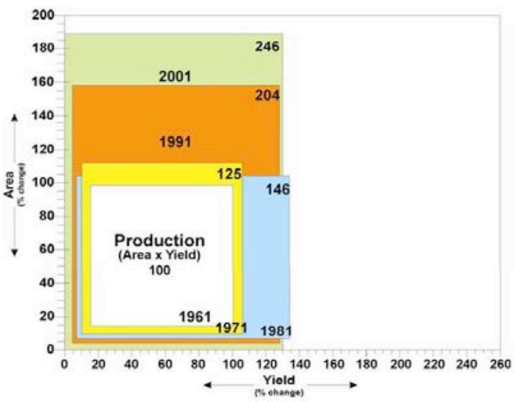


Figure 1. Changes in Cereal Production in Sub-Saharan Africa Due to Changes in Area and Yield (1961 = 100)

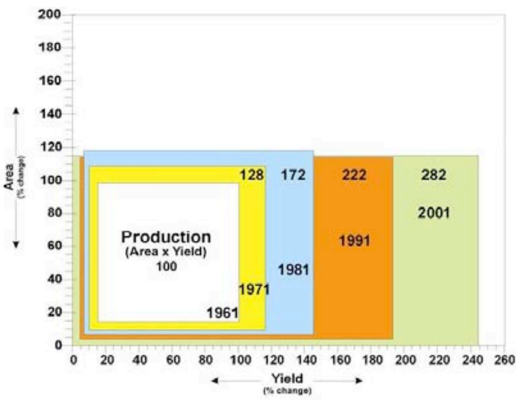


Figure 2. Change in Cereal Production in Asia Due to Changes in Area and Yield (1961 = 100)

Source: Henao and Baanante (2006) p. 3.

The diagram in 1.2.1 illustrates how increased agricultural production has been realised in Africa and Asia. Increases in grain production in Africa have been achieved largely by increasing the area under cultivation with relatively small increases in yield over time. By contrast, cereal production in Asia has shown a dramatic increase in yields accompanied by a relatively small increase in the total area cultivated.

Both routes to increasing agricultural productivity generate land management challenges for farmers and states.

> ✍ Before we continue – make a list of the problems you think might arise from
>
> (a) areal expansion
>
> (b) intensification in agriculture

Your answer may have included the following points.

Problems arising from extensification (increase in area cropped)

- expansion into areas less suited to agriculture (marginal lands)
- reduction of fallow periods so that the ratio of land under cultivation to uncultivated land increases – leading to soil degradation
- increased use of 'natural' landscapes – wilderness, forests

Problems arising from intensification (higher yields from fixed area)

- nutrient loading – excessive nutrients entering ecosystems
- intensive monocropping, continuous cultivation – leading to soil degradation
- salinisation – from irrigation
- pollution/toxicity – from overuse of agrichemicals

In addition to creating problems locally (on- or off-site), two of the processes listed above are charged with contributing to global environmental change these are firstly land use change (specifically relating to the loss of natural ecosystems and biodiversity due to the expansion of agriculture) and nutrient loading (which is having a profound effect on ecosystem functioning, especially freshwater ecosystems). Land use change also contributes to carbon emissions. The effects of increased agricultural production are therefore important to global environmental sustainability. These global issues are summarised in 1.2.2.

1.2.2 Impact of land use change on ecosystem functioning

Land use and land cover changes at the global level significantly impact key aspects of Earth systems functioning:

– They directly impact biodiversity worldwide

– They contribute to local and regional climate change and global warming

– They are the primary source of soil degradation

– They affect the ability of biological systems to support human needs (ecosystem services).

Source: adapted from Lambin *et al* (2001) p. 262.

1.3 Why does land use change threaten agricultural sustainability?

Why are these two trends in land use practice (extensification and intensification) considered to be unsustainable or damaging to the environment?

Increases in agricultural production are not necessarily unsustainable, however, in some cases the process of expansion and intensification leads to the adoption of land management practices that have a damaging or degrading effect on the land resource. Common pathways of land use change in developing countries, and the potential land degradation problems that may arise from them are listed in 1.3.1.

1.3.1 Five pathways of land use change experienced in developing countries and their associated land degradation problems

Land type	Changes in recent decades	Common problems
Irrigated	– increase in irrigated area – increased multicropping – HYVs – high agrochemical use	– salinisation and waterlogging – nutrient imbalance – biological degradation – nutrient pollution in groundwater
High quality rainfed	– transition from short fallow to continuous cropping – HYVs – mechanisation – high agrochemical use	– nutrient depletion – physical degradation – acidification – de-vegetation, loss of perennials – biological degradation – pesticide pollution – deforestation of commons
Densely populated marginal	– transition from long to short fallows or continuous cropping – use of new landscape niches	– soil erosion – soil fertility depletion – devegetation, biodiversity loss – soil compaction – acidification – watershed degradation
Extensively managed marginal	– immigration and land clearing for agriculture	– soil erosion from land clearing – soil erosion from cropping – soil nutrient depletion – weed infestation – biological degradation – deforestation, loss of biodiversity – watershed degradation
Urban and peri-urban land	– rapid urbanisation – expansion and diversification of urban food markets – urban poverty, unemployment	– soil erosion – soil contamination – overgrazing and compaction – air and water pollution

Source: summarised from Scherr (1999) p. 14.

Definitions

Land degradation can be defined as 'a reduction in the capability of land to satisfy a particular use' (Blaikie and Brookfield 1987 p. 6). Note that this definition explicitly links land degradation with social criteria (the use to which the land is put). A conceptualisation of land degradation which encompasses ecosystem services might broaden this to include the capability of land to provide particular services. However, for the main part, definitions of land degradation encompass a decline in biological productivity and usefulness to humans.

> *'The substantial decrease in either or both of an area's biological productivity or usefulness to humans due to human activities.'*
>
> *Source: Johnson and Lewis (2006) p. 2.*

1.4 Land degradation processes

Types of land degradation that can be triggered by unsustainable land use practices are categorised and listed in 1.4.1. A broader definition of environmental degradation might add biodiversity loss and climate change to this list. However, here we will focus on the effects of land use practice on the soil resource. The most important of these are described briefly below.

