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Institut Royal des Etudes Stratégiques
Royal Institute for Strategic Studies

STRATEGIC REPORT 2017

MOROCCO IN THE WORLD: A PANORAMA

GLOBAL CHALLENGES FOR THE BIOSPHERE

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July 30, 2016

SUMMARY

DOCTRINE OF THE KINGDOM OF MOROCCO

"... What we need is to develop a comprehensive strategy, based on true partnership, genuine solidarity and an efficient "close proximity" approach. In addition, we should develop norms and standards to curb and contain the dangers resulting from climatic changes and from overexploitation of water, forest and fish resources, as well as the risks arising from the pressure being exerted on ecosystems and biodiversity **..."**

Excerpt from the Statement by His Majesty King Mohammed VI at the World Summit on Sustainable development, 2 September 2002

"... The fragile ecosystems of African countries, the vulnerability of their economies and the limited means they can rely on to cope with climate change will inevitably lead to more poverty and less security in many parts of the continent. This is particularly unjust as these countries, which are low greenhouse gas emitters, are among the hardest hit by the effects of climate change. More than ever before, international solidarity, equity and shared responsibility are needed to support these countries as they develop and implement measures to adapt to climate change, for which they will need technical assistance as well as appropriate financial backing **..."**

Excerpt from the Message addressed by His Majesty King Mohammed VI to the participants in the International Meeting on Climate Change: Challenges and Adjustment Prospects in Morocco, held by The Royal Institute for Strategic Studies, 16 October 2009

DOCTRINE OF THE KINGDOM OF MOROCCO

"... Climate change is one of the major issues facing humanity today since it now represents a real threat not only to the environment, but also to economic and social development and to global security and stability.

... The new system should also be based on the principle of justice as well as on the right of developing countries to respond to their current and future development needs **..."**

Excerpt from the Message addressed by His Majesty King Mohammed VI to the participants in the Sixth Islamic Conference of Environment Ministers, 8 October 2015

"... The African continent deserves special attention. The whole of Africa is experiencing an awakening. Africa is discovering itself and is gaining confidence. It is therefore in Africa - the continent of the future - that the planet's future will be decided. In this context, promoting the transfer of technology and raising funds, particularly for the benefit of developing countries, is fundamental. Above all, let us guard against compelling these countries to choose between economic development and the protection of the environment. Developing countries' commitment to combat the effects of climate change must also take into account their respective development models as well as their inhabitants' customs **..."**

Excerpt from the Speech delivered by His Majesty King Mohammed VI at the United Nations conference on Climate Change (COP21), 30 November 2015

FOREWORD

In 2015, the Royal Institute for Strategic Studies (IRES) launched a new series of strategic annual reports, titled ***Morocco in the World: a Panorama***. These reports aim to provide the **bigger picture that helps to better understand systemic issues.**

Moroccan and international public or private decision-makers have thus access to a tool that allows them to fully grasp the major challenges of the 21st century and form a view towards the Kingdom's forward-looking strategic vision.

After a first issue on **major transitions and their impact on Morocco** (2015) followed by a second one on the **International Relations of the Kingdom** (2016), this third Panorama is devoted to the crucial issues of **climate change and the ecological footprint**.

On the eve of COP22, to be held in Marrakech in November 2016, this Panorama is specifically meant to raise awareness on the **global challenges faced by the biosphere**. The case of Morocco is merely presented in this report for illustrative purposes. Though there were significant and advanced accomplishments in the Kingdom, here the global vision prevails on the recognition of Morocco's achievements.

Climate change is perhaps the greatest threat ever posed to the future of humanity.

Yet it is not the first threat that humans face, and their ability to adapt has always enabled them to survive.

However it is the first time that we are witnessing not only rapid change, but also at the same time, a significant degradation of our planet, as a consequence of our excessive ecological footprint. The cumulative effect of these events means that the 21st century will be a crucial time. The very survival of humankind at worst, or its development path at best, may be at stake.

For this reason, this report chooses to focus on some of the key factors that are most often overlooked, and the most operational strategies.

Tawfik MOULINE
Director-General of IRES

Source : National World History (http://nationalityinworldhistory.net/ch3.html)

INTRODUCTION (1)

Humankind has always shaped its own evolution by mastering technologies and nature. Today, it is faced with a formidable obstacle: the growing autonomy of machines on the one hand, and the alteration of its biotope on the other.

This year, in 2016, Morocco will be organising the COP22. IRES wished to contribute to the international debate on climate change by offering a systemic and forward-looking point of view on this great challenge: the transformation of the natural conditions of human beings' living environment.

Several terms can be used to indicate this challenge: ecosystem, biota, ecosphere, biosphere... The concept of "bioshpere" was selected for its holistic and interdisciplinary nature and, more importantly, for its scientific rather than political reference.

The **biosphere** refers to all living organisms on planet Earth, from the single cell to multiple biomes (ecoregions).

Based on research conducted by IRES and the contribution of national and international experts who participated in the Institute's study programme on climate change, this report addresses two of the major issues considered to be pivotal for the future of societies: climate change and the excessiveness of the human ecological footprint.

Indeed, over the past two decades, awareness of climate change has grown. It confirmed what had been established by almost a century of observing nature: that the way we manage and exploit natural resources is unsustainable[1].

Indeed, these two phenomena – climate change and depleting natural resources – are now combining to jeopardize the very survival of the human species on this planet.

The conclusion is clear and definitive: **without an active anticipation and adaptation strategy, our days are numbered**.

INTRODUCTION (2)

From prospects...

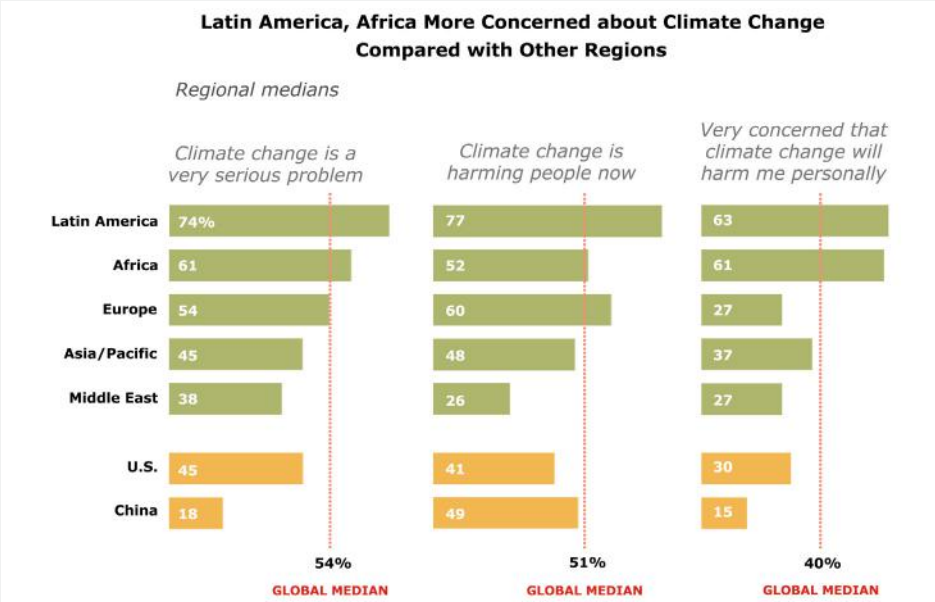
The world is currently going through one of the **great transitions** in human history. During the first transition, humans went from being animals to experimenters (prehistory), in a world dominated by nature. The second occurred when we became builders (architects, engineers, managers, industrialists) who mastered nature.

The third great transition, which we are experiencing today, is one where we move from an agro-industrial world, in which territorial and cultural divides are all-important, to a very digital and globalised world of services. This transition is marked by growing awareness of the limits of the biosphere, and by the need to steer development in a way that is mindful of such limits.

Prospects seem rather grim, due to the **Volatility, Uncertainty, Complexity and Ambiguity** (VUCA) that distinguish our world today[2]. Crises are multiplying and governments seem helpless.

Some are convinced that it will be difficult to remedy the situation early enough to avoid **collapse** – just as was the case for some pre-Columbian societies[3] – either because it is already too late to halt the phenomenon, or because any attempt at remediation – in particular re-engineering the Earth's climate – would be disastrous.

The neologism "collapsology", which refers to the science of climate collapse, attests to this.



Note : Russia and Ukraine not included in Europe median. Asia-Pacific median includes China.

Source : Spring 2015 Global Attitudes Survey : Question 32, 41 & 42_Pew Research Center_ IRES reprocessing

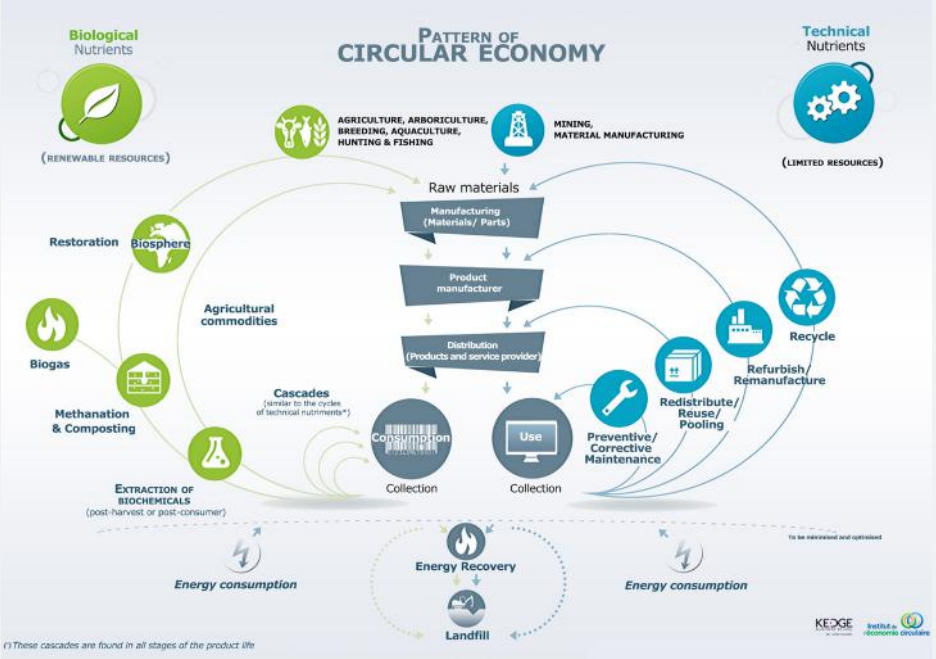
INTRODUCTION (3)

... to hope

Yet people are becoming increasingly aware of these issues and, around the world, new economic models are being invented that are both profitable and concerned with preserving capital for future generations. Such is the purpose of the **positive economy** movement, which refers to an economic growth that restores natural capital which provides resources and services, and an economy based on common interest and the interest of future generations[4].

The relatively elusive and top-down concept of sustainable development is giving way to more concrete and experimental possibilities. For instance, the **circular economy** aims to create added value by processing waste, which is now considered to be a new commodity. Another example is **socially responsible investment** which promotes "*investments that aim to reconcile economic performance and social and environmental impact*" (Novethic).

Indeed, well beyond the fight against the multiform degradation of the biosphere, a new world is emerging from thousands of initiatives and millions of people who are getting involved, all around the world, to preserve future generations[5]. This is a formidable opportunity. This is because "the fight against climate change not only requires our societies to shift to an economic model that is more acceptable for the environment, but it also opens the door to radical social transformation, a transformation that could lead us to a better, healthier and fairer world"[6].



Source : Chart of the Ellen MacArthur Foundation adapted by the Institute of circular economy and Chair «business as unusual» of Kedge Business School, 2013 _ IRES reprocessing

STRUCTURE OF THE REPORT

Climate change and the ecological footprint both constitute a part of this Panorama issue and are addressed in the same manner, according to the following approach:

- Causes and evolution of the phenomenon.
- Effects of the phenomenon (situations and consequences), present (2015) and future (2050).
- Implemented or contemplated strategies

Three geographical standpoints are put forward:

- The global scale, which provides an accurate picture of the situation in its systemic magnitude.
- A focus on key regions for Morocco: the Mediterranean eco-region and the African continent.
- A national approach focused on Morocco.

Climate change related data, in this report, was taken from the latest report of the Intergovernmental Panel on Climate Change (IPCC), except where otherwise mentioned. The IPCC's intermediate scenario is chosen here for its high probability of occurrence (**RCP 4.5**).

Lastly, IRES's forward-looking approach highlighted a number of **decisive factors** which generate major uncertainties and risks for the anticipated developments. These are identified throughout the text.

Morocco, at the crossroads of Africa and the Mediterranean

Part 1

CLIMATE CHANGE

SUMMARY OF PART 1

Chapter 1

ISSUE AT STAKE

Source : http://neobservatory.org/wp-content/uploads/2012/12/near-east-observatory-climatechange.jpg

OVERVIEW

Earth's climate never ceased to fluctuate, from ice ages to warmer periods. This is a natural phenomenon, which arises from the movement of the planet, the composition of its atmosphere, solar activity and plate tectonics.

But the pace of this evolution has considerably accelerated over these past two centuries due to human activity – and in particular because of the release of greenhouse gases (GHGs) into the atmosphere, which trap solar radiations, hence the warming.

