Land degradation and satellite images

Erik de Ruiter
Gymnasium Celeanum Zwolle, The Netherlands

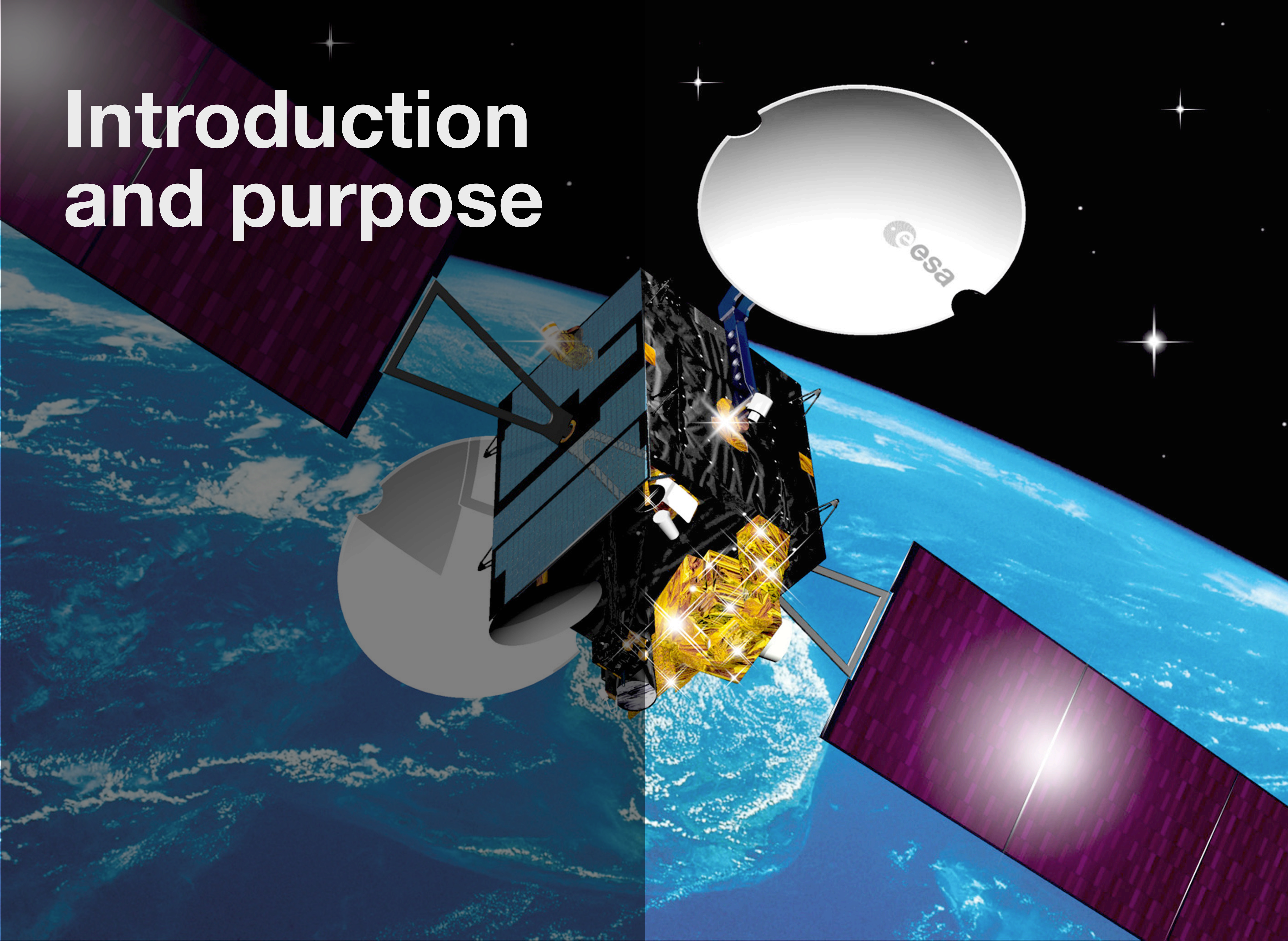
PREFACE

This iBook was written by order of the ESA (European Space Association). It was written as part of a Comenius-project in which several European secundary schools were involved. The idea was to write an iBook with a theme which is linked to the ESA and the International Space Station.

This iBook is about the usage of satellite images to combat land degradation and deforestation. Satellite images can be used to map the land degradation which is taking place in several region on the earth and to think about possible solutions to reduce the problem of land degradation.

The iBook is designed for students in secundary school. There are several excercises within this iBook in which students look at land degradation, its solutions and also at the usage of satellite images with a program called LEOWorks.

Introduction and purpose



Section 1

Introduction and purpose

CONTENT

Film Introduction and purpose.1 ESA and Europe

Introduction

Land degradation is occuring globally and is getting and the consequences of land degradation are getting worse. The most severe impact of land degradation is occurring in developing countries. There are many examples of land degradation. The most popular forms of land degradation are erosion, desertification and salinity. The causes of land degradation are mostly related to human activitites. Land degradation is a phenomenon which is taking place in every part of the world. Some regions are well known for the land degradation which is taking place. Examples of that are the Sahel-region in Africa and the Amazon-region in South America. Land degradation is taking place because of human activities, such as deforestation, agriculture and an extensive usage of water.

Satellite images are playing an important role in mapping land degradation and therefore in the fight against land degradation. The images help institutions and governments to make plans and to find solutions how to fight the land degradation in the region. ESA and NASA are playing a very important role in this.

Image 1.1 The consequences of deforestation: a form of land degradation.

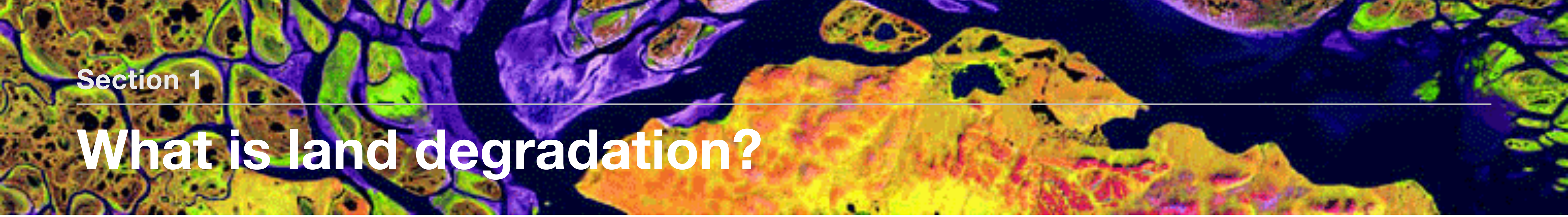
Purpose

The purpose of this ebook is to provide the students of more knowledge of land degradation. Students will learn about land degradation and desertification. They will also learn about the different forms of land degradation that exists and will take a look at some examples of land degradation. Students will learn about some possible solutions to fight land degradation. Besides that, they will look at the role that satellite images are playing in mapping land degradation and will focus especially on the Rondônia-region in Brazil. At last, students will practice with the program LEOWorks. LEOWorks is a program in which students can make maps of the changes in a region by using satellite images.

Quiz Land degradation

Chapter 2

Landdegradation in general: description and statistics



Section 1

What is land degradation?