1.4.1 Categorisation of degradation

Soil erosion by water	Loss of topsoil Gully erosion Mass movement
Soil erosion by wind	Loss of topsoil Deflation and deposition
Chemical soil deterioration	Fertility decline and reduced organic matter content Acidification Soil pollution Salinisation
Physical soil deterioration	Compaction Sealing and crusting Waterlogging
Water degradation	Aridification (decrease of average soil moisture content) Change in quantity of surface water Change in groundwater/aquifer level Decline in surface water quality Decline of groundwater quality
Biological degradation	Reduction of vegetative cover Loss of habitats Biomass decline

Source: summarised from WOCAT (undated).

Soil erosion by water

Soil erosion by water can be defined as the removal of soil material by water. This may be observed as sheet erosion (the removal of soil particles by water flow or rainfall), rill erosion (where flowing water carves small channels), and gully erosion (where overland flow is concentrated and causes large channels). Mass movement of soils (such as landslides) is also considered a form of soil erosion. Although soil erosion on steep lands is often dramatic, soil movement by water can be significant on only moderately sloping land.

Erosion is degrading because it removes the most productive part of the soil, the top soil. In addition to reducing the amount of nutrients to crops this also reduced the quality of soil physical properties affecting rooting and water availability.

Soil erosion by wind

Wind erosion occurs predominantly in dry zones (arid, semi-arid) when the removal of natural vegetation leaves finer soil particles vulnerable to displacement by wind. Again, the loss of topsoil leads to loss of nutrients and the depletion of organic matter leads to a reduction in soil fertility.

Chemical soil deterioration

The removal of nutrients in crops and livestock without replenishment leads to nutrient depletion. Nutrient mining is considered a critical issue in environments where deeply weathered soils with low inherent fertility are farmed without replenishment. Hence, the soil nutrient depletion debate has largely been focused on Sub-Saharan Africa where the problem is seen as an impediment to agricultural development and the problem of market access to fertilisers, critical. Soil organic matter (SOM) depletion occurs where insufficient quantities of organic matter are returned to the soil. In addition to providing a source of nutrients, SOM plays a critical role in soil structure and affects a soil's capacity to hold nutrients and moisture.

Salinisation of agricultural soils arises when there is an increase in the salt content of the topsoil. Salinity reduces plant growth and causes a decline in productivity.

Pollution in soils is more likely to occur in intensive systems where the use of agricultural inputs is higher. Pollution may be a result of excessive use of pesticides or the careless disposal of waste.

Physical soil deterioration

The use of heavy machinery or trampling by animals can cause compaction of the soil; pore space is destroyed, thus creating problems for plant growth due to reduced water infiltration and holding and offering impediment to root growth. Surface sealing occurs due to the formation of a relatively impermeable layer at the soil surface due to the impact of raindrops packing soil particles. This reduces infiltration and therefore water availability to crops. Structural crusts are compacted layers at the soil surface caused by trampling or traffic.

1.5 Unsuitable land use practices

The following section briefly examines a number of common land use practices and why they may threaten sustainable land use.

Deforestation

There has been a significant change in total forest cover in the past 50 years. Forest cover has been reduced by both the large-scale clearing of forests for timber extraction, plantations, rangelands, small-scale agriculture or settlements; and the piecemeal clearance of forest by shifting cultivators where the reduction in fallow length due to land shortages has led to a more or less permanent agricultural use of former forest soils.

Once cleared of natural vegetation, forest soils may be subject to a number of degradation processes such as loss of organic matter and nutrient depletion, and increased risk of soil loss though erosion. Loss of forest vegetation also has an implication for water resources and can affect river flows.

Increased cultivation of marginal lands

Marginal lands are those considered less suited to agricultural production due to topographic or climatic conditions. Lands may be marginal due to low water availability and low fertility; such soils may be especially vulnerable to nutrient depletion following cultivation. Marginal lands may be able to support agricultural production at low intensity but are vulnerable to degradation if production is increased. Dryland degradation (or desertification) may occur where intensification of land use is not matched by increased levels of inputs (organic or inorganic), and soils are exposed to wind or water erosion.

On sloping lands, soils exposed through cultivation are especially vulnerable to erosion by water. Soil erosion can result in loss of soil fertility through a reduction in soil depth, water-holding capacity, and nutrients.

Decreasing length of fallow periods

In many traditional farming systems of both humid and dry climates, soil fertility has been managed by the use of fallow periods. In areas of increasing population density a reduction in fallowing is a common response to land scarcity. The usual consequence of reduced fallow periods in systems where no alternative mechanism for regenerating soil fertility is in place is the degradation of soil fertility. This is often due to a decline in soil organic matter and soil nutrients. A reduction in the water-holding capacity of soils is also an important consequence of soil degradation and may be a significant contribution to reduced soil fertility.

Land users' decisions to fallow land may be in response to increases in weed populations rather than soil fertility decline alone. Productivity declines due to shortened fallow can therefore be, in part, due to weed infestations as well as to changes in soil properties.

Overgrazing/rangeland degradation

Where grazing pressure is too high, either through livestock numbers or climatic factors (eg drought), grasslands may not be able to sustain productivity. Reduced vegetation cover leads to exposure of soils leaving them vulnerable to wind erosion. Removal of nutrients (by livestock) without replacement may reduce soil fertility.

The issue of rangeland degradation is highly debated – it is increasingly recognised that rangelands do not represent natural climax vegetation but rather are complex semi-natural ecosystems within which humans play a functional part. This has led a number of researchers to conclude that modifications to the productivity of rangelands are mainly governed by biophysical drivers rather than stocking densities (Lambin *et al* 2001).

Land degradation problems can arise where a shortage of grazing land means that pastoralists are not able to employ traditional strategies of stock movement to manage their herds. In these circumstances conflict may occur between pastoralists and farmers, and pastoralists may be forced to alter their nomadic practices.