This translates to an overall rise of air, ground and sea temperatures. But it also leads to thawing of the permafrost in glaciated areas, melting of perennial snow (large water reservoirs), rising sea levels, expansion of drylands, higher precipitation in some places and drying up of water reserves in others.

The impacts of climate change are systemic: drinking water, health, agriculture, land use, disaster management (extreme events), biodiversity…

Gradually, the planet's countries established instruments to evaluate this phenomenon (such as the IPCC), then implemented platforms to discuss globally coordinated policies (the various summits, and later the COPs), and lastly established local planning tools (Agenda 21).

But the debate is getting bogged down by assignment of responsibilities and aspirations to full development. Though action becomes more urgent every day, it is taking time. Scientific estimates as well as field observations show that **current mitigation policies are already overrun by the extent and acceleration of this global phenomenon** (chapter 2).

Indeed, these policies will only bear fruit by the end of this century at best. By then, we must deal with urgent matters and implement adaptation strategies that are rapid and effective, especially as **the global context is significantly changing** (chapter 3).

TRANSFORMATION OF THE GLOBAL CONTEXT

The world is undergoing profound change (see the first issue of *Panorama*). When it comes to climate change, the key transformations are of a **demographic** and **techno-economic** nature.

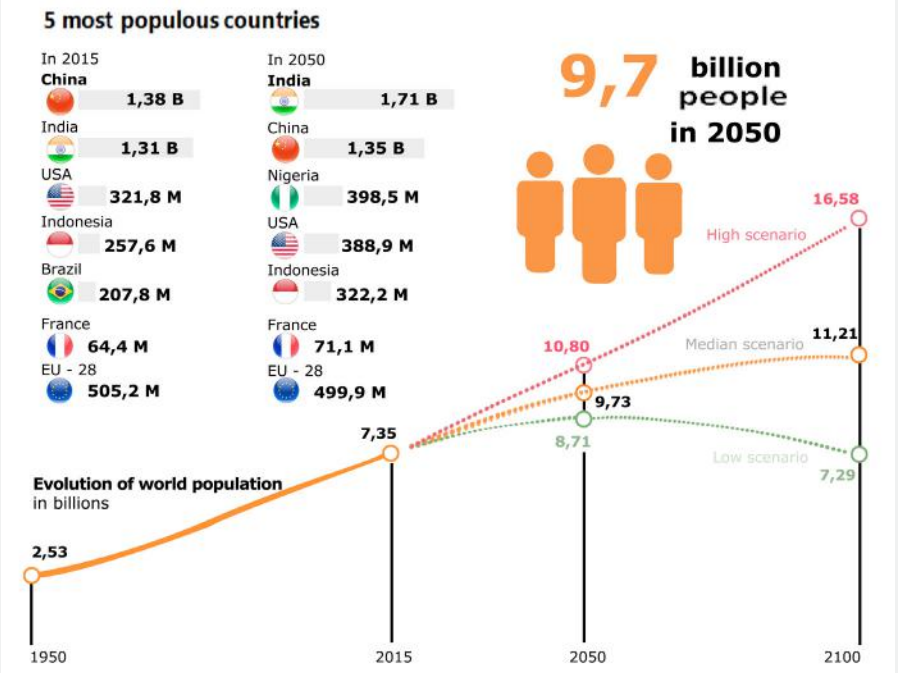
By the first half of the 21st century, the planet will have to host **2 billion more people**[7].

Not only will agriculture have to better meet the needs of people around the world suffering from undernourishment and malnourishment today (785 million and 1.2 billion, respectively), but it will also have to provide for these additional 2 billion people.

Given that developing countries are increasingly consuming meat, the planet's meat production will have to expand by 70% by 2050 to meet the food requirements of its inhabitants. This is likely to considerably increase the release of methane into the atmosphere…

All these new people will not just have to eat; they will need jobs, a place to live away from areas at risk of flooding, and other needs related to human development also ought to be be fulfilled.

World population in 2050 and beyond



Source : United Nations, Department of Economic and Social Affairs, World Population Prospects, the 2015 Revision _ IRES reprocessing

AN EVOLVING GLOBAL CONTEXT

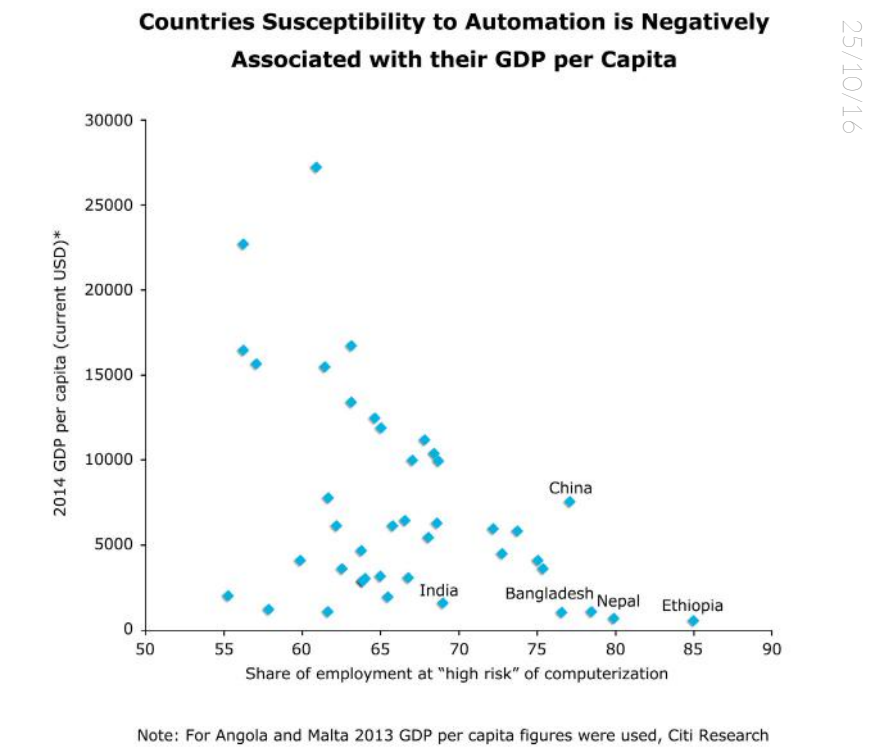
3.3 billion jobs (formal or informal) would have to be created **by 2050** to include the entire active population[8]. Depending on the sectors in which they will be created, how will these jobs impact climate change? Or how will climate change impact them?

The planet's economy increasingly relies on **automation** of activities and digitization of exchanges.

In developing countries, 5 to 15% of a manufacturing worker's tasks could be automated by 2025[8].

Developing countries' vulnerability to automation varies from 55% in Uzbekistan to 85% in Ethiopia. Nearly 77% of jobs in China and 69% in India stand to be automated[8].

The rapid growth model allowing farmers to become workers has now run its course. How can low-income countries address not only their development needs, but also the consequences of climate change on their population?



Source : World Bank Development Report 2016 ; World Bank national accounts data

ANTHROPOGENIC

The **anthropogenic nature** of current climate change is no longer open to question. Greenhouse gas (GHG) emissions caused by human activity contribute to over 50% of the warming of our climate, in particular carbon dioxide (CO_2) and methane (CH_4).

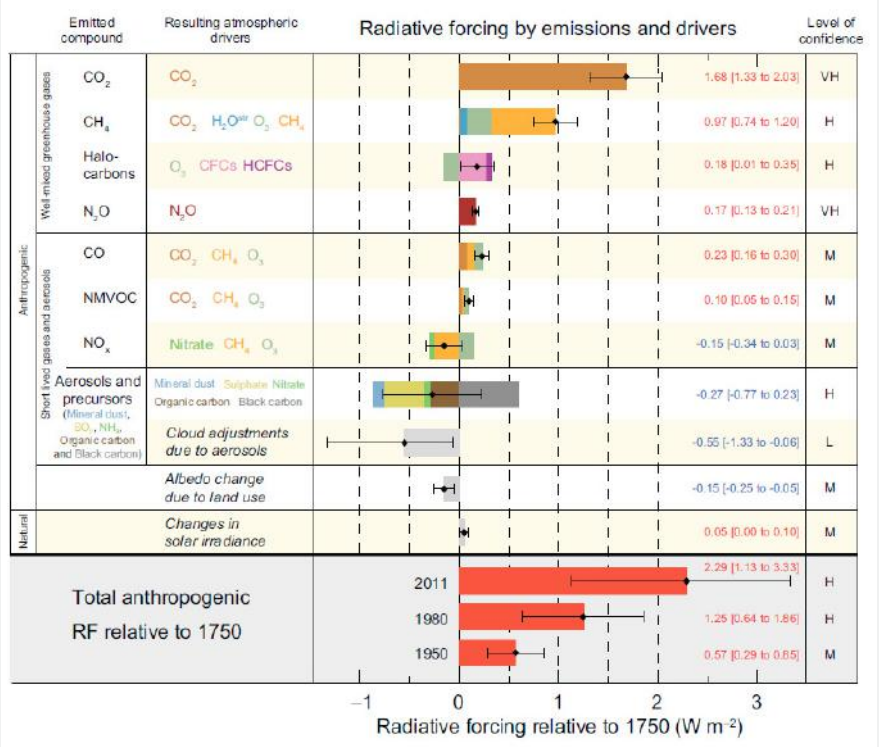
Since 1975, anthropogenic CO_2 emissions have been responsible for 78% of the total increase in GHG emissions. For the 2005-2014 time period, the distribution of these anthropogenic CO2 emissions is as follows:

- 86% derived from the combustion of fossil fuels (coal and hydrocarbons), including 46% in Asia and the Pacific (Carbon Dioxide Information Analysis Center, 2011),
- 5% came from the cement industry,
- 9% were due to deforestation and other land uses.

To have a chance to ensure that warming does not exceed 2°C by 2081-2100, "by that time total CO_2 emissions should not exceed 2 900 gigatons. Yet, between 1870 and 2011, 2/3 of this total has already been emitted and, at the current pace of emissions, this limit will be reached in 2040"[9]. Hence the sources of these emissions must quickly be brought under control.

However, a **chain reaction** has already been set in motion. Nature itself now participates in climate change, in particular through the impact of ocean warming (slowing down of the Gulf Stream, for instance) and longer-term natural mechanisms, such as lower ice-albedo, exchanges between the ocean and the atmosphere...

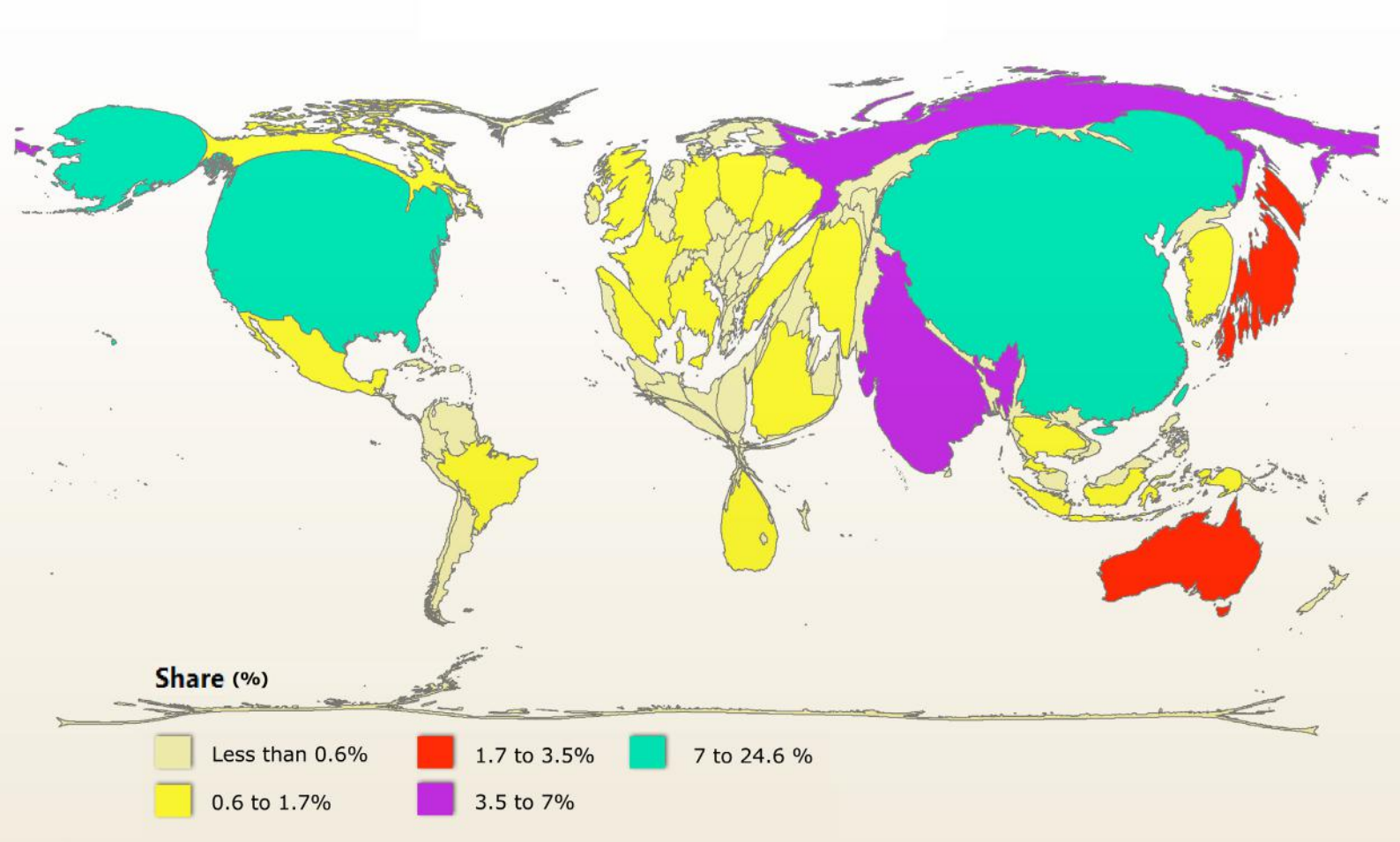
2011 Radiative forcing estimates compared to 1750 and associated aggregate uncertainty on main climate change drivers