What is land degradation?

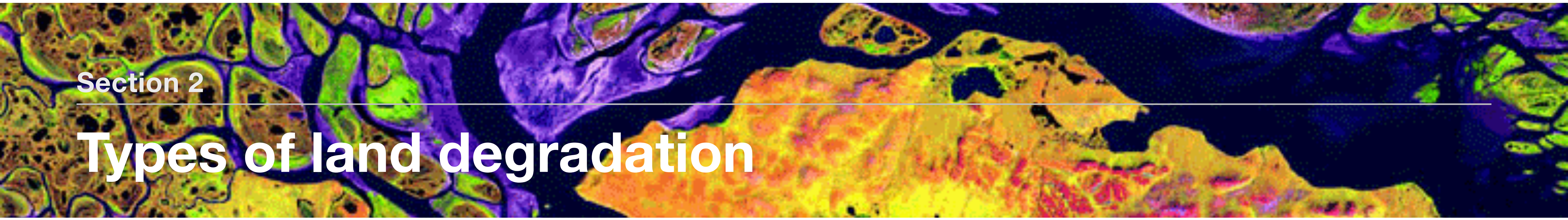
Land degradation is a composite term; it has no single readily identifiable feature, but instead describes how one or more of the land resources (soil, water, vegetation, rocks, air, climate, relief) has changed for the worse. A landslide is often viewed as an example of land degradation in action it changes the features of the land, causes destruction of houses, and disrupts activities. In the longer term, however, the area of a landslide may regain its productivity. In places such as Jamaica and Papua New Guinea, old landslide scars are noted for supporting better crops and more intensive agricultural possibilities than on the adjacent land not affected by landslides especially when the new soil is derived from less weathered rock materials, such as calcareous mudstones. So, land degradation is far from being a simple process, with clear outcomes. This complexity needs to be appreciated by the field assessor, before any attempt is made either to define land degradation or to measure it.

Land degradation generally signifies the temporary or permanent decline in the productive capacity of the land (UN/FAO definition). Another definition describes it as, "the aggregate diminution of the productive potential of the land, including its major uses (rain fed, arable, irrigated, rangeland, forest), its farming systems (e.g. smallholder subsistence) and its value as an economic resource." This link between degradation (which is often caused by land use practices) and its effect on land use is central to nearly all published definitions of land degradation. Theemphasis on land, rather than soil, broadens the focus to include natural resources, such as climate, water, landforms and vegetation. The productivity of grassland and forest resources, in addition to that of cropland, is embodied in this definition. Other definitions differentiate between reversible and irreversible land degradation. While the terms are used here, the degree of reversibility is not a particularly useful measure given sufficient time all degradation can be reversed, as illustrated by the landslide example above. So, reversibility depends upon whose perspective is being assessed and what timescale is envisaged. Whilst soil degradation is recognised as a major aspect of land degradation, other processes which affect the productive capacity of cropland, rangeland and forests, such as lowering of the water table and deforestation, are captured by the concept of land degradation.

Land degradation is, however, difficult to grasp in its totality. The "productive capacity of land" cannot be assessed simply by any single measure. Therefore, we have to use indicators of land degradation. Indicators are variables which may show that land degradation has taken place they are not necessarily the actual degradation itself. The piling up of sediment against a downslope barrier may be an 'indicator' that land degradation is occurring upslope. Similarly, decline in yields of a crop may be an indicator that soil quality has changed, which in turn may indicate that soil and land degradation are also occurring. The condition of the soil is one of the best indicators of land degradation. The soil integrates a variety of important processes involving vegetation growth, overland flow of water, infiltration, land use and land management. Soil degradation is, in itself, an indicator of land degradation. This chapter will, therefore, dwell primarily on the use of evidence from the soil (mainly soil degradation) and from plants growing on the soil.

Land degradation and desertification

Land degradation is often confused with desertification. Desertification is a form of land degradation in a specific region. Desertification is the persistent degradation of dryland ecosystems by variations in climate and human activities. Home to a third of the human population in 2000, drylands occupy nearly half of Earth's land area. Across the world, desertification affects the livelihoods of millions of people who rely on the benefits that dryland ecosystems can provide.



Section 2

Types of land degradation

Types of land degradation

Land degradation if a very broad term. Therefore different types of land degradation can be distinguished. There are natural influences on the land, such as water and wind. Land degradation also takes place because of the influences of human on the land. Types of land degradation include:

1) **Soil erosion by water**
The removal of soil particles by the action of water. Usually seen as sheet erosion (a more or less uniform removal of a thin layer of topsoil), rill erosion (small channels in the field) or gully erosion (large channels, similar to incised rivers). One important feature of soil erosion by water is the selective removal of the finer and more fertile fraction of the soil.

2) **Soil erosion by wind**
The removal of soil particles by wind action. Usually this is sheet erosion, where soil is removed in thin layers, but sometimes the effect of the wind can carve out hollows and other features. Wind erosion most easily occurs with fine to medium size sand particles.

3) **Soil fertility decline**
The degradation of soil physical, biological and chemical properties. Erosion leads to reduced soil productivity.

4) **Waterlogging**
Caused by a rise in groundwater close to the soil surface or inadequate drainage of surface water, often resulting from poor irrigation management. As a result of waterlogging, water saturates the root zone leading to oxygen deficiency.

5) **Increase in salts**
This could either be salinization, an increase in salt in the soil water solution, or sodication, an increase of sodium cations (Na+ on the soil particles. Salinization often occurs in conjunctionwith poor irrigation management. Mostly, sodication tends to occur naturally. Areas where the water table fluctuates may be prone to sodication.

6) **Sedimentation or 'soil burial'**
This may occur through flooding, where fertile soil is buried under less fertile sediments; or wind blows, where sand inundates grazing lands; or catastr ophic events such as volcanic eruptions.

7) **Lowering of the water table**

This usually occurs where extraction of groundwater has exceeded the natural recharge capacity ofthe water table.

8) **Loss of vegetation cover**

Vegetation is important in many ways. It protects the soil from erosion by wind and water and it provides organic material to maintain levels of nutrients essential for healthy plant growth. Plant roots help to maintain soil structure and facilitate water infiltration.

9) **Increased stoniness and rock cover of the land**

This would usually be associated with extreme levels of soil erosion causing exhumation of stones and rock.exhumation of stones and rock.