Insufficient nutrient recycling

On most soils, nutrients removed in produce (crops, meat, fibre) need to be returned to the soil to ensure future productivity. Where these nutrients are not replaced, soils experience a depletion of soil nutrients or nutrient mining.

Where there are high inputs of soluble nutrients into the farming system, the wider environment has to absorb these excess nutrients. This transfer may occur via run-off of surface waters, the leaching of nutrients into aquifers, or waste discharge from the production unit (eg intensive livestock units). The problem here is one of nutrient loading where a concentration of excess nutrients disrupts some functions of the wider ecosystem (these are considered to be off-site impacts or externalities).

Monoculture – inappropriate crop rotation

In intensive systems where monocultures dominate, farming systems can experience a build-up of pests and disease, and soil management problems. Micronutrient deficiencies may occur; mechanisation can cause compaction and soil structural problems.

Poor irrigation practice

Good management of irrigated lands is essential to avoid problems of salinity. This is a problem associated with irrigated lands where poor management of water causes a rise in the groundwater level and brings salts to the soil surface. Salinity problems can also arise where irrigation water is of low quality and results in the build-up of salts in the soil.

Section 1 Self Assessment Questions

Question 1

Match the definitions.

Identify the role of the ecosystem services listed below.

(a) Provisioning services	(i) affect climate, floods, disease, wastes, and water quality
(b) Regulating services	(ii) provide necessities such as food, water, timber, and fibre
(c) Cultural services	(iii) soil formation, photosynthesis, and nutrient cycling
(d) Supporting services	(iv) provide recreational, aesthetic, and spiritual benefits

Question 2

List the two principal routes to increased agricultural production.

Question 3

True or false?

(a) Decrease in the length of fallow periods may be the consequence of bringing more land into cultivation.

(b) Problems of salinity do not occur if the irrigation water is of sufficient quality.

(c) Where soils are farmed without replacement of nutrients removed by crops, nutrient mining is likely to occur.

2.0 THE CAUSES OF LAND DEGRADATION

Section Overview

This section briefly describes a number of factors that have been identified as underlying causes of land degradation and give examples of where this has occurred.

Section Learning Outcomes

By the end of this section, students should be able to:

- explain what is meant by proximate and underlying causes
- list with examples frequently cited causes of land degradation

2.1 Considering the causes of land degradation

We have already described a number of land use practices that may lead to land degradation. These are the activities of the land user and can be described as proximate causes. For policy and intervention it is often necessary to understand the reasons why the land user is undertaking damaging practices. A number of factors that are commonly identified as underlying causes (those that drive the damaging land management practice) are listed in 2.1.1. In this section we describe briefly how these factors can drive land degradation and give example of circumstances where this is has occurred.

2.1.1 Causes of land degradation

(1) Natural hazards

(2) Population change

(3) Health

(4) Marginalisation

(5) Poverty

(6) Weak property rights

(7) Political instability

(8) Economic factors

Source: summarised from Barrow (1991).

Natural hazards can be the cause of land degradation. Catastrophic weather events hurricanes, flooding, droughts, may lead to a decline in land productivity by erosion (mass wasting) pollution or loss of vegetation.

Example: The South Asian Tsunami of 2001 damaged many thousand hectares of paddy land mainly through the deposition of mud and debris and increased salinity due to sea water incursion (Iskander *et al* 2006).

Climate change is predicted to have a serious impact on the world's land resources, it is anticipated that areas currently experiencing water stress will face greater pressures and extreme weather events will become more common. Without changes to existing land management these processes could lead to land degradation.

Population change can reduce the availability of land for cultivation and cause an increase in land use intensity. In traditional systems where fallow periods are relied upon to restore fertility after cropping, the shortening or virtual elimination of fallow periods will lead to soil degradation in the absence of technical change. The patterns of technical change in response to increasing land scarcity are complex and their direction depends upon a range of factors including opportunities for migration, diversification or markets for higher value agricultural goods.

A reduction in population (for example, due to rural–urban migration) may lead to labour shortages in agriculture and reduce farm households' ability to maintain conservation structures.

Example: In the Bolivian Andes, increased diversification of economic activities by peasant farmers, including temporary labour migration to urban centres, reduced the amount of labour available for farm production and, in particular, reduced the implementation of soil conservation tasks (Zimmerer 1993).

Health issues may have similar consequences to outmigration by creating labour shortages. The disproportionate impact of HIV/AIDS on adults of working age means that in many HIV/AIDS affected households there is a shortage of labour. Research evidence has shown that households respond by shifting to crops that require less labour and reducing livestock. In a climate of low labour availability, reduction in livestock holdings, and lower incomes, farm households have less to invest in their land.

Example: In Uganda it was found that, in HIV/AIDs affected households, land management activities such as mulching, terracing, and fallowing were in some cases abandoned (Barnett and Blaikie 1992).

Marginalisation defined in the sociopolitical sense refers to people excluded from opportunity and influence; in the ecological sense it refers to environments where adverse conditions are expected to occur, ie those less favourable for agricultural production. Those on the sociopolitical margins are often to be found in marginal environments either through inequitable land distribution or allocation. Inhabitants of marginal environments may also find themselves politically marginalised as a consequence of their location and limited assets.

Examples of the former: In the plantation economies of the Caribbean large-scale commercial agriculture occupy the flat lands, whilst the peasantry (originating from the freed slave population) were concentrated on the less suitable hillside lands. Colonial administrations in southern Africa removed native populations from productive lands to make way for white settlers. In both these examples the concentration of populations on lands less suited to agricultural production has resulted in land degradation.

Poverty is frequently cited as both a cause and effect of environmental degradation. The explanation is that poor people cannot afford to conserve their land and are further impoverished by its degradation (the 'downward spiral'). Numerous empirical studies have suggested that this model is an oversimplification of the process of change and should not be applied uncritically. Nonetheless, the ability of households to invest in land management strategies is strongly influenced by their access to resources; poor households with low availability of cash, labour or land may be unable to manage their land resources sustainably.