Source : Contribution of Working Group I to the Fifth Assessment Report of the IPCC _ Climate Change 2013 : the Physical Science Basis

CLIMATE CHANGE

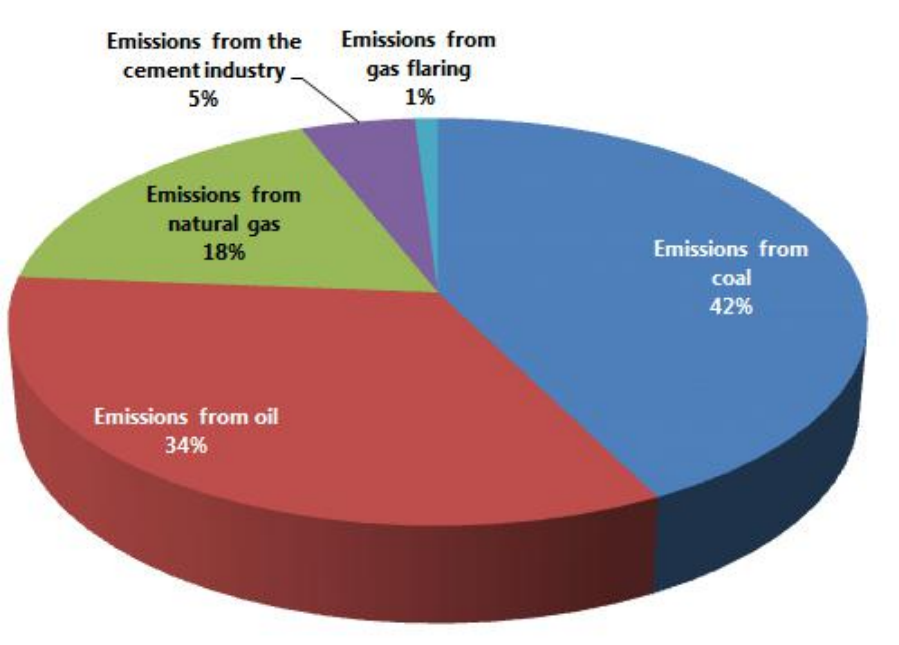
Cartogram of global CO_2 emissions, 2011



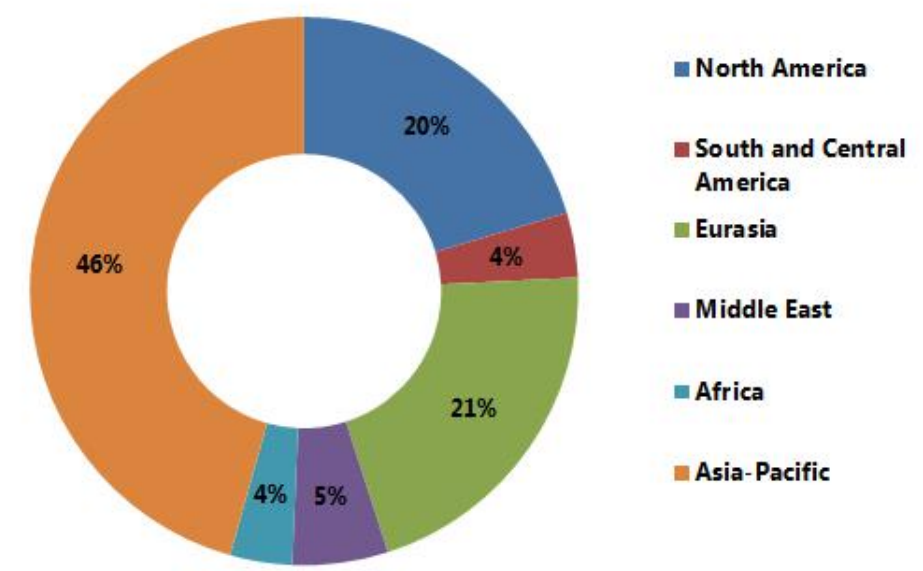
Source : Data from the Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States _ IRES processing

ANTHROPOGENIC

Global anthropogenic CO_2 emissions by source, 2011



Regional distribution of CO_2 emissions caused by combustion of fossil fuels, 2011



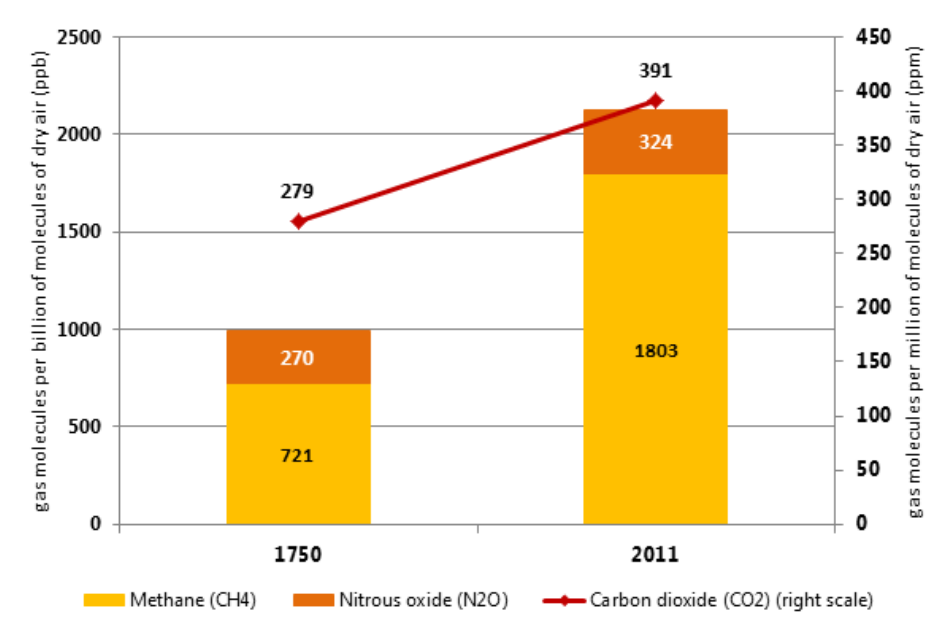
Source : Data from the Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States _ IRES processing

CLIMATE CHANGE

The main features of anthropogenic climate change are set out below:

- Exponential growth of GHG concentration, with significant increase of methane emissions.
- A strong **correlation between level of development and CO_2 emissions** (see map p. 17).
- CO_2 lingers in the atmosphere for **1 century.**
- World carbon emissions often come from **coal**, currently the main source of power production, ahead of oil.
- The share of total carbon dioxide emissions by **Asia and the Pacific** (46%) (see graph) is now higher than that of North America and Europe combined (41%), which prefigures the upcoming surge of emissions from emerging countries.

Atmospheric concentration of greenhouse gases between 1750 and 2011



Source : Data from the Fifth Assessment Report of the IPCC _ IRES processing

METHANE :

In 2010, methane made up for **16% of total GHG emissions**.

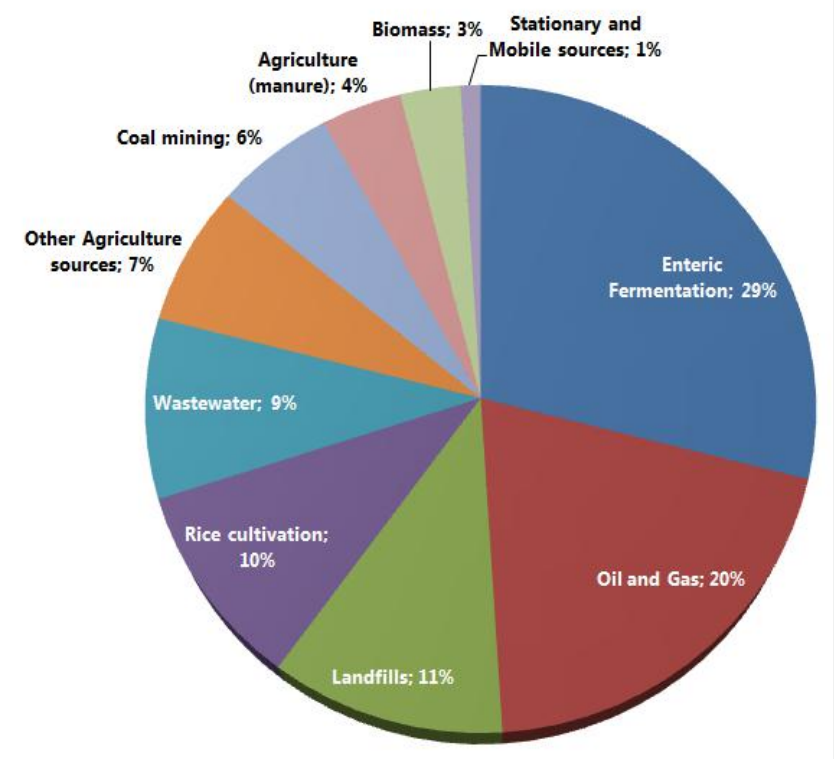
While its lifetime in the atmosphere is relatively short (12 years), it **contributes 25 times more** than carbon dioxide to the greenhouse effect (GWP = 25) as its molecules trap about 30 times more heat than carbon dioxide molecules do[10].

Methane primarily comes from agriculture (slash-and-burn, ruminant farming, rice farming), landfills, and hydrocarbon and coal use.

A country's level of development is not correlated to the intensity of its methane emissions (see map p. 21).

Thawing permafrost in the cold regions of the globe could also lead to the release of methane pockets that it contains (stocks are estimated at 400 billion tons of carbon-equivalent)[11].

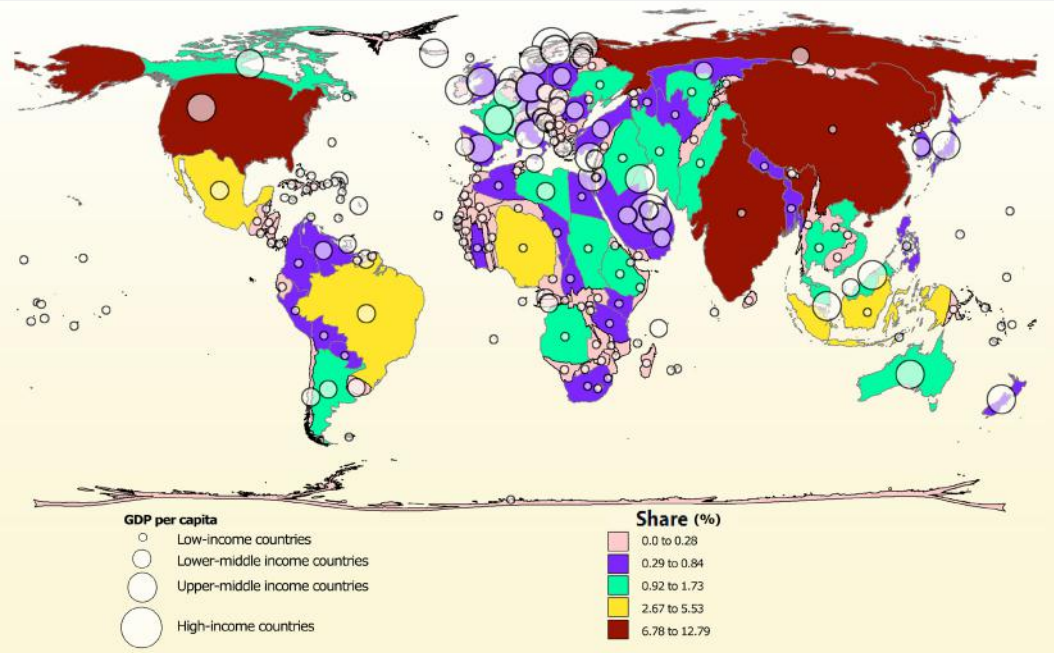
Distribution of methane emissions by source (%), 2010