Galery 2.1 Different types of land degradation

Soil erosion caused by the loss of vegetation cover

Figures related to land degradation

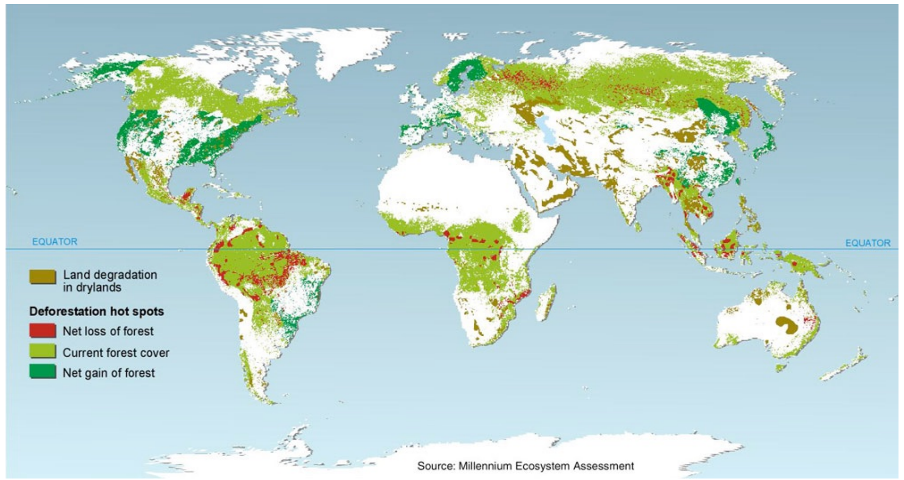


Image 2.1 Land degradation and deforestation on a global scale

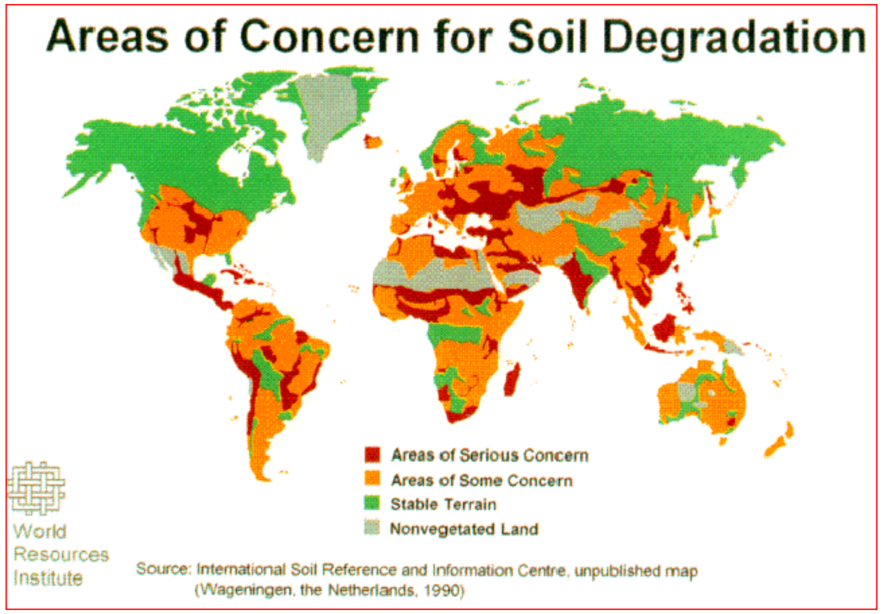


Image 2.2 Areas of concern for soil degradation

Area	Overgrazing	Deforestation	Misma-nagement in agriculture	Other causes	Total (in millions of hectares)	Part of degraded land with respect to total area covered with vegetation on continent
Asia	26,6%	39,9%	27,3%	6,3%	746	20%
Africa	49,2%	13,6%	24,5%	12,7%	494	22%
South America	27,9%	41,0%	26,2%	4,9%	244	14%
Europe	22,7%	38,2%	29,1%	10%	220	23%
North and Central America	24,0%	11,4%	57,6%	7,0%	158	8%
Australia, New Zealand and South Pacific	80,5%	11,7%	7,8%	0%	103	13%
World	34,5%	29,4%	28,1%	7,9%	1.965	17%

In the table, which is shown above, you can see the degraded land by continent. The causes of the land degradation are also shown by continent. The continent which has the biggest part of degraded land, with respect to the the total area covered with vegetation is Europe. The cause has the biggest impact on land degradation in the world is overgrazing, followed by deforestation and mismanagement in agriculture.

Section 4

Exercise land degradation in several countries

Exercise

Search for some land degradation statistics of the following countries: Brazil, USA, The Netherlands and your own country in the GLADA report ‘Global assessment of land degradation and improvement. Compare the following statistics:

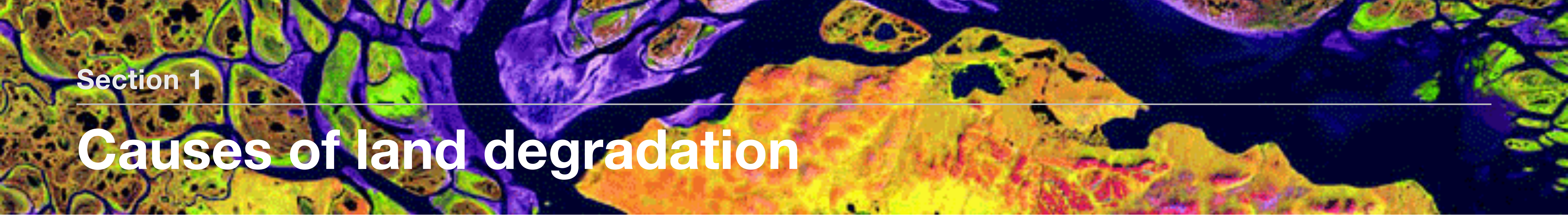
- Degraded area
- % of total area
- Affected people

Chapter 3

Land degradation: causes and solutions

3.1: causes of land degradation

3.2: solutions to combat land degradation



Section 1

Causes of land degradation

Causes of Land Degradation

Although degradation processes do occur without interference by man, these are broadly at a rate which is in balance with the rate of natural rehabilitation. Accelerated land degradation is most commonly caused as a result of human intervention in the environment. The effects of this intervention are determined by the natural landscape. The most frequently recognised main causes of land degradation include:

1) Overgrazing of rangeland;

2) Over-cultivation of cropland;

3) Waterlogging and salinization of irrigated land

4) Deforestation

5) Pollution and industrial causes.

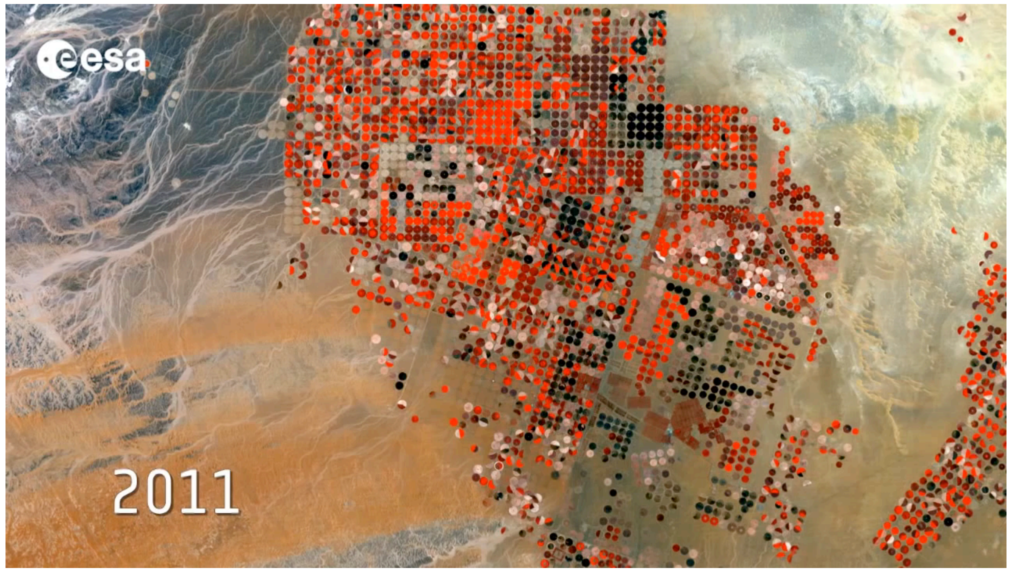
Within these broad categories a wide variety of individual causes are incorporated. These causes may include the conversion of unsuitable, low potential land to agriculture, the failure to undertake soil conserving measures in areas at risk of degradation and the removal of all crop residues resulting in 'soil mining' (i.e. extraction of nutrients at a rate greater than resupply). They are surrounded by social and economic conditions that encourage land users to overgraze, over-cultivate, deforest or pollute.