Insecurity of tenure or weak property rights are also often cited as a cause of land degradation. This is because land users are expected to be reluctant to invest in land where the returns are not certain. Land use security can influence crop choices (especially tree crops) or decisions to build conservation structures. A number of analyses exploring the factors influencing farmer adoption of soil conservation practices have found a positive correlation between the practice of soil conservation and security of tenure.

Example: In Rwanda, soil conservation structures, planting of perennial crops, and use of inputs (organic and inorganic) were all found to have a positive relationship with land ownership (Clay *et al* 1998).

Caution should be exercised before assuming that this generalisation is true in a specific context. First we need to understand what constitutes secure tenure in the case considered. Second, changes in property rights (for example, the promotion of freehold tenure) should consider the impact of such changes on distribution and access to land in the affected community.

Where there is an absence of formal land title, local norms and customs regarding the use of land may still operate. The absence of legally defined property rights governing the use of 'open access' resources such as rangelands and forest has often been blamed for the overuse and exploitation of these resources ('The tragedy of the commons'). It has, however, been recognised more recently that what are now often termed 'common-property resources' may be subject to management by local communities, moreover, imposing changes in ownership of access rights on formerly commonly held resources may have a disproportionate effect on certain groups (especially the poor).

Political instability or conflict can have a devastating effect on the environment for a range of reasons. On one side, the movement of people to new areas where they are not equipped with the technical knowledge or social organisation to manage their environment can be detrimental (UNHCR 1997). On the other, where households are living in situations of uncertainty, lack of stability in markets and possible displacement reduce incentives to invest in their land. Where public order is reduced the mechanisms governing land-use systems (both traditional and modern) may be disrupted.

Economic or market factors as a cause of land degradation refers to economic incentives behind land users' management decisions. Decisions to clear land for agriculture, plant certain crops, or adopt destructive land management practices may occur in response to market demand. This has been an important factor in deforestation (Geist and Lambin 2002). In response to market signals farmers may clear more land or intensify production which may, in turn, lead to degradation. In some circumstances, outside entrepreneurs may carelessly employ degrading practices in pursuit of short-term profits.

Example: In Bangladesh the expansion of aquaculture into rice-growing areas in response to a growing global demand for shrimp has reduced soil fertility through chemical pollution and salinisation (EJF 2003).

✍ Can you think of a case of land degradation in your country? What are the physical processes involved? What is causing this problem? Why is this happening? Share your thoughts online.

Section 2 Self Assessment Questions

Question 4

Match the proximate causes of land degradation with possible underlying drivers. Note that an underlying driver can appear more than once in the table.

Proximate	Underlying		
(a) Reduced fallow			
(b) Cultivation of steep slopes			
(c) Clearing of forest for cultivation			
(d) Neglect of conservation structures			

(i) Demographic pressure – shortage of land

(ii) Market factors/opportunities

(iii) Resettlement programmes, transmigration

(iv) Rural–urban migration

(v) Structural inequalities in land distribution

Question 5

True or false?

Depopulation of rural areas reduces pressures on land resources and therefore has a positive impact on agricultural sustainability.

Inequalities in land distribution such as those established by colonial powers are an example of marginalisation which has, in some cases, led to land degradation.

Secure tenure arrangements are dependent on private land ownership.

3.0 WHERE ARE LAND MANAGEMENT PROBLEMS OCCURRING?

Section Overview

In this section we consider the global evaluation of land resources. First we review the world's major biogeographical zones and why land degradation problems are associated with different geographic regions. We then consider the attempts that have been made to formulate a global assessment of land degradation and why the data aggregation is problematic both in practical and policy terms.

Section Learning Outcomes

By the end of this section, students should be able to:

- identify the main biogeographical zones of the world and list their associated land management problems
- discuss critically the limitations of global land degradation assessments
- explain what is meant by environmental or degradation 'narratives' and describe their role in policy formation

3.1 Biogeographical zones

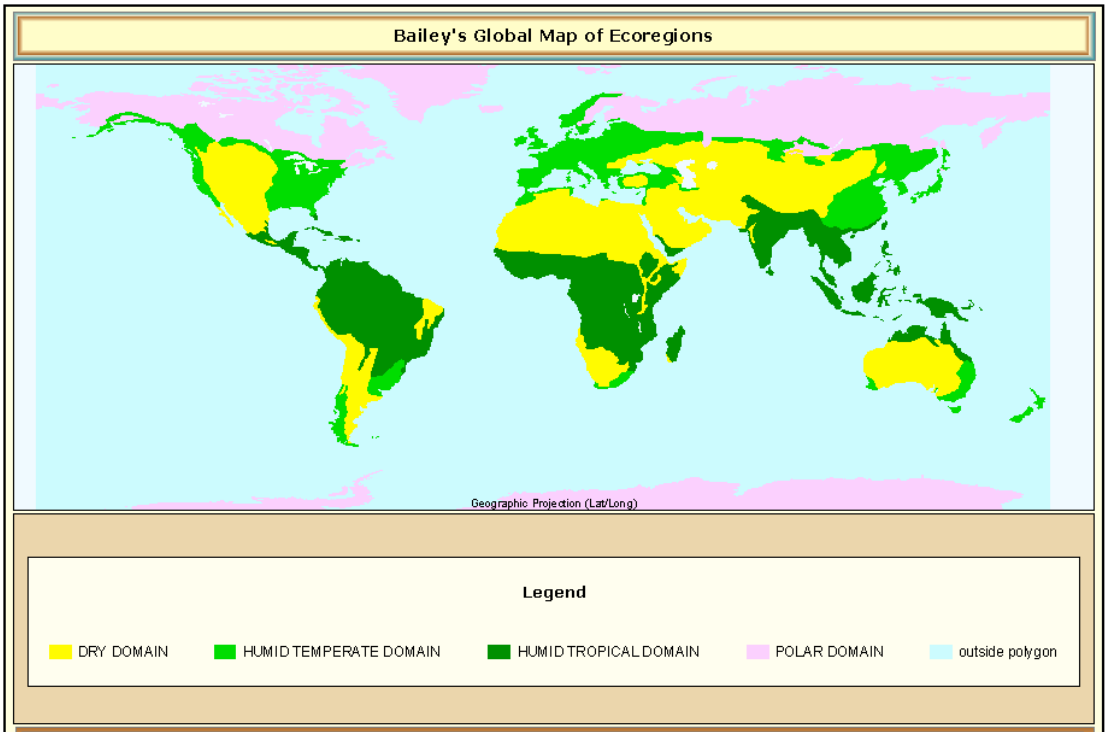
Land management choices alone do not give rise to degradation problems. It is the combination of soil type and topography, climate, and land use that can make land vulnerable to degradation. For this reason, certain land degradation problems are associated with different geographic regions.