Source : Global Methane Initiative, 2010

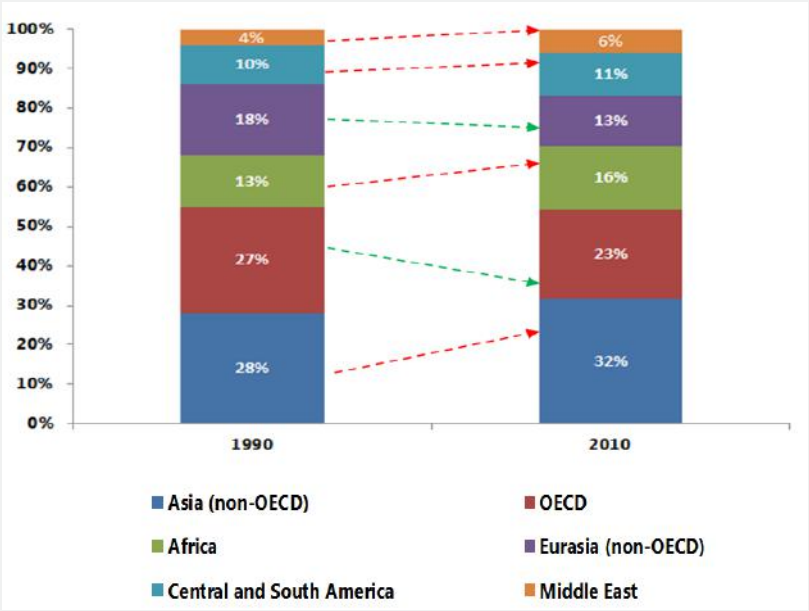
A DECISIVE FACTOR

Cartogram of global methane (CH_4) emissions according to the income level of countries, 2010



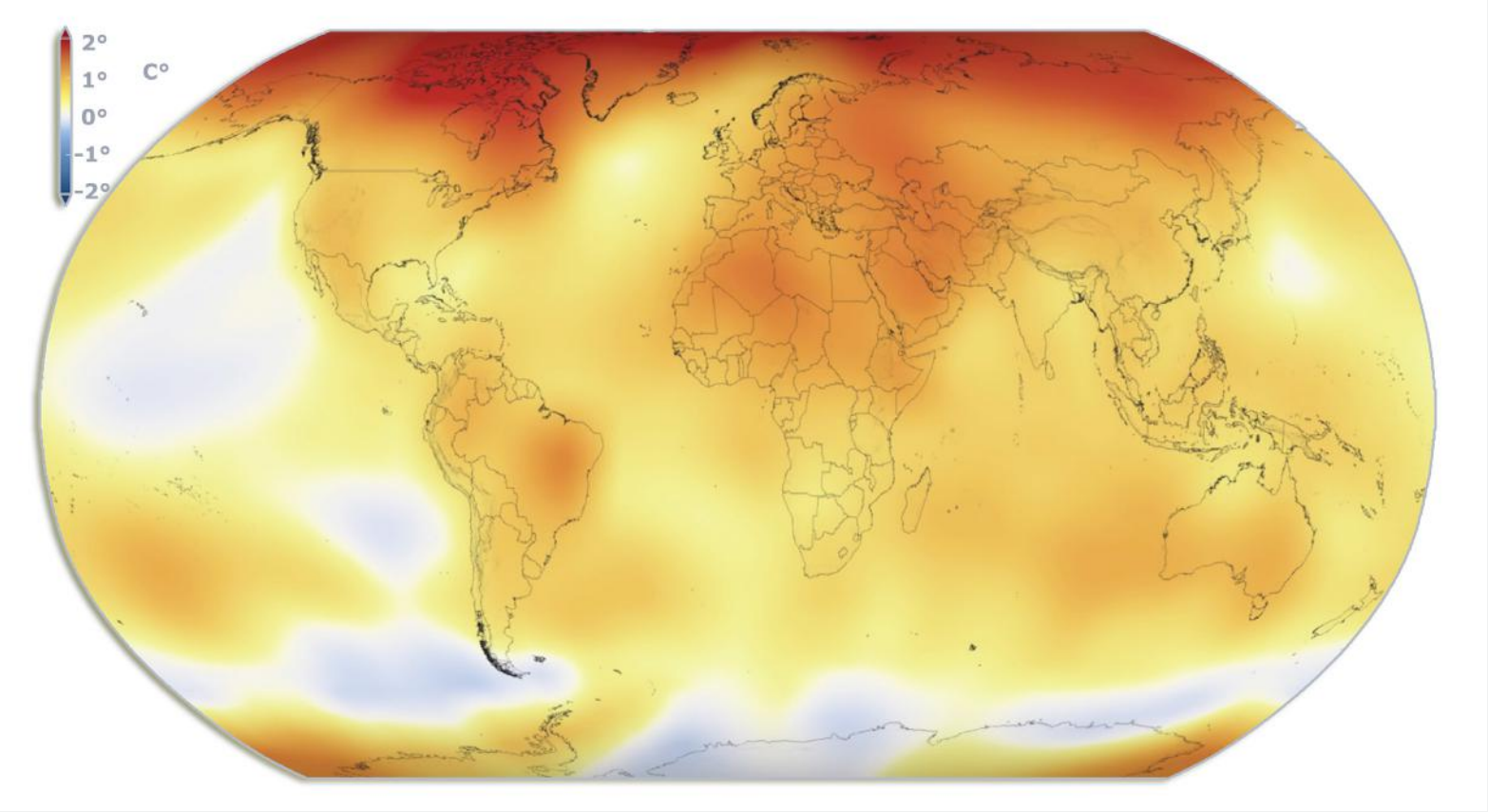
Source : Methane data: United States Environmental Protection Agency. Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2030: Data annexes. 2012; GDP data: World Bank _ IRES processing

Regional distribution of methane emissions (CH_4) (%)



Source : United States Environmental Protection Agency. Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions : 1990-2030 : Data annexes. 2012 _ IRES processing

Observed change in global average temperature, period 2010-2014



Source : National Aeronautics and Space Administration (NASA), 2014

Chapter 2

STATE AND CONSEQUENCES OF CLIMATE CHANGE 2015-2050

STATE AND CONSEQUENCES
OF CLIMATE CHANGE
2015-2050
IN THE WORLD

CLIMATE CHANGE 2015-2050

Based on the IPCC's work which summarizes many different climate models and multiple emission scenarios, be those emissions natural or human-induced, the planet's average climate should experience approximately a 4°C rise by 2100 compared to the 1986-2005 period.

Consequences appear clearly if one accepts a 32 to 63 cm sea level rise in 2081-2100 compared to 1986-2005, knowing that 60% of the world population in 2015 lives within 150 km of a coast.

The expected evolution being not linear but exponential, the most obvious consequences of climate change will only fully appear during the second half of the 21st century, precisely when world population will start to decline, as many countries will have gone through the demographic transition.

The present chapter highlights the impacts of climate change during the first half of the 21st century, with 2015 as a starting point, and discusses the plausible situation in 2050.

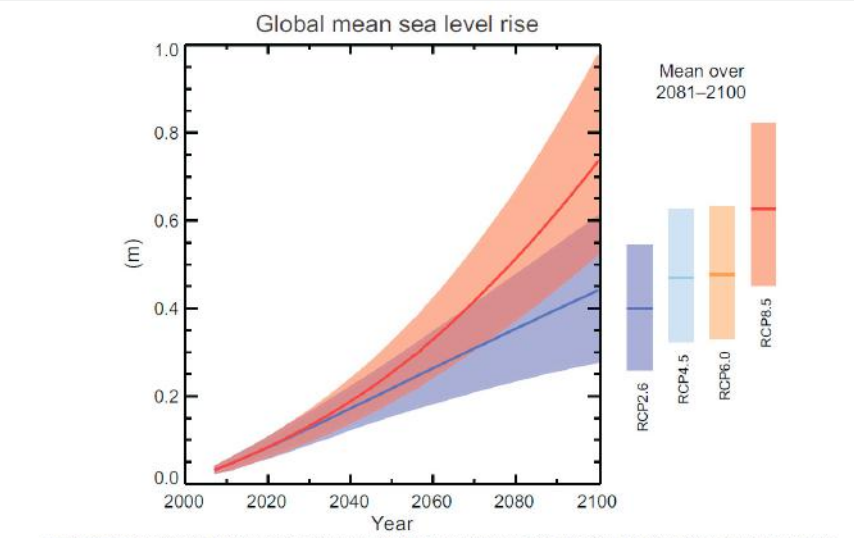


Figure SPM.9 | Projections of global mean sea level rise over the 21st century relative to 1986–2005 from the combination of the CMIP5 ensemble with process-based models, for RCP2.6 and RCP8.5. The assessed *likely* range is shown as a shaded band. The assessed *likely* ranges for the mean over the period 2081–2100 for all RCP scenarios are given as coloured vertical bars, with the corresponding median value given as a horizontal line. For further technical details see the Technical Summary Supplementary Material (Table 13.5, Figures 13.10 and 13.11; Figures TS.21 and TS.22)

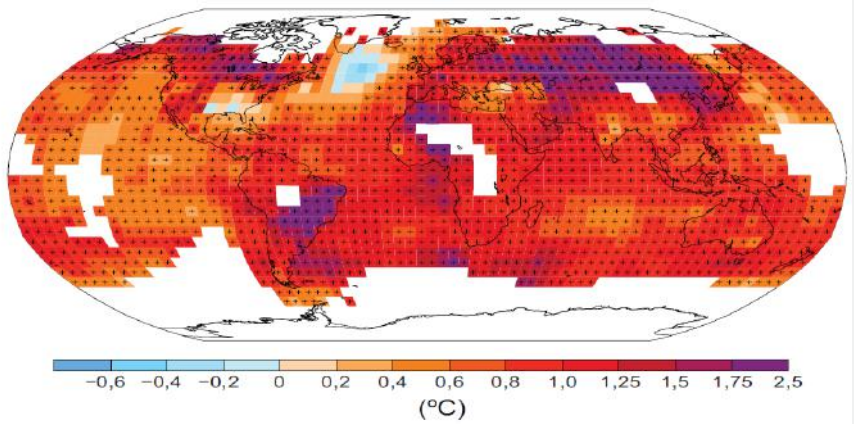
Source : Contribution of Working Group I to the Fifth Assessment Report of the IPCC _ Climate Change 2013: the Physical Science Basis

SITUATION IN 2015

The effects of climate change can already be felt in 2015, as indicated by the following:

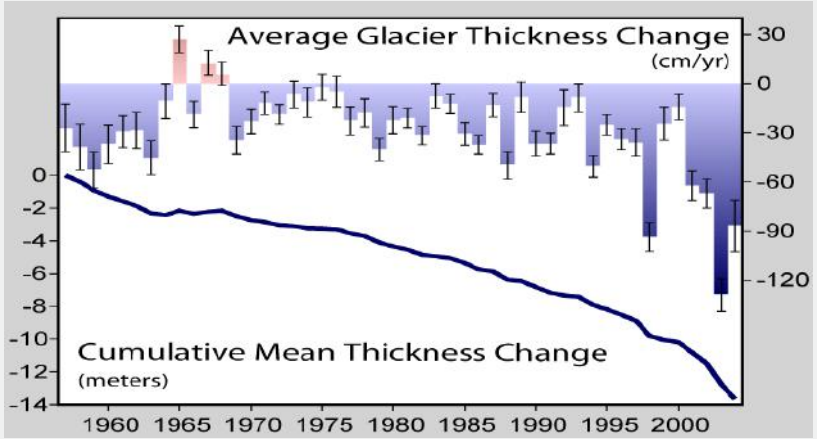
- **Record temperatures**: the warming threshold of +1°C in 2011-2015 was reached, as compared to the preindustrial period.
- **Altered precipitation regimes**: increase of heavy rainfall in the North and minimized wet seasons in the South.
- **Extreme weather events occurring with increasing frequency**:
  - Across the globe, fewer cold days and nights and more hot days and nights,
  - Extreme weather events: heat waves, droughts, floods, tropical cyclones and uncontrolled fires, underlining the high exposure of some ecosystems and numerous human systems to climate variability.
- **Retreating glaciers** in both hemispheres, a serious threat to drinking water reservoirs:
  - 90% of world glaciers are retreating,
  - Melting glaciers contribute to 20% of sea level rise,
  - Critical decline in water supply between 1962 and 2014 for countries such as Pakistan (-75%), Afghanistan (-71%) Mongolia, Peru (-66%) and Nepal (-64%).

Observed average surface temperature changes between 1901 and 2012



Source : Contribution of Working Group I to the Fifth Assessment Report of the IPCC, Climate Change 2013: the Physical Science Basis.