It is possible to distinguish between two types of land degrading actions.

The first is unsustainable land use. This refers to a system of land use that is wholly inappropriate for a particular environment. It is unsustainable in the sense that, unless corrected, this land use or indeed any other could not be continued into the future. Unsustainability has the implication of being irreversibly degrading. Many 'badlands' (extremely bare, devegetated and eroded slopes) are effectively irreversible. However, a large input of technology could start a rehabilitation process, if enough time and resources were to be devoted. Usually, this is uneconomic.

Secondly, inappropriate land management techniques also cause land degradation, but this degradation may be halted (and possibly reversed) if appropriate management techniques are applied. The effect of a land degrading process differs depending on the inherent characteristics of the land, specifically soil type, slope, vegetation and climate. Thus an activity that, in one place, is not degrading may, in another place, cause land degradation because of different soil characteristics, topography, climatic conditions or other circumstances. So, equally erosive rainstorms occurring above different soil types will result in different rates of soil loss. It follows that the identification of the causes of land degradation must recognise the interactions between different elements in the landscape which affect degradation and also the site-specificity of degradation.

Film 2.1 Derert growth in Saudi Arabia



Section 2

Solutions to combat land degradation

Solutions to combat land degradation

One crucial step to beginning land reclamation is the removal of livestock. This removal decreases soil compaction, thus allowing more water infiltration, which is important for the regrowth of plant material. According to a research of Castellano, including raising of livestock, stopped on an area of desertified land in the African Sahel, it began to regrow vegetation after 20 years. The increase in water infiltration has a positive feedback relationship with perennial grass cover; as perennial grass grows, the erosional capability of water decreases, and the rate of water infiltration increases.

Another possible tool we have to combat the issue of desertification and land degradation is shrub encroachment, which is the increase in the density and cover of shrubs in former grasslands. Shrub encroachment is brought about by many different factors such as: climate change, grazing, and fire suppression. These factors contribute because they generate heterogeneity in soil resources, which “creates opportunities for shrub colonization.” Shrub encroachment can increase runoff and erosion,

If nothing is done about the situation, desertification and land degradation will increase. Grasses will be overgrazed, water infiltration will decrease, and the grass will be unable to survive. This will create much drier soil, which in turn is more vulnerable to erosion and runoff. All of these factors will combine to create a very stable but very unproductive desert environment. However, if acted upon quickly, there is a possibility for land reclamation and reversal of desertification. In the Sahel region there is a project to combat land degradation and desertification by constructing a Green Wall of vegetation. This can be seen in the video in this section.

It is also possible to fight land degradation by using terracing in agriculture. The principal objective of terracing is generally to reduce the runoff and the loss of soil, but it also contributes to increasing the soil moisture content through improved infiltration and to reducing peak discharge rates of rivers.