Biogeographical classification of the world's land area is usually based on climatic characteristics. The Bailey classification identifies three broad domains (see 3.1.1 on the next page):

- Humid temperate
- Humid tropical
- Dry

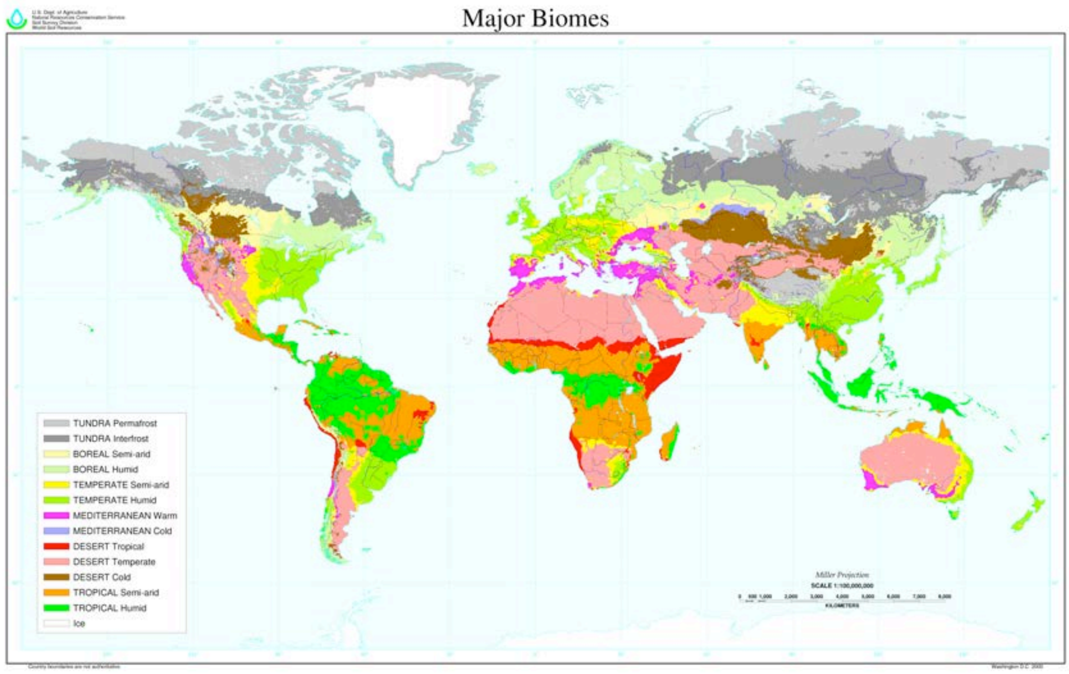
The broad agroecological zones of the tropics can be further categorised as humid, sub-humid, arid, and semi-arid based on the length of the growing period. The Köppen classification system presents a detailed classification of the world's climatic regions (see 3.1.2), in which these zones (see 3.1.1) can be identified.

3.1.1 Bailey's global map of ecoregions



Source: FAO/Geonetwork (1989).

3.1.2 Map of the world's biomes



Source: USDA Natural Resources Conservation Society (NRCS).

Climatic conditions have important implications for both the soils found in a particular region (weathering rates) and for the degradation pressures that soils may be subject to (for example, the intensity of tropical rainstorms).

Parent material, residual bedrock or transported material, also varies geographically and has an important influence on soil properties. These two important factors, climate and parent material, influence the global distribution of soils (see 3.1.3).

3.1.3 Map of the world's soils

Source: USDA Natural Resources Conservation Society (NRCS).

Soils also vary in their susceptibility to erosion and the impact of erosion on crop yields. For example, Ferrasols and Acrisols (together accounting for 63% of soils in the tropics and subtropics) are both susceptible to erosion and sensitive (in terms of yield response) to this loss. By contrast, Nitosols are relatively resistant to land degradation (Stocking 2003) (see 3.1.4 on the next page).