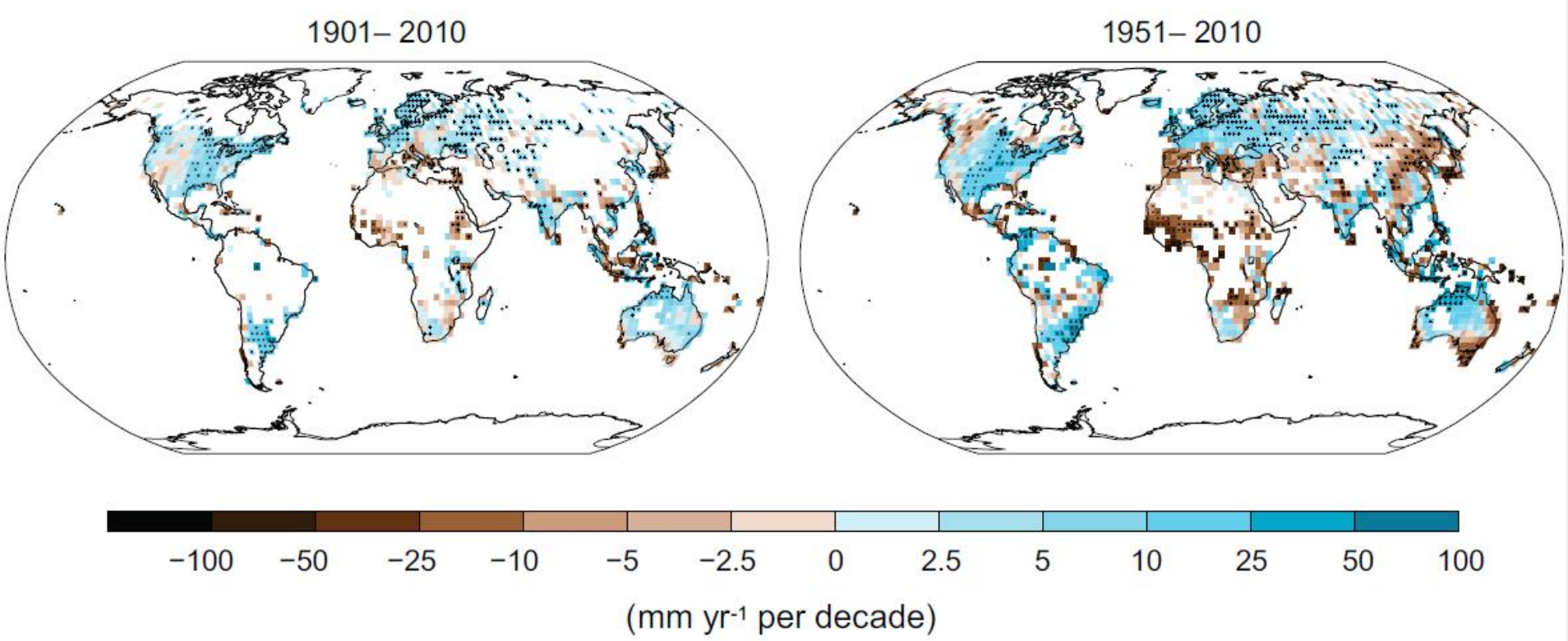
World glacier mass balance 1950-2000



Source : World Glacier Monitoring Service

SITUATION IN 2015

Observed change in annual precipitation over land

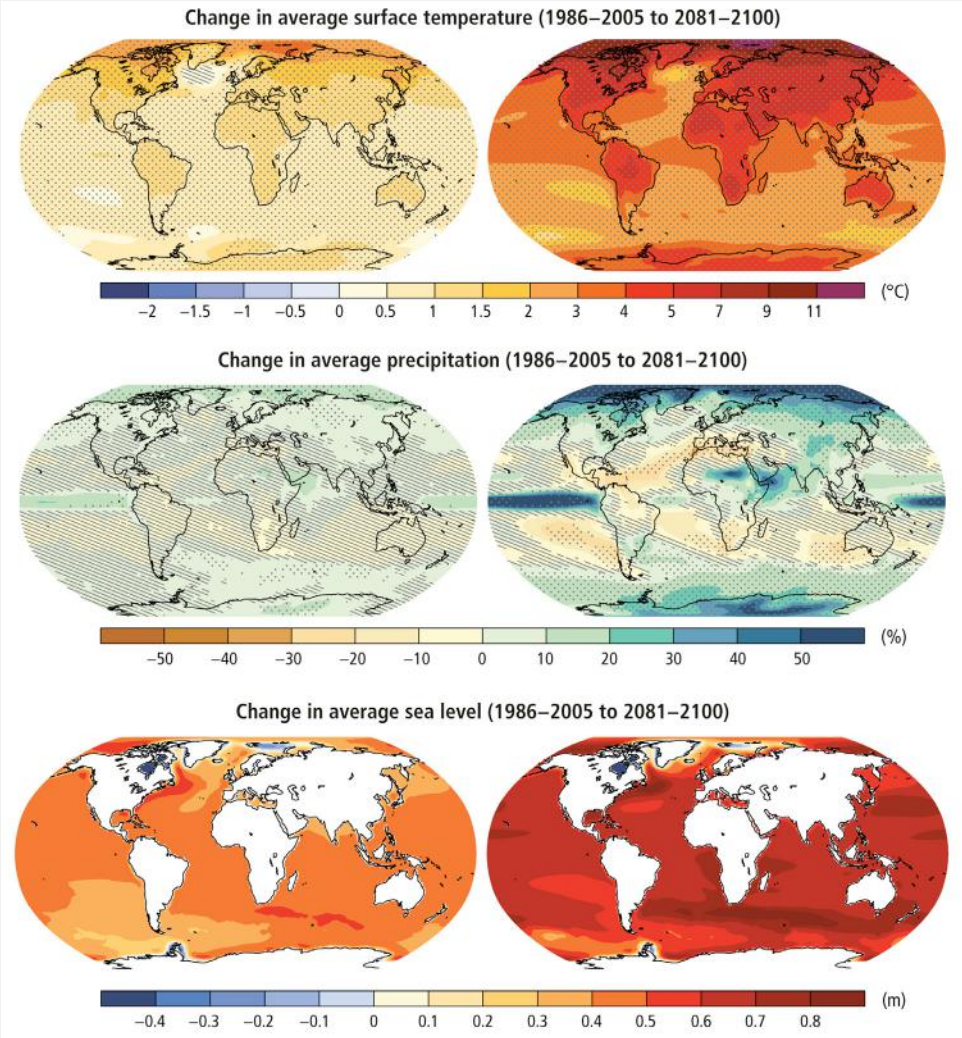


Source : Contribution of Working Group I to the Fifth Assessment Report of the IPCC, Climate Change 2013: The Physical Science Basis

OUTLOOK TO 2050

The main prospects for the world in 2050 in the context of climate change are as follows :

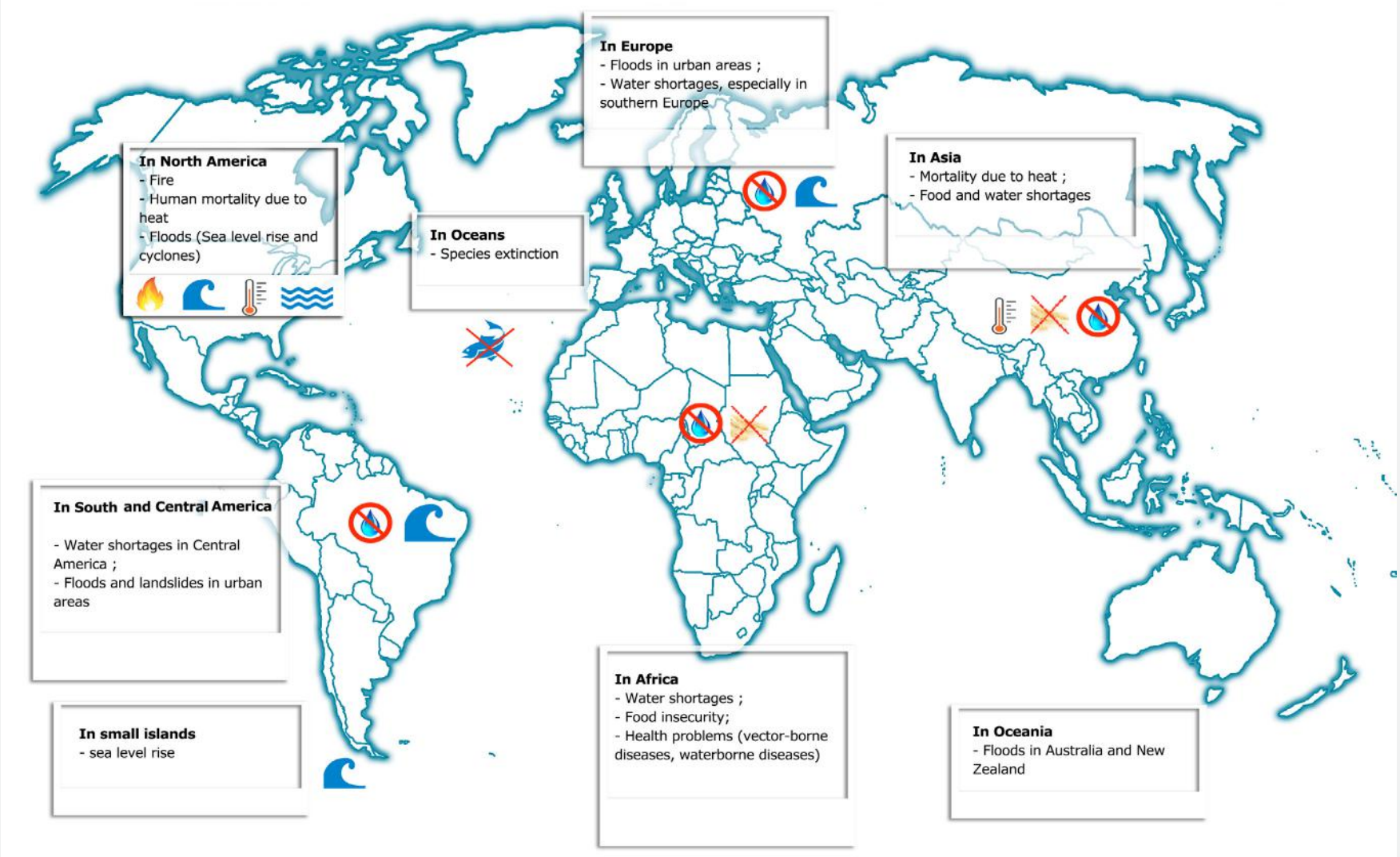
- **A temperature rise**: Between 2046 and 2065, given current mitigation, average temperature on the Earth's surface would probably increase by 1.4°C, compared to 1986-2005, based on the intermediate scenario (RCP 4.5).
- **Greater precipitation variability**: Heavy precipitation events would very likely become more intense and frequent on mid-latitude continental masses, and El Niño-related rainfall would experience increased variability on a regional scale.
- **A significant sea level rise**: Faster than that observed between 1971 and 2010, the rise would be 0.26 m on average (RCP 4.5) by 2046-2065.



Source : Contribution of Working Group I to the Fifth Assessment Report of the IPCC _ Climate Change 2013: the Physical Science Basis

OUTLOOK TO 2050

Climate change: main threats by continent



Source : Forecasts of the 2014 report of IPCC Working Group II _ IRES processing

2 015-2050 IMPACTS

Climate change is already having an impact:

- crops and natural resources are under heightened threat,
- new risks are being generated for natural and human systems ,
- Negative effects are often proportional to lack of preparation and means: underprivileged communities of all countries, regardless of their level of development, are the hardest hit.

The main impacts of climate change on human societies affect **food**, **physical structures** (buildings and human activity support: housing, infrastructure, factories…), **security**.

Food

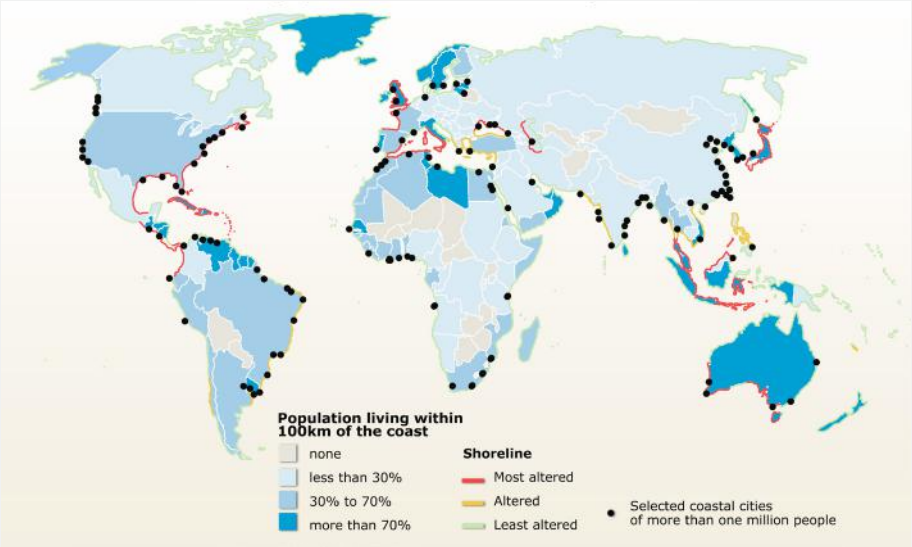
- **Reduced availability of water resources, in terms of both quantity and quality**, especially in dry or subtropical regions:
  - 9% of world population does not have access to quality drinking water in 2015[12],
  - by 2050, 3.9 billion people, that is to say over 40% of the world population, will live in hydrographic basins subject to high water stress[13].
- **Lower crop yields**, due to floods as well as droughts, particularly in countries with growing demand resulting from demographics or access to improved standards of living.
- **Higher ocean acidity**, negatively impacting coral reefs and crustaceans. Freshwater runoff could also reduce seawater salinity, thereby contributing to the **decline in fishery resources**.