Image 3.1 Using terracing in agriculture to combat erosion and land degradation

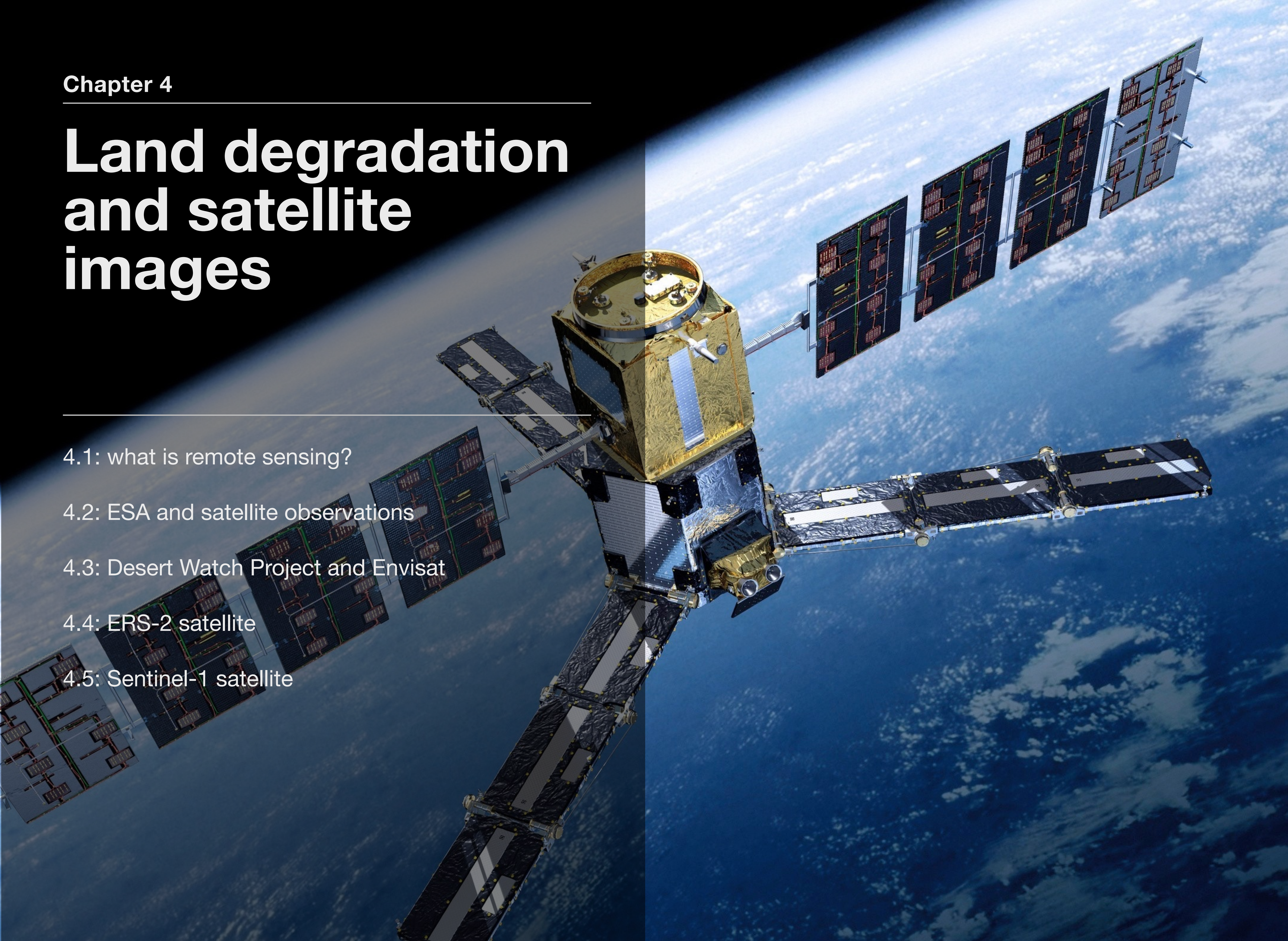
Terracing fields in Vietnam

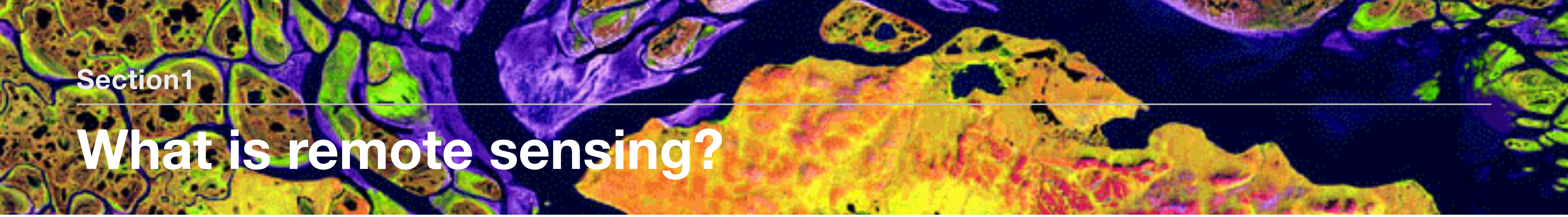
Film 3.2 Fighting land degradation in the Sahel: the Green Wall

Film 3.3 Integrated ecosystem management to combat land degradation

Chapter 4

Land degradation and satellite images





Section1

What is remote sensing?

What is remote sensing?

Remote sensing is a way of collecting and analysing data to get information about an object without the instrument used to collect the data being in direct contact with the object. For example, if you take a photograph of your house, and on the picture you see that the house is composed of a roof, walls and windows, all of which appear as different colours, then this is remote sensing.

In remote sensing, three elements are essential. They are:

1) a platform to hold the instrument
2) a target object to be observed
3) an instrument or a sensor to observe the target

For example, when you take a photograph of your house, you are the platform, the photographic emulsion of the film inside the camera is the sensor and the house is the target object. A key additional element, and the main purpose of remote sensing systems, is:

4 - the information that is obtained from the acquired data, and how it is used and stored

In the example of the photograph of your house, the information obtained is all you can identify about the house from the photograph. Examples could be the colour of the shutters, a hole in the roof, and an open window.

When Earth scientists talk about remote sensing, the observed object is the Earth. In general terms then, remote sensing is a tool to observe and study the Earth, its land surface, the oceans, the atmosphere and its dynamics from space.

For scientists, the platforms are all means used to be 'at a distance' from the Earth's surface, such as planes and satellites. The target is our planet itself, the sensors are contained in all the instruments used to observe the Earth (cameras, scanners, radars, etc) and finally the information obtained is everything that increases our knowledge about our planet, such as cloud cover over Europe, the evolution of the ozone hole, the spreading of the deserts, the progress of deforestation, and much more.

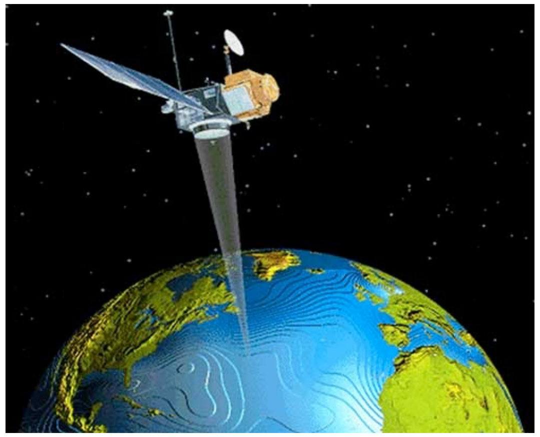
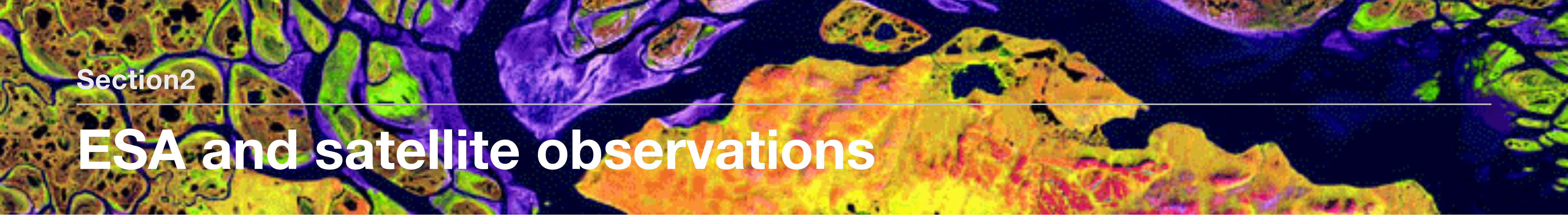


Image 4.1 Remote sensing



Section2

ESA and satellite observations

ESA and satellite observations

Earth-observing satellites allow for efficient, reliable and affordable monitoring of our planet from global to local scales. In many cases, it is the only way to obtain trend information on essential environmental variables.

The large volume of data acquired from over 30 years of satellite observations gives scientists an unique and detailed view of the changing physical characteristics of the earth surface, sampled at a rate impossible to obtain with only in-situ observations.

The strong contributions that space observations can bring to environmental monitoring have now been recognised by the Rio Convention bodies: the UN Framework Convention on Climate Change (UNFCCC), the UN Convention to Combat Desertification (UNCCD) and the Convention on Biological Diversity (CBD).

For example, satellite data at national and local scales help the implementation of UNFCCC protocols and assist the Contracting Parties in their reporting duties.

The CBD develops national strategies for the conservation and sustainable use of biological diversity. Earth-observing satellites are seen as promising instruments for the systematic observations of essential biodiversity variables such as ecosystems status and trends.

The UNCCD is the centrepiece in the international community's efforts to combat desertification and land degradation in drylands. The Convention is currently developing a monitoring and assessment process of the world's drylands, where satellite observations will play a key role.

During the side event, representatives from all three Conventions reiterated that the collection of earth observation data needs to be sustained.

ESA plans to continue to provide operational data delivery to these Conventions as well as for many other applications with the upcoming Sentinel family of satellites being developed under Europe's Global Monitoring for Environment and Security (GMES) programme.

At the conclusion of the summit, the Rio+20 Declaration stressed the need for the continuation of a regular review of the state of earth's changing environment, as well as access to reliable, relevant and timely data in areas related to sustainable development.

It also recognised the relevance of global mapping and recognise the efforts in developing global environmental observing systems.

Rio+20 saw additional side events on Earth observation organised by the Group on Earth Observations, the Japan Aerospace Exploration Agency and the UN Office for Outer Space Affairs.

Desert Watch Project and Envisat

Desert Watch Project

DesertWatch (DW) is an European Space Agency (ESA) project aiming at developing auser-oriented Information System based on EO technology to support national and local authorities in responding to the reporting obligations of the UNCCD and in monitoring land degradation trends over time.

As part of the Data User Element (DUE) of the Earth Observation Envelope Programme, the ESA launched in 2004 the DesertWatch project. The original project was restricted to the UNCCD Annex IV countries and has seen the participation of the UNCCD National Focal Points from Portugal, Italy and Turkey.