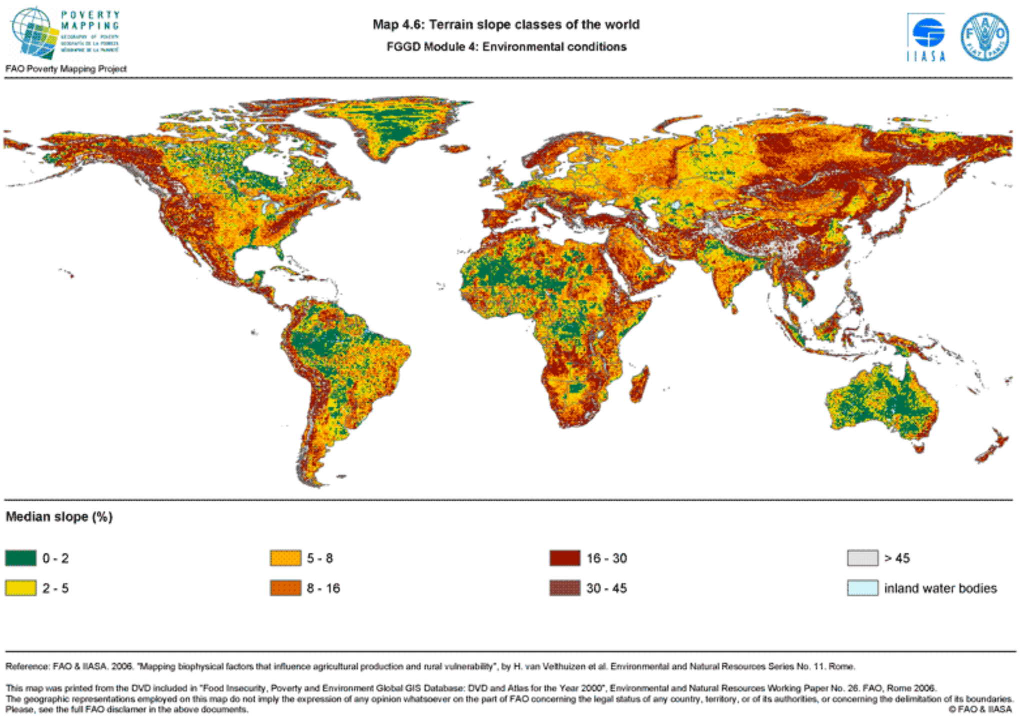
3.1.4 Matrix of resilience-sensitivity

		Sensitivity	
		High	Low
Resilience	High	Resists erosion well but soil quality declines rapidly with poor management [Phaeozems]	Only suffers degradation under persistent poor management [Nitosols; Cambisols]
	Low	Easily degraded with severe impact on productivity [Acrisols]	Can tolerate erosion and degradation with limited impact on productivity [Ferrasols]

Source: adapted from Stocking (2003) p. 1358.

In addition to climatic conditions and soil type, land form also has important implications for land management. The most obvious category here is that of sloping lands. Otherwise known as steeplands, these are the mountain and hill lands. These occur in the major mountain ranges and are also a feature of many island environments (see 3.1.5).

3.1.5 Map of the world's steeplands: terrain slope classes of the world (FGGD)



Source: FAO/Geonetwork (2007).

Another important category of land to consider is alluvial lands. These are the floodplains, river terraces, and deltas that are important areas of agricultural land in all climatic zones (see 3.1.6). Soils here are derived from river sediments and are relatively fertile and their association with river systems means that they are important areas of agricultural productivity, often irrigated.

3.1.6 Nile River and delta from orbit

Source: NASA (2006).

3.2 Global assessment of land degradation

Assessing the extent and impact of land degradation is a difficult challenge. Aside from the logistics of the task, there is the problem of identifying suitable indicators that can be measured easily and consistently over widely varying terrains and environments. These issues, plus the costs involved in measuring biophysical indicators, mean that many land degradation assessments consider land degradation risks (calculated from knowledge about land use and geography) rather than actual physical status.

GLASOD

In 1987, a world map of the incidence of human-induced soil degradation was commissioned by UNEP. The results of this work were published in 1990 as the global assessment of soil degradation or 'GLASOD' (Oldeman *et al* 1990). Data for this exercise were collected using a survey of soil scientists around the world. The status of soil degradation was reported based on their expert judgements. The type, degree, rate, and main cause of degradation were then transferred to a global map.

Despite its limitations this survey provided the first comprehensive assessment of global land degradation and has been an important document for informing policy.

Criticisms of this assessment focus on the consistency of the expert judgements, the mapping units used, and the assumptions made regarding the relationship between land degradation and production (Sonneveld and Dent 2009).

The results from GLASOD showed a high level of land degradation. A total of almost 2 billion hectares were reported to be suffering from degradation, 15% of this (over 300 000 ha) was considered to be strong or extremely degraded (by account of its impact on productivity).

Land degradation Assessment in Drylands (LADA)

More recently the LADA project, funded by the Global Environment Fund (GEF) and the Global Mechanism (GM) of the UNEP, has undertaken a large-scale land degradation assessment exercise to provide information support to combat land degradation (UNCCD).

The LADA project outcomes include baseline regional and global assessments of land degradation in drylands. The project methodology is based on the assumption that human activities are the main driver of land degradation. In order to create a global assessment on land degradation in drylands the LADA project has first created a global map of Land Use Systems (LUS). The LADA approach differs from previous assessments in that it includes stakeholder consultations supplemented with field measurement of biophysical indicators. Pilot assessments are being carried out in six countries. A map of land degradation has been produced using satellite vegetation data and rainfall records (Bai *et al* 2008) (see 3.2.1).

3.2.1 Land degradation assessment – LADA project (2008)

'The LADA project, in partnership with ISRIC – World Soil Information, has produced a global map of land degradation based on more than 20 years of satellite vegetation data and rainfall records. Preliminary findings show that land degradation is relevant in many parts of the world, affecting agricultural and forest areas. The established relation between degradation and land cover suggest that anthropic factors have an important role in determining the degradation process. Improvement areas are also identified by the study. Those areas are often located in croplands, and represent an encouragement to the efforts carried out by the international and national agencies to promote more sustainable agricultural management.

Findings

… The data indicate that despite the stated determination of 193 countries that ratified the United Nations Conference to Combat Desertification in 1994, land degradation is worsening rather than improving.

Some 22 percent of degrading land is in very arid to dry-subhumid areas, while 78 percent of it is in humid regions. The study found that degradation is being driven mainly by poor land management.

Comparing with previous assessments, the present study shows that land degradation since 1991 has affected new areas; while some historically degraded areas were so severely affected that they are now stable having been abandoned or managed at low levels of productivity.

…

Bright spots

But the news is not all bad. Bright spots were also identified in the study where land is being used sustainably (19% of cropland) or is showing improved quality and productivity (10% of forests and 19% of grassland).

Many gains in cropland are associated with irrigation but there are also swaths of improvement in rain-fed cropland and pastures in the Prairies and Great Plains of North America, and western India. Some gains are a result of increasing tree cover, either through forest plantations, especially in Europe and North America, and some significant land reclamation projects, for instance in North China. However, some of the positive trends represent woodland and bush encroachment into rangeland and farmland — which is not generally regarded as land improvement.'

Source: LADA (undated).

3.3 The difficulties of assessing degradation

Assessing land degradation whether at the site-specific or regional level is problematic. Even where it is possible to measure biophysical indicators of degradation (for example, loss of SOM or topsoil) or estimate losses through modelling (for example, soil nutrient budgets) assessing the impact of these changes on productivity is not straightforward.