2015-2050 IMPACTS

Human structures

- **Large portions of fertile agricultural land** will be lost to salinization and flooding; Bangladesh, for instance, could lose over 30% of its farmland by 2050.
- **Heightened vulnerability** of populations concentrated in urban coastal areas which, as New Orleans during hurricane Katrina, will be exposed to:
  - **health risks**: risk of epidemics in large urban concentrations,
  - **economic risks**: destruction of economic infrastructure in urbanized coastal areas with high population concentration,
  - **political risk**: threat of destabilization following a disaster, particularly in capital cities.
- **Climate migration**: about **200 million** people could migrate by 2050, as a result of flooded low plains and deltas, the erosion of coastal areas and the disruption of agriculture, according to the International Organization for Migration.

Coastal populations and shoreline degradation



Source : Philippe Rekacewiez, Vital Water Graphics, UNEP/GRID Arencial 2002. World Resources Institute, 2001 : Paul Harrison and Fred Pearce, Atlas of population and environment, 2001, American Association for the Advancement of Science (AAAS), University of California Press _ IRES reprocessing

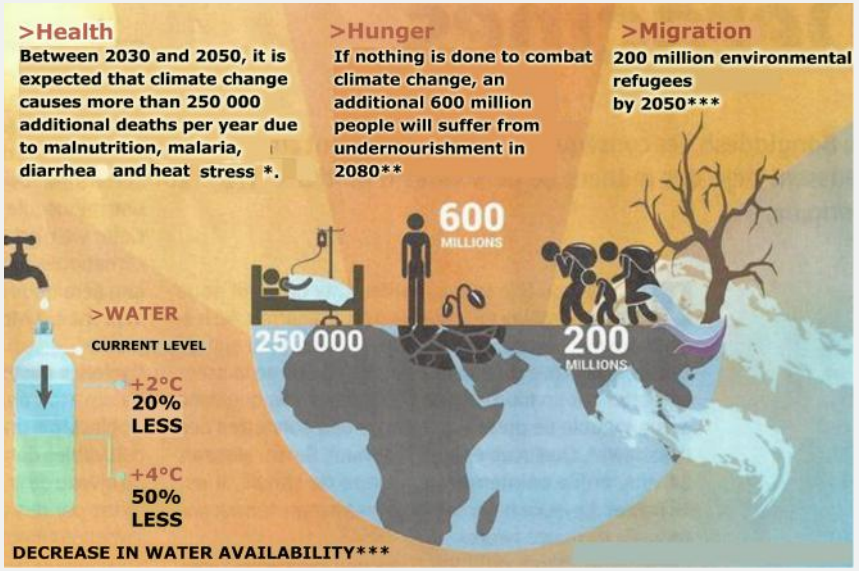
2015-2050 IMPACTS

Security

❖ Food security

Despite the significant progress to combat world hunger over the past two decades (795 million people suffering from undernourishment in 2015), in the absence of effective mitigation or adaptation policies, an added **400 million people would be undernourished by 2050** (FAO), due to climate change and alteration of resources. Taken as a whole, this would represent 13% of world population.

Each year, 500 000 additional deaths could be brought about by nutritional imbalance induced by food insecurity in 2050[14].



Source : *World Health Organization ;
** United Nations Development Programme ; *** World Bank
(URL : http://www.sarra-oullins.fr/secu_alimentaire/) _IRES reprocessing

2 015-2050 IMPACTS

❖ Health security

Despite continued economic growth and progress in the field of health, **between 2030 and 2050, about 250 000 additional deaths per year** could be attributed to effects of climate change: exposure to heat, diarrhoea, malaria and child undernourishment[15].

Vector-borne diseases – Lyme disease, malaria, dengue, West Nile fever and chikungunya – are prime examples of the effect of climate warming on the spread and emergence of diseases.

Even with international aid, the health repercussions of climate-related natural disasters (floods, tropical cyclones…) will tend to be more serious the poorer or more unprepared a country is.

❖ Civil security

The increased frequency and scale of climate events has an impact on internal security of the affected territory: **pillaging, public disturbances, panic phenomena, paralysed public services…**

Climate migrations may also produce dangerous reactions, affecting the safety of people.

❖ State security

Exacerbated competition to access natural resources could be a source of armed conflict within or between states.

Some countries' vulnerability to climate change impacts could drive them to expand their living space beyond their borders.

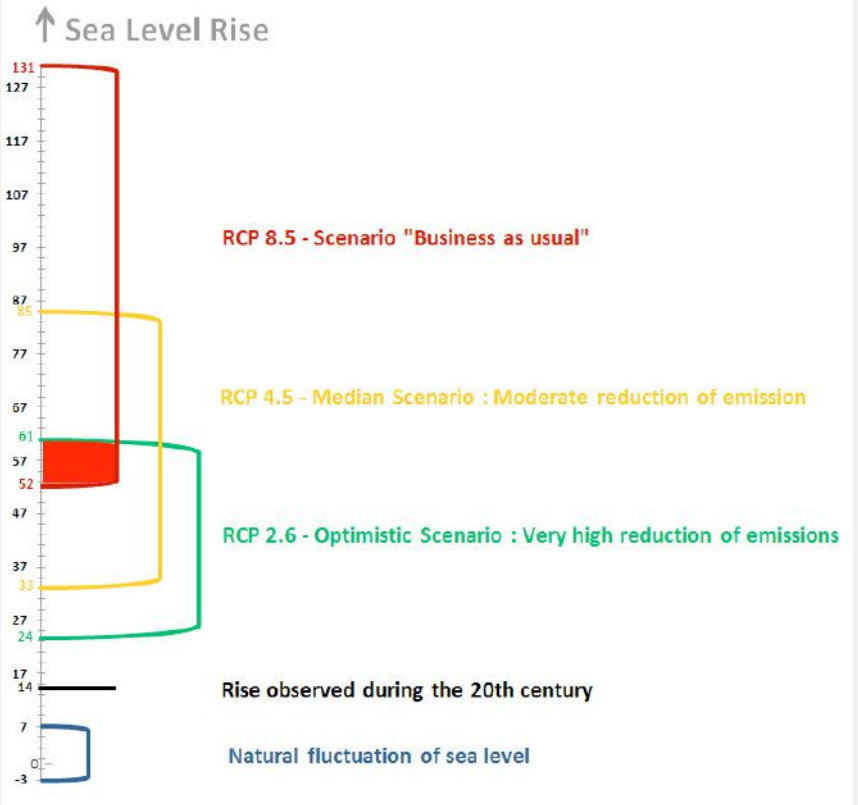
OCEANS :

The sea level rise in 2100 is likely to oscillate between 24 cm (lowest hypothesis) and 131 cm (highest hypothesis) based on the 3 IPCC scenarios that are generally used (see chart). The mid-range scenario (RCP 4.5) anticipates a 32 to 63 cm rise. The interval common to all the scenarios mentioned above is **52 to 61 cm**.

However, the Antarctic could **add over 1 meter to expected sea level rise by 2100** and over 15 m by 2500 if emissions continue unabated, due to the melting and collapse of the ice sheet. The conjunction of climate warming and ocean warming is a crucial **multiplying** factor to take into account.

Even in the event of a significant slowdown of emissions, the lasting warming of oceans **would delay climate recovery by thousands of years**[16].

Sea level rise (in cm)



Source : Data source: Temperature-driven global sea-level variability in the Common Era, Proceedings of The National Academy of Sciences of The United States of America _ IRES processing.

A DECISIVE FACTOR

Oceans are the critical place where climate change and the huge ecological footprint meet with full force.

Oceans absorb nearly 30% of carbon dioxide emissions due to human activities[17], regardless of climate change, hence:

- A 26% increase of ocean **acidity** in the past two centuries according to the 5th IPCC report, impacting biodiversity (25% of corals are affected),
- **Deoxygenation** in some areas, owing to the disappearance of plankton that convert CO_2 into oxygen.

Oceans store over 90% of excess energy resulting from the rise in GHG concentration in the atmosphere:

- Water expands because of the heat, thereby contributing, with melting ice, to rising sea levels.
- Warming could also have an impact on ocean currents, which renew water by moving it around, and shape our climate. The Gulf Stream has already started to slow down.

This raises crucial questions: up to what point can the oceans fulfil this role of temperature moderators? What is the price to pay for ecosystems and what will happen once oceans can no longer fulfil such a role?

PHOTOGRAPHY BY PAUL NICKLEN, NATIONAL GEOGRAPHIC CREATIVE

SHOULD COASTAL AREAS

Whereas their population and the value of their buildings and land is growing, **coastal cities will increasingly have to pay** the price of climate change.

- A spectacular escalation of insurance premiums and the ensuing fall of real estate investment are anticipated.
- A 40 cm rise of sea levels in 2050 could cost 1 trillion dollars each year in flood damage to port cities[18].
- Fortifications (dykes, seawalls) could temporarily restrict flooding. But beyond the substantial initial investment that they require, the cost of maintaining and continuously improving them to face rising waters seems prohibitive.
- Such an investment would probably be put to more effective use by transferring coastal cities inland.

The unavoidable departure of affected populations is also to be expected.

- Beyond temporary floods, permanent submersions of low-lying areas could prompt hundreds of thousands of people to move because of land loss by 2050. The majority of these people are in Southeast Asia[19],
- Potential dangers liable to aggravate the situation include political instability in the country of origin and the host country, food shortages or even famines, deteriorated health conditions and epidemiological risks.

BE ABANDONED?

The most vulnerable regions are:

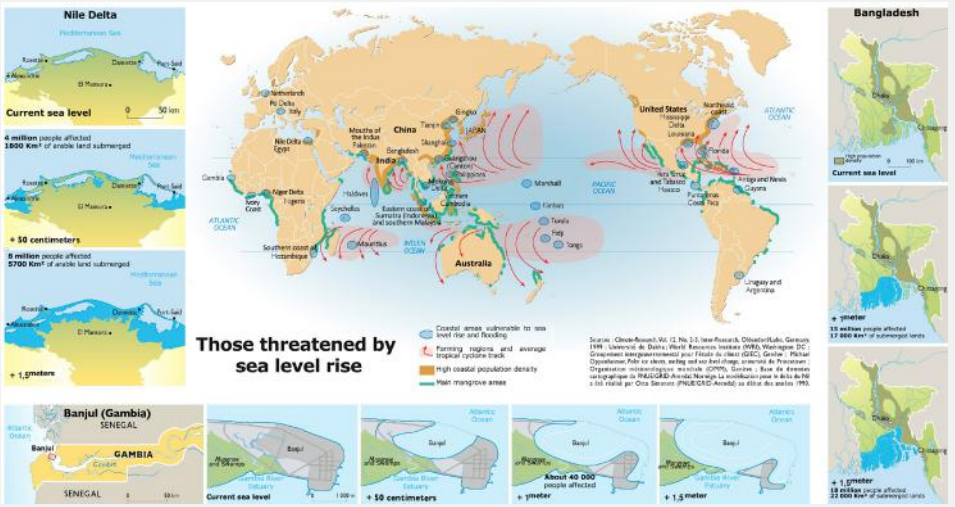
❖ Low islands

Most of the hardest hit small states and insular territories are located in the Pacific and Indian Ocean. Their means of action are limited. The destruction of coral barriers amplifies their vulnerability.