Following the success of the project, ESA has decided to fund the adaptation of the DW-O approach to make it applicable in a global context.

Envisat

Launched on 1 March 2002 on an Ariane-5 rocket from Europe's spaceport in French Guyana, Envisat was the largest Earth observation spacecraft ever built.

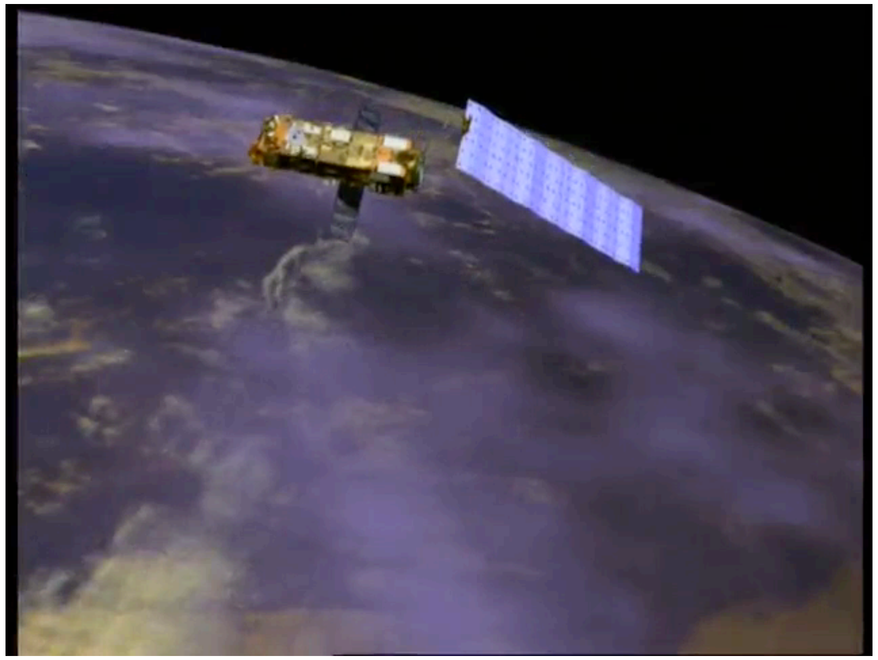
The eight-tonne satellite orbited Earth more than 50 000 times over 10 years – twice its planned lifetime. The mission delivered thousands of images and a wealth of data used to study the workings of the Earth system, including insights into factors contributing to climate change.

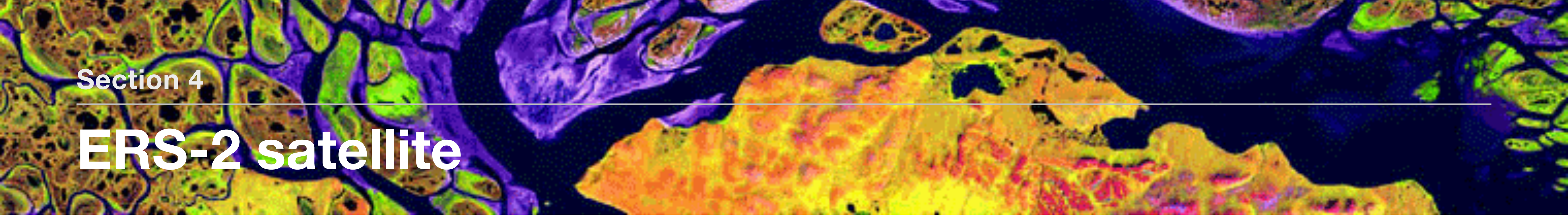
Contact with Envisat was suddenly lost on 8 April 2012. Following rigorous attempts to re-establish contact and the investigation of failure scenarios, the end of the mission was declared on 9 May 2012.

But ten years of Envisat's archived data continues to be exploited for studying our planet.

Image 4.1 Envisat satellite

Film 3.1 Envisat satellite





Section 4

ERS-2 satellite

ERS-2 satellite

The European Remote Sensing satellite ERS-1, launched in 1991, carried a comprehensive payload including an imaging synthetic aperture radar, a radar altimeter and other powerful instruments to measure ocean surface temperature and winds at sea. ERS-2, which overlapped with ERS-1, was launched in 1995 with an additional sensor for atmospheric ozone research.

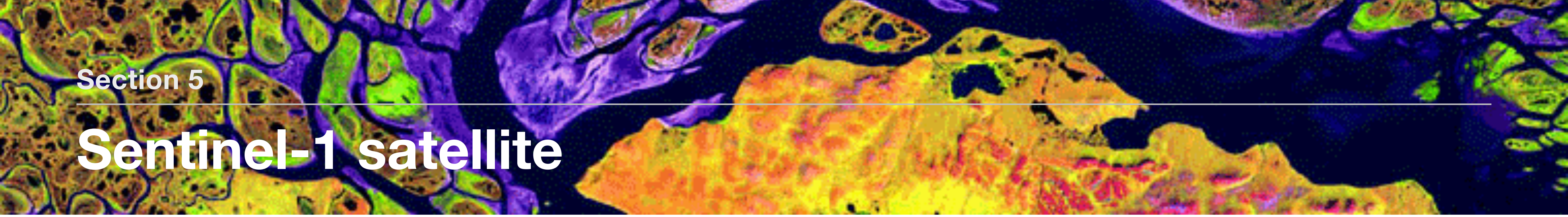
At their time of launch the two ERS satellites were the most sophisticated Earth observation spacecraft ever developed and launched by Europe. These highly successful ESA satellites collected a wealth of valuable data on Earth's land surfaces, oceans, and polar caps and were called upon to monitor natural disasters such as severe flooding or earthquakes in remote parts of the world.

Both ERS satellites were built with a core payload of two specialised radars and an infrared imaging sensor. The two were designed as identical twins with one important difference: ERS-2 included an extra instrument to monitor ozone levels in the atmosphere.

Shortly after the launch of ERS-2 in 1995 ESA decided to link the two satellites in the first 'tandem' mission which lasted for nine months. During this time the increased frequency and level of data available to scientists offered a unique opportunity to observe changes over a very short space of time, as both satellites orbited Earth only 24 hours apart.

In March 2000, a computer and gyro control failure led to ERS-1 finally ending its operations, after far exceeding its planned lifetime.

In July 2011, ERS-2 was retired and the process of deorbiting the satellite began.



Sentinel-1 satellite

Sentinel-1

The Sentinel-1 mission opens up new possibilities for many land applications. The satellites' frequent revisits over the same area allow changes in land cover to be closely monitored. This is particularly useful for keeping an eye on tropical forests that are typically shrouded by cloud and for detecting illegal timber harvesting worldwide.

Land cover information is also important for agriculatural practices, to estimate crop acreage, to provide soil moisture information and to forecast yields. This makes Sentinel-1 a valuable complement to the upcoming Sentinel-2 multispectral optical mission. Moreover, this new mission is the only European satellite specifically designed for fast response to emergencies and disasters such as flooding and earthquakes.

Radar images – such as those provided by Sentinel-1's C-band synthetic aperture radar – are the best way of tracking land subsidence and structural damage.