At the farm level the impact of erosion may be difficult to assess (or predict) for a number of reasons:

- losses due to erosion have different impacts on different soils – some soils are more resilient than others
- agricultural systems are dynamic and changes in technology or cropping practice may make reduction in productivity difficult to assess
- variability in other environmental factors (for example, rainfall) means that it is difficult to isolate the changes due to degradation

Where data are available from field measurements problems are encountered when we seek to generalise or extrapolate these findings to the farm or catchment level.

- Estimations of topsoil losses though erosion extrapolated from plot to farm or watershed level ignore processes of deposition.
- Aggregation of data (for example, nutrient budgets) at farm level may ignore the variability at lower scales that farmers exploit to maintain production.

For all these reasons, creating a 'true' picture of environmental change is difficult; it becomes even more problematic if we recognise that the perspective of the viewer determines (or shapes) the interpretation of the landscape or environment.

The examination of the way in which understandings of the natural environment are framed has been a focus of post-structural, constructivist analysis, frequently through the examination of environmental discourse. Much of this analysis has arisen from a critique of the failing of interventions in the area of soil conservation in particular.

Section 3 Self Assessment Questions

Question 6

True or false?

(a) The natural fertility of alluvial land-use systems means that they are rarely subject to degradation.

(b) The GLASOD was based on standardised measurements of soil properties at over 250 sites globally.

(c) The LADA assessment is based on satellite vegetation data over 20 years.

Question 7

Identify three reasons why the impact of land degradation may be difficult to ascertain.

(a) it is not possible to measure deterioration in soil properties

(b) variability in landscapes

(c) changes in external factors

(d) adaptation in farming systems

4.0 CHANGING POLICY IN SOIL AND WATER CONSERVATION

Section Overview

State intervention to change land-use practices, and thereby halt perceived land degradation, has a long and predominantly unsuccessful history. It is useful to review the origins of research and policy in the area of soil and water conservation in order to understand how past approaches arose and some of the reasons why they have been unsuccessful. In recent decades recognition of the importance of land management in global environmental change has made available new policy instruments for influencing land use decision.

Section Learning Outcomes

By the end of this section, students should be able to:

- describe the origins of soil and water conservation
- discuss how this history shaped the practice of soil and water conservation in the 20th century
- describe recent trends in the study of land degradation and how these relate to wider trends in social science and development

4.1 Introduction

The second part of the 20th century has seen major shifts in the way in which land degradation, in particular that which occurs as a result of soil erosion, has been approached by governments and policy-makers. In a nutshell this can be characterised by a shift from the top-down implementation of soil conservation projects based on engineering solutions towards a more participatory approach which takes greater consideration of the needs and skills of the land user and employs a more holistic attitude to land management.

The issue of soil erosion in particular became a prominent feature of British colonial agricultural policy during the 1930s. This was due in part to the experience of the American Dust Bowl and the powerful images of destruction that emerged from it. However, soil conservation was also one aspect of a more interventionist colonial policy that developed during this period. The colonial origins of soil conservation interventions in the tropics are important to recognise because this has shaped the style of intervention that dominated state soil conservation efforts for many decades (see 4.1.1, below).

Land degradation was commonly attributed to the ignorance of land users, together with their failure to adapt to changes brought by increasing populations and settled agriculture. Prescriptive, technical solutions were coupled in many cases with legislation to coerce the land user into changing his or her ways. In some colonies, protest against unpopular soil conservation laws was harnessed to raise popular resistance to colonial rule.

4.1.1 Colonial origins of 'Soil and Water Conservation'

'[T]he knowledge that erosion was both costly and damaging was first appreciated by agricultural authorities in the USA and colonial Africa and India a century ago. They took the view that farmers were mismanagers of soil and water, and so had to be encouraged to adopt conserving practices. Erosion was considered to be a technical problem requiring technical action, and solutions known to be successful elsewhere were widely applied. Intervention has taken several forms. Authorities have encouraged farmers to construct terraces, bunds, ditches and drains and to adopt alternative cropping practices and contour planting. They have resettled people to discourage the use of certain lands. They have destocked regions of livestock to reduce grazing pressure and introduced compulsory paddocking. They have isolated water sources and prevented cultivation of riverine areas.'

Source: Pretty and Shah (1994) p. 3.

It can be argued that the 'colonial approach' to soil conservation persisted well into post-colonial times. Blaikie (1985) characterised the colonial approach as one in which:

- the problem is identified largely as an environmental one
- mismanagement of the environment occurs chiefly through ignorance
- overpopulation is a key contributor
- incorporation into the market economy presents a solution by increasing incentives to practise modern methods

This view of soil degradation as primarily a technical problem borne of land mismanagement fostered a technicist view of the soil erosion problem defined largely by the objectives of agricultural engineers. The subsequent extension of soil conservation methods within a 'transfer-of-technology' model of agricultural development has been credited with leading to the failure of most soil conservation initiatives. As we will see below, a top-down engineering approach to soil conservation has largely given way to a more holistic 'farmer-first' approach to land management. However, it should be noted that, whilst the style of intervention may have changed, it can be argued that the 'colonial approach' still underlies much work on land degradation.

4.2 Failings of a top-down approach to soil conservation

The pool of expertise from which the British Colonial Service drew its ideas for tackling soil erosion came from the United States Soil Conservation Service. The work of researchers in the United States has continued to be a driving force in soil conservation. However, in retrospect, it is widely held that the attempt to transfer the large-scale earth-moving technology developed in the USA has been a major reason for the failure of soil conservation projects in the tropics.

A key problem with a top-down approach to soil conservation is that it ignores the differences between the perspectives of land users and planners. This problem is clear in the case of soil conservation but applies wherever outside intervention seeks to change the practices of land users for environmental goals which may not be shared.