❖ Deltas and low plains

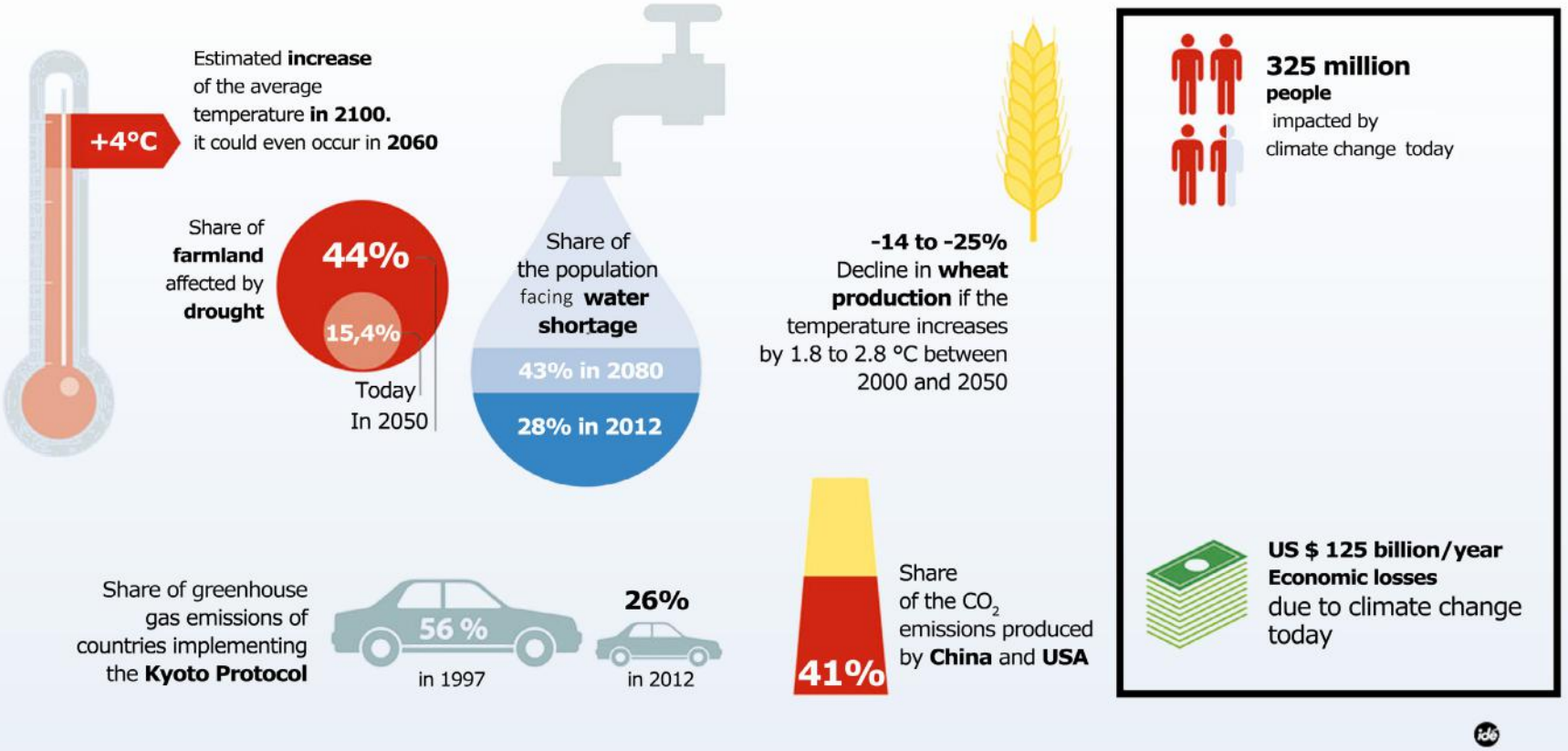
They host some of the world's most fertile farmlands and are threatened not only by floods, but primarily by salinization. This is already happening, for example, in the Mekong delta in Vietnam (17 million people, 50% of the country's rice production).

Most vulnerable regions to sea level rise



Source : Commission of foreign affairs, defence and armed forces of the French Senate_ IRES reprocessing

Global climate change in figures



Source : Global Humanitarian Forum; World Bank; Stern Review; IPCC, 2015 _ IRES reprocessing

STATE AND CONSEQUENCES
OF CLIMATE CHANGE
2015-2050
IN AFRICA

SITUATION IN 2015

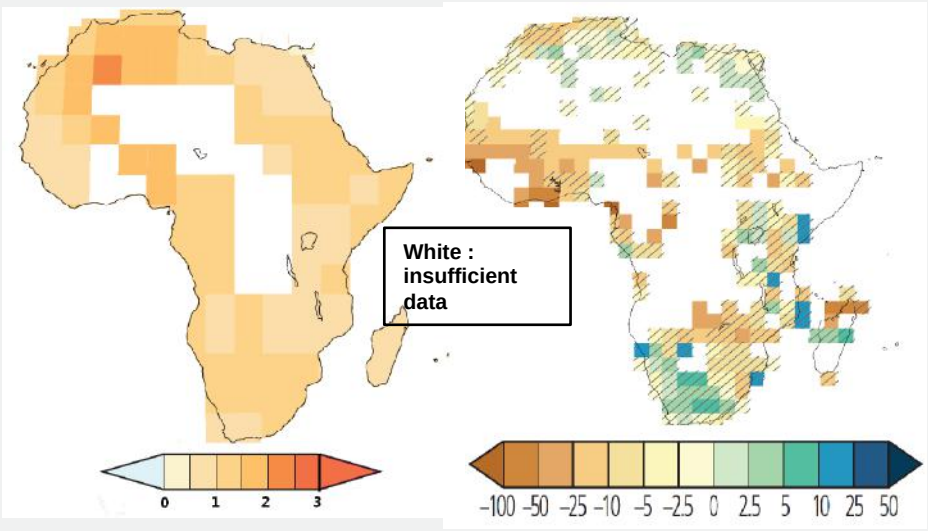
The lack of data in Africa prevents us from tracking year-to-year changes in precipitation and temperature in a number of African regions.

Nevertheless, existing observations already indicate the following:

- **higher frequency or intensity of extreme weather events** in the continent as a whole:
  - **recurrent droughts** (semi-arid areas of northern and southern Africa and the Sahel region),
  - **sharp decline of rainfall** in winter and early spring (northern and central Africa),
  - recurrent **floods** (central Africa).
- **a growing trend towards a warmer climate throughout the continent**. According to IPCC, average temperature in Africa probably increased by at least 0.5°C **over the course of the last 50 to 100 years. Permanent water stress is** already affecting some regions (countries of the Sahel).
- **a higher sea level** in the river deltas of the Nile, Niger and Mozambique.

Annual temperature change in Africa, 1901-2012 (°C)

Annual precipitation change in Africa, 1951-2010 (mm)



Source : Fifth Assessment Report of the IPCC _ contribution of Working Group II _ Climate change 2014: Impacts, Adaptation, and Vulnerability

OUTLOOK TO 2050

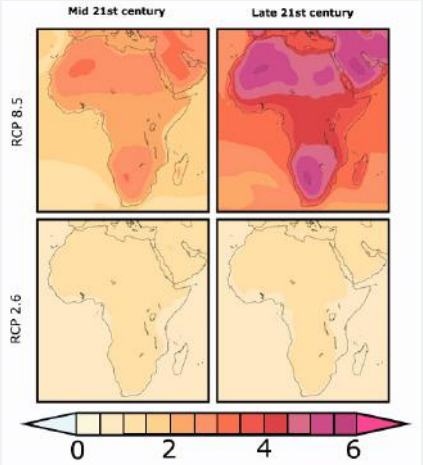
Based on the mid-range RCP 4.5 IPCC scenario, the **temperature rise could exceed 1.5°C on average** in 2046-2065 compared to 1986-2005 **in most of Africa**.

In all cases (see maps opposite) **precipitation** forecasts indicate:

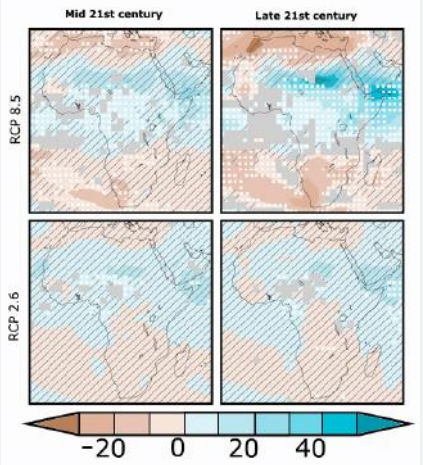
- a probable decline in northern and southern Africa by 2050,
- an increase of the yearly average in central and eastern Africa.

Sea levels in Africa would exceed world average along the Indian and Atlantic coasts. Deltas and low-lying coastal areas (e.g. in **Mozambique, Tanzania, Benin, Cameroon, Nigeria, Senegal and Morocco**) would face flood and salinization risks.

Annual temperature change in Africa in 2050 and 2100 – difference from 1986-2005 mean (°C)



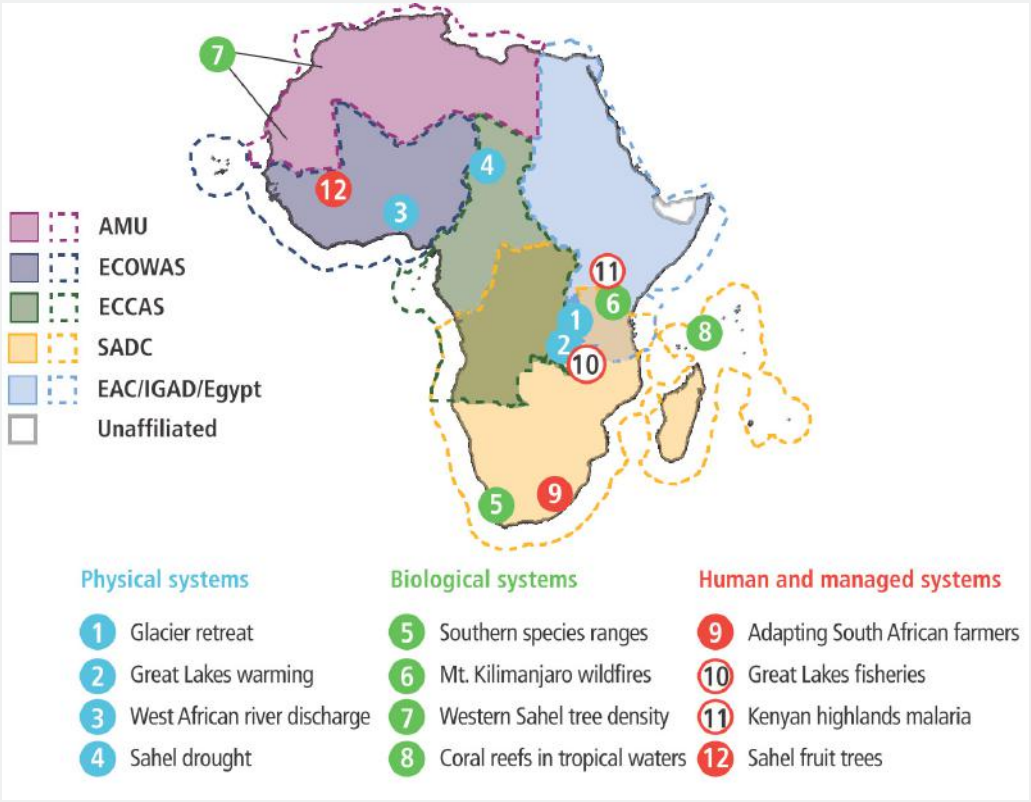
Annual precipitation change in Africa in 2050 and 2100 – difference from 1986-2005 mean (%)



Source : IPCC, Fifth Assessment Report _ Contribution of Working Group II _ Climate Change 2014: Impacts, Adaptation, and Vulnerability

2015-2050 IMPACTS

Observed climate change and impacts in Africa



Source : Niang, I., O.C. Ruppel, M.A. Abdrabo, A. Essel, C. Lennard, J. Padgham, and P. Urquhart, 2014 : Africa. In : Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265 8 _ IRES reprocessing

2015-2050 IMPACTS

The combination of significant poverty, dependence on rainfall, weak infrastructure and limited social protection makes Africans extremely **vulnerable** to climate risks.

Water availability would decline in the North and South of Africa. By 2050, 350 to 600 million Africans would be exposed to water stress, which climate change would make more acute. However, in East and West Africa, **water stress** would be lower.

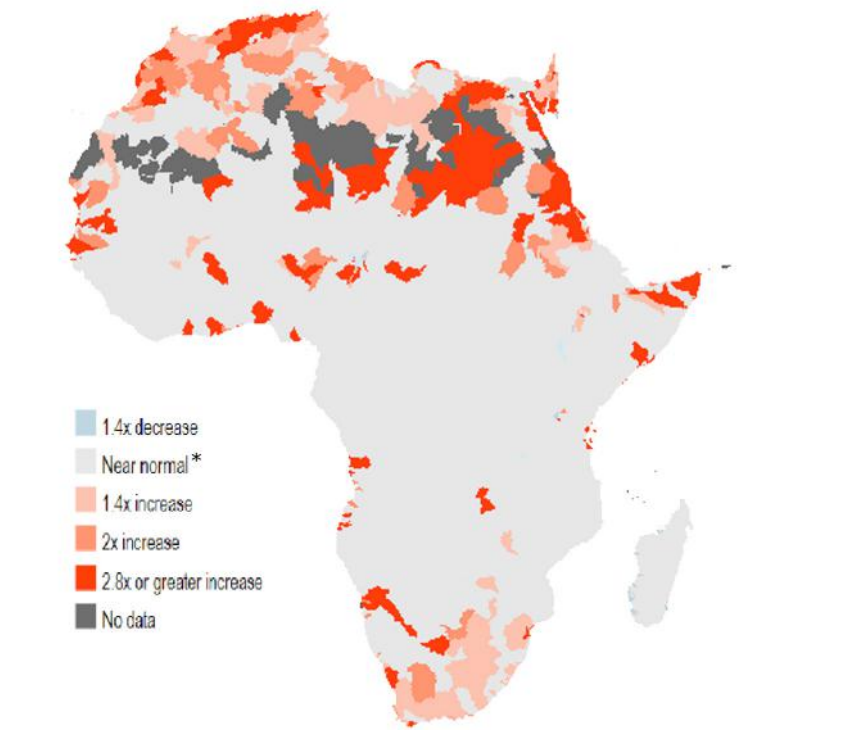
Increasing numbers of people would be **displaced by climate**. According to the Global Environment Facility, by 2020, nearly 60 million Subsaharan Africans will leave their region of origin to reach northern Africa and Europe.

Changes in precipitation patterns would hurt crops. Approximately a 2°C temperature rise would induce a 10% decline of total crop yield in Subsaharan Africa by 2050. This percentage could reach 15 to 20% in the event of further warming. Moreover, if no action is taken, Africa could only meet 13% of its food needs by 2050.