The 'radar interferometry' remote sensing technique combines two or more radar images over the same area to detect changes occurring between acquisitions. Interferometry allows for the monitoring of even slight ground movement – down to a few millimetres – across wide areas. As well as being a valuable resource for urban planners, this kind of information is essential for monitoring shifts from earthquakes, landslides and volcanic uplift.

While Sentinel-1 offers timely information for a multitude of operational land applications, it continues more than 20 years of radar imagery.

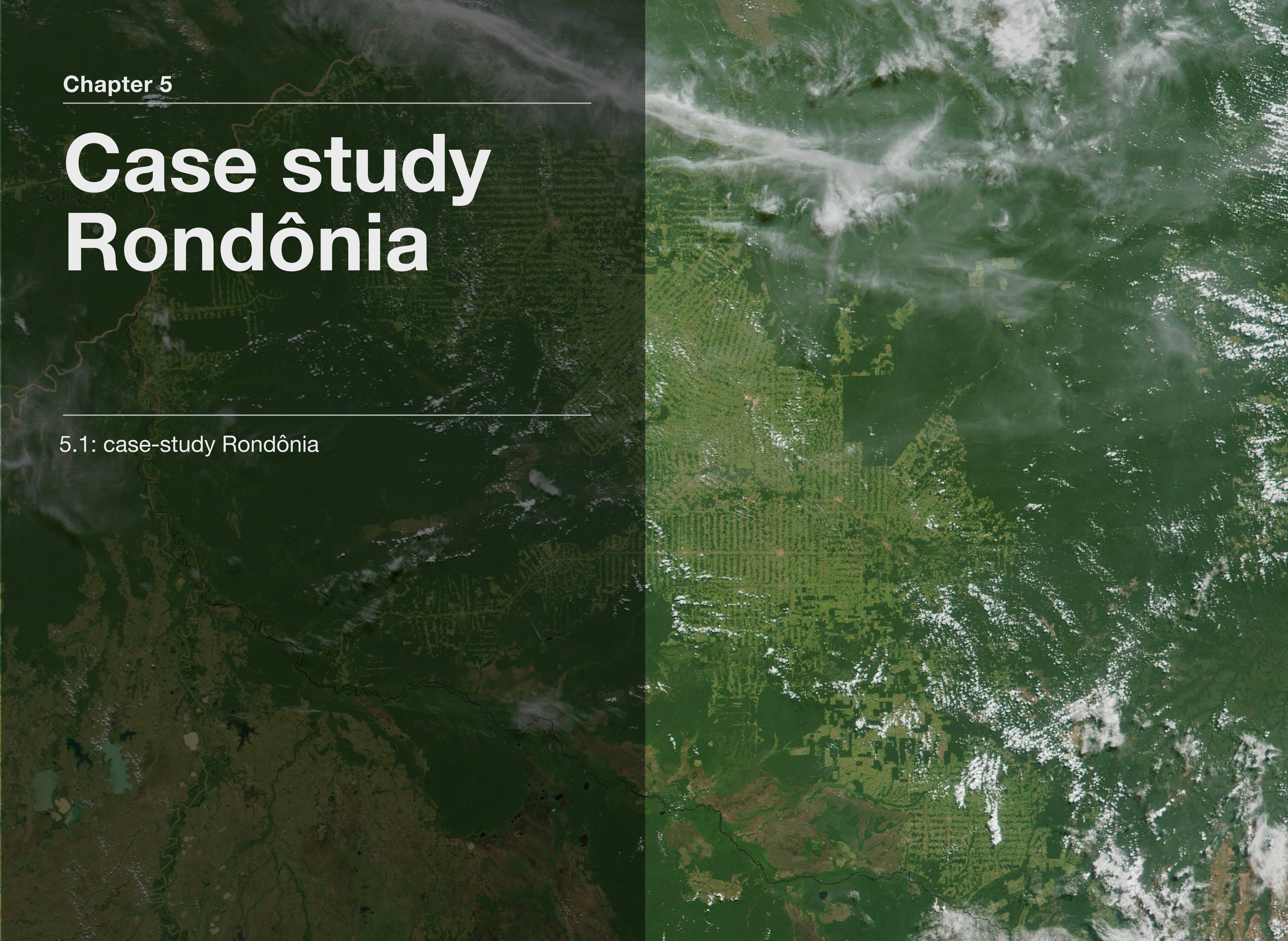
This archive is not only essential for practical applications that need a long-term dataset, but also for understanding the long-term impacts of climate change. Sentinel-1 will, therefore, help to arm decision-makers with the information they need to make informed choices for a sustainable future.

Film 3.2 Sentinel-1 satellite

Chapter 5

Case study Rondônia

5.1: case-study Rondônia



Case-study Rondônia

Case study Rondônia

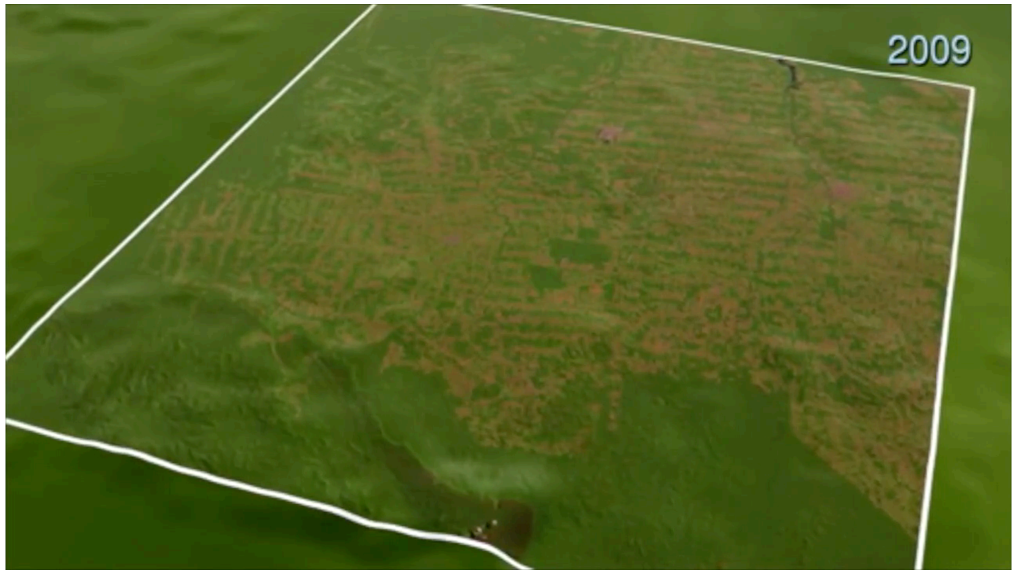
In this chapter we will take a look at an example of a region in which deforestation is taking place. It is the Rondônia region which is located in the western part of Brazil, in the Amazon rainforest

Deforestation in the Amazon takes many different patterns, depending upon the origin of the forest clearing. In Rondônia, a state in Western Brazil, deforestation from the 1970s until the 1990s had a distinctive "fishbone" pattern. Access to this remote region began with a major road cutting through the dense tropical forest, opening up new territory for small farms and ranches. Then, other roads developed at right angles to the initial road. In this visualization, these roads shoot off a stretch of the main "backbone" road for about 31 miles (~50 kilometers) long, each secondary road branching off about every 2.5 miles (~4 kilometers). This creates the "fishbone" pattern.