In the past, soil conservation intervention was often planned by agricultural engineers for whom the primary goal was to reduce soil loss (often by controlling overland flow to prevent excess run-off and gullying). Through research it was known that by reducing slope angle and length soil erosion may be reduced. Hence, bench terraces and other structural techniques were widely recommended. Unfortunately the construction of bench terraces does not necessarily improve productivity of the land and in many cases (through the exposure of less productive subsoil and the loss of land for cultivation) may actually reduce production for the land user. If the labour requirements and other costs of terrace construction are taken into account, soil conservation by this means becomes very unattractive to farmers.

Emphasis was also paid to structures designed to trap run-off or discharge of it safely. This resulted in complicated engineering works involving techniques such as backward sloping terraces, diversion ditches, and artificial waterways. The focus on physical structures was to the neglect of agronomic techniques for reducing soil loss (maintaining ground cover, improving soil structure and infiltration). This omission can be explained in part by the later discovery of the importance of rain splash in soil erosion. However, it also reflects a difference in objectives between planners and farmers.

A top-down approach means that this difference is unlikely to be reconciled. Land users may be concerned with maintaining or improving production; preventing soil erosion *per se* is not usually a priority goal of farmers.

As alluded to above, a difference in perspective between planners and land users is not simply a problem for compliance or adoption of soil conservation technologies, ignoring local perspectives can also lead to the implementation of damaging or degrading 'solutions'.

4.3 Trends towards more farmer-centred 'land husbandry' approaches

An approach to soil conservation that focuses on the soil quality (rather than the quantity of soil lost) more closely reflects land users' own concerns and thus addresses another problem of top-down interventions – the need for coercion or incentives. The trend towards more 'farmer-friendly' conservation reflected a wider movement in rural development and agricultural extension towards 'participatory' and 'farming systems' approaches to technology development that took into account both farmers' existing skills and knowledge and also the social and economic context in which they operate. Within this perspective attention has been paid to indigenous soil and water conservation, and building on farmers' existing practices to improve productivity and protect the land resource.

4.4 Sustainable land management and climate change mitigation

More recently land management and land degradation have received attention within the wider frame of climate change mitigation. Land use change is an important contributor to carbon emissions and soil organic carbon pools represent a significant global carbon sink (Lal 2004). Land management strategies such as Conservation

Agriculture are promoted on the basis of their potential contribution to reducing greenhouse gas emissions as well as their role in maintaining soil productivity. Likewise schemes that pay farmers for adopting certain practices or avoiding deforestation (for example, REDD+) are of growing importance in debates about land management.

Section 4 Self Assessment Questions

Question 8

True or false?

British colonial officers were unaware of the environmental disaster taking place in the American mid–west.

Question 9

Fill in the missing word/phrase.

The ‘colonial approach’ to soil conservation saw soil erosion as primarily a _______ problem.

(a) technical

(b) social

Question 10

True or false?

(a) The move towards more farmer-centred approaches to soil and water conservation reflected contemporary trends for increased participation in rural development.

(b) Proponents of Conservation Agriculture have ignored the potential contribution of these practices to climate change mitigation.

UNIT SUMMARY

Sustainable land management is concerned with the use of land resources whilst preserving their productive capacities.

Intensification of land use can lead to land being subject to degrading processes. These biophysical processes include soil erosion, chemical soil degradation, physical soil degradation, and often result in reduced soil fertility.

Unsustainable land use practices may trigger these processes. These include deforestation, cultivation of marginal lands, reduced fallow periods, overgrazing, nutrient mining, and poor water management leading to salinisation.

In addition to the anthropogenic factors that influence land degradation processes, biogeographical factors influence the rate and extent of degradation at a locality. Soil type, climate, and topography influence the resilience of land.

Having considered the 'what', 'why', and 'where' the final section considers some 'how' questions – how has land degradation been tackled and how are environmental problems constructed? Environmental problems are framed according to the perspectives and priorities of the viewer. This observation helps to explain how degradation problems are tackled and accounts for some of the failings of land management interventions in the past. It also encourages us to be critical when presented with explanations of land degradation.

Unit Self Assessment Questions

Question 1

'Land degradation is a biophysical process driven by socioeconomic and political causes'

What do you understand by this statement, and what are the implications for policy to counter land degradation?

Question 2

Assessing the extent and degree of land degradation presents challenges at both the small and large scale. Outline the reasons this is so.

KEY TERMS AND CONCEPTS

alluvial lands	lands created from the deposition of material carried by water (ie rivers)
compaction (of soil)	downward pressure on soil leading to a reduction in pore space
extensification	increased agricultural production through expansion of area farmed
externalities	consequences or impacts of an activity that are felt by those outside
global environmental change	changes in the biophysical environment manifest at the global scale or so widespread as to be a global phenomenon
intensification	increased agricultural production through increased inputs per unit area
land use change (or land cover change)	change in use of land, for example, from forest to cropland. Changes in land use or land cover affect the local environment (soils, watershed) but also impact the global climate through biogeophysical and biogeochemical processes
nutrient depletion/mining	the removal of more nutrients from the soil than are being added or returned
nutrient loading	quantity of nutrients entering an ecosystem. Excess nutrients can cause ecological imbalance. Two important sources of excess nutrients are: (1) nutrients applied to land but not taken up by crop plants (2) disposal of animal wastes
off-site impacts	degradation effects, especially pollution (sediment, nutrient loading), that are felt away from the location of the driving factor
provisioning services	functions of the landscape that provide us with goods such as food, water, timber, and fibre
salinity/salinisation	increase in the concentration of salts in the soil resulting in conditions less amenable to plant growth
soil erosion	loss of soil particles due to the effects of water and wind
soil organic matter depletion	reduction in soil organic matter occurs as soil carbon is lost from the soil due to oxidation. The rate of loss may be increased due to cultivation practices, and a failure to return organic matter to soil (for example, in crop residues)
steeplands	lands with a slope over 12% (FAO)

surface sealing	breakdown of soil structure at the soil surface leading to the formation of a surface crust
sustainable land management	the use of land resources such as soils, water, animals, and plants for the production of goods while assuring the long-term productive potential of these resources, and the maintenance of their environmental functions