Farmers and ranchers in the Amazon commonly burn areas to create open spaces for fields and grazing lands.

Settlers clear the forest on their parcels of land all along the main and secondary roads, first cutting and then burning the cleared forest. The cleared areas slowly get larger and larger and closer together until finally what's left is one large area of deforestation.

Film 5.1 Time lapse deforestation in Rondônia



Exercise:

In the video you can see the deforestation in the Rondônia region.

a During which period did the most deforrestation take place?

b Describe the pattern in which the region is deforrested.

c Why did the deforrestation of the region take place in this pattern?

"Because these roads cut deep into the rainforest and then spread outwards, there's a much greater loss of habitat and species than if there was a single area of deforestation, because the amount of 'edge' is critical for biodiversity," says Compton Tucker, a biologist and tropical forest expert at NASA's Goddard Space Flight Center in Greenbelt, Md

A detailed study of Landsat images by Tucker and David Skole, a physical scientist now at Michigan State University in East Lansing, Mich., showed that the annual rate of deforestation in the Amazon from 1978 to 1988 was lower than previously thought, but the impact on biodiversity was much greater than assumed, because of habitat fragmentation caused by the "fishbone" deforestation pattern in Rondônia.

Tucker says this biodiversity paradox lies in the nature of fishbone deforestation; it creates many more miles of "edges" between deforested areas and intact forest. These "edge" areas between deforestation and remaining forests are where there's much greater wind damage and desiccation of forest and because it's easier for humans to access these areas, there's also increased rates of hunting, poaching, and animal capture, as well as higher levels of legal and illegal logging.

Skole and Tucker published their research in the journal Science in 1993. They found that between 1980 and 1992 more than 1,000 square miles (~3,000 square kilometers) of forest in Rondônia was lost each year. The beginning of the forest loss coincides with a 1979 decision by Brazil's Program of National Integration to build roads across the forest and offer cheap land for agriculture, thus encouraging a population boom in the area. The images of "fishbone" deforestation in Rondônia were widely publicized, and have become the visual shorthand for tropical deforestation worldwide.

In recent decades the locus of deforestation in Brazil has shifted east to the states of Mato Grosso and Pará, where large tracts of land are being cleared for mechanized agriculture, rather than small-hold farming. Even so, Brazil's overall rate of deforestation has slowed in recent years.

Even with the deforestation, Brazil is still home to more than a quarter of Earth's tropical forests. In addition to their astounding biodiversity, these forests act as a major carbon "sink." These are places where carbon dioxide in the atmosphere is absorbed by living things, like

Film 4.2 Deforestation Rondônia in satellite images

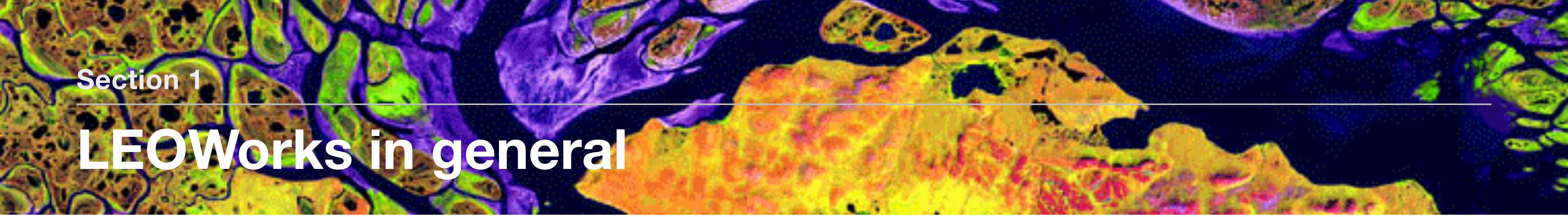
trees and plants, and thus the carbon is said to be trapped or sequestered. With increasing carbon dioxide levels around the world, the ability of these forests to hold onto carbon has beneficial implications for stabilizing the world's climate.

Excercise:

Describe a solution to combat deforestation in the Rondônia region.

Chapter 6

Land degradation and LEOWorks



Section 1

LEOWorks in general

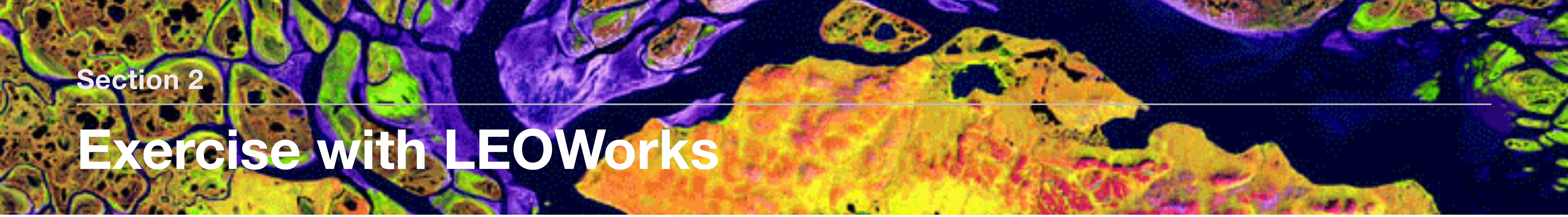
LEOWorks

LEOWorks is an important feature of Eduspace. It allows secondary school students to do actual processing of satellite imagery. LEOWorks is able to perform basic and advanced processing operations, such as geometric correction, pan-sharpening and image classification. Several tools are available, such as Geographical Information Systems (GIS) functionalities that enable the displaying, drawing and managing of information layers as points, lines and polygons, on top of images.

LEOWorks is a didactical tool with extensive help pages and an all-inclusive tutorial (see right of page). With the assistance of this documentation, students will be able to experiment with their own imagery and undertake their own processing. LEOWorks is compatible with data collected by several Earth Observation missions, and can read most standard image formats (e.g. jpg, tif, bmp, png).

The students can do a tutorial to see how they can work with this program.

After finishing the tutorial. go to the website of ESA. You will research the deforestation in the Rondônia region.



Section 2

Exercise with LEOWorks

In this case study, you will learn how remote sensing can aid in the monitoring of tropical rainforests, such as the Amazon rainforest. You will see how this forest disappeared over a period of 30 years, and how the rate of deforestation can be measured. You will also learn that, even in deforested areas, the process of vegetation growth still goes on.

The satellite sensor you will be working with is Landsat TM. The exercise will be done using the LEOWorks image processing software.

Excercise 1: Imagery

The imagery we will use in this exercise comes from the Landsat 5 TM sensor. Find out more about this sensor by going to 'Earth observaation satellites' in the 'Remote Sensing Principles' section of the Eduspace website.

A zipped file (Rondonia.zip) containing all the images can be downloaded from the right menu on the website

(http://www.esa.int/SPECIALS/Eduspace_Global_EN/SEMCIS4XX2H_0.html)

Do the excercises which are presented on the website.

Excercise 2: Quantifying the deforested area

In this excercise we will take a look at the deforested area and quantify the area which has been deforested during the 30 years. The excercise and the images you need can be found on the following website:

http://www.esa.int/SPECIALS/Eduspace_Global_EN/SEMRQY4XX2H_0.html