Extreme weather events (storms, heavy rain, heat waves and droughts) would be substantially more intense.

Water-borne and vector-borne diseases could spread significantly.

Expected water stress in Africa by 2040, as compared to 1950-2010 average (mid-range "RCP 4.5" IPCC scenario)

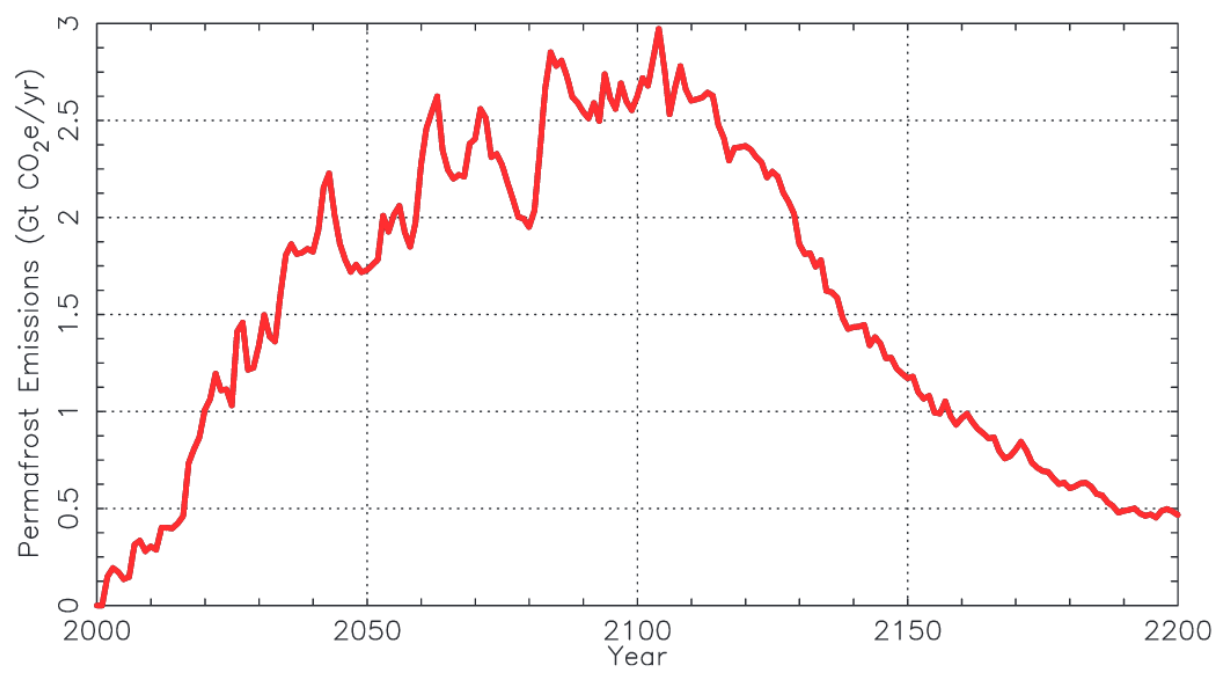


*: Regions that increase in stress but remain at low stress levels (<0.1) and regions that decrease in stress but remain at extremely high stress levels (>0.8) are shown as "near normal."

Source : Data from AQUEDUCT Water Risk Atlas 2015, World Resources Institute _ IRES processing.

As the graph indicates, thawing of permafrost is expected to generate carbon dioxide and methane emissions well beyond 2200, according to the intermediate "A1B" IPCC scenario. This same scenario also estimates that human-induced emissions will peak by 2100 (Schaefer et al., 2011).

Greenhouse Gas emissions from thawing permafrost, 2000-2200



Source : Policy Implications of Warming Permafrost, UNEP, 2012

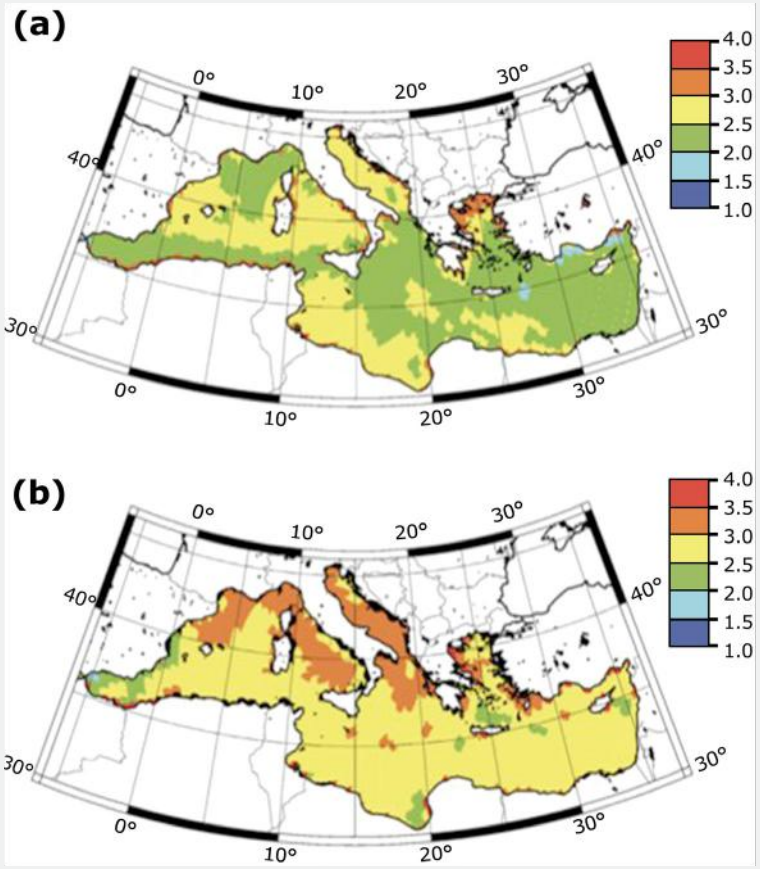
STATE AND CONSEQUENCES
OF CLIMATE CHANGE
2015-2050
IN THE MEDITERRANEAN REGION

SITUATION IN 2015

The state of climate change in the Mediterranean region features the following:

- **Coastal waters have warmed** by about 1°C over the past 30 years.
- **Acidification of the Mediterranean**: all Mediterranean waters seem to be contaminated by anthropic CO_2, with a higher concentration than in other seas and oceans. Differences in acidification can vary by up to a factor of three (from 0.055 to 0.156 pH units). This phenomenon is most intense in the western basin.
- **A significant decline of rainfall**, especially to the south of the Mediterranean.
- **Severe weather events** have been occurring for the **past two decades**, particularly to the North and East of the Mediterranean (floods, fires, mudslides…)

Predictable changes in sea surface temperature in winter (a) and summer (b) in 2070-2099 compared to 1961-1990

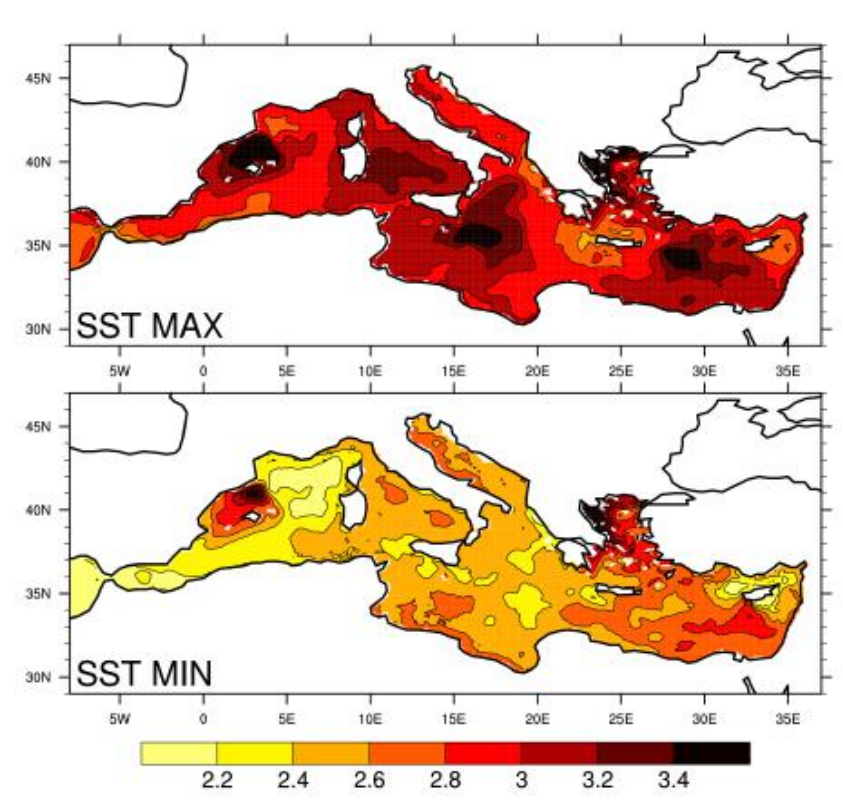


Source : Somot et al., 2007

OUTLOOK TO 2050

- **2.46°C warming of surface waters** by 2070-2099 compared to 1961-1990, based on the intermediate scenario A1B (Climate Dynamics, 2015).
- **Very rapid acidification**, with further acceleration around 2050. The IPCC's most optimistic scenario forecasts a 0.5263 rise in acidification in the eastern basin and 0.5571 in the western basin by the second half of the 21st century. The most pessimistic scenario predicts a 1.3998 and 1.4103 increase in the eastern and western basins respectively.
- **Rising sea levels** causing the submersion of low-lying coastal areas. This is already occurring, for instance, in the Nile and Rhône deltas and in the Venetian Lagoon. This rise could be about 0.20 m by 2050.
- **Saltwater intrusion into aquifers**, inducing their salinization.
- **Heightened severe weather events**.

Minimum and maximum surface temperature anomalies predicted by late 21st century in all simulations (difference from late 20th century)



Source : Mediterranean Sea response to climate change in an ensemble of twenty first century scenarios , Climate Dynamics, 2015

2015-2050 IMPACTS

The Mediterranean, along with its eponymous climate, is one of the areas that is most affected by climate change: **environmental and socio-economic impacts** will be particularly pronounced throughout the region, particularly as regards water resources, degradation of ecosystems, crop damage and crop yields.

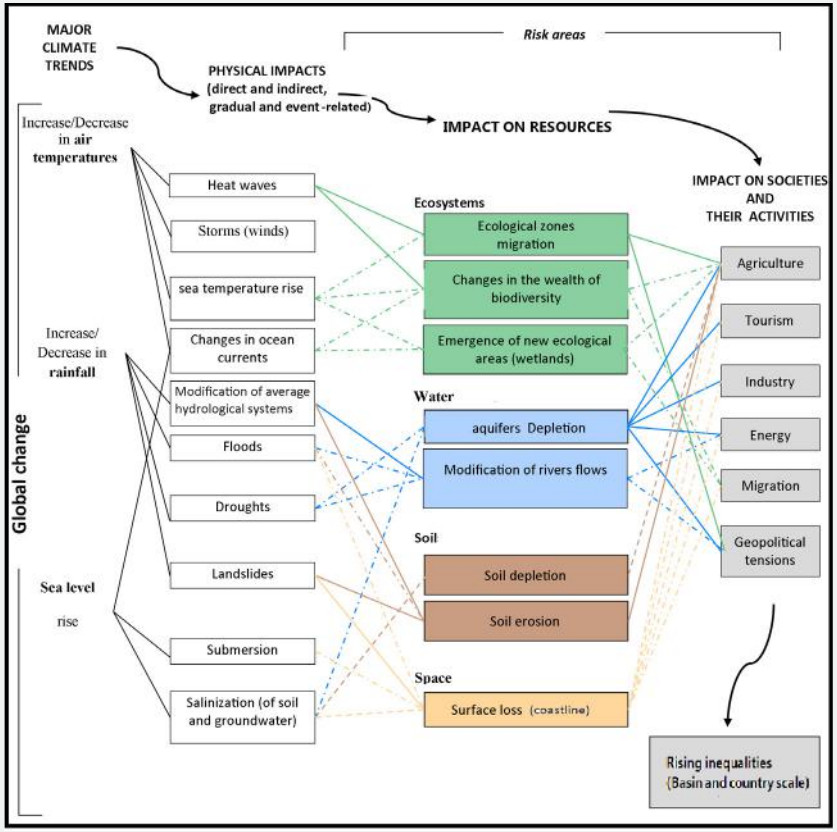
The most **vulnerable** areas in the Mediterranean are **North Africa, coastal zones and large deltas**.

The **main factors of vulnerability to climate change in countries to the South of the Mediterranean** are the following:

- exposure to **desertification and water scarcity**,
- **economic structures** that highly depend on natural resources.

Financial and technical capabilities of southern Mediterranean countries do not allow them to pursue climate change adaptation policies.

The future of the Mediterranean: from climate change impacts to adaptation issues



Source : Iddri, 2009 _ IRES reprocessing

STATE AND CONSEQUENCES
OF CLIMATE CHANGE
2015-2050
IN MOROCCO

SITUATION IN 2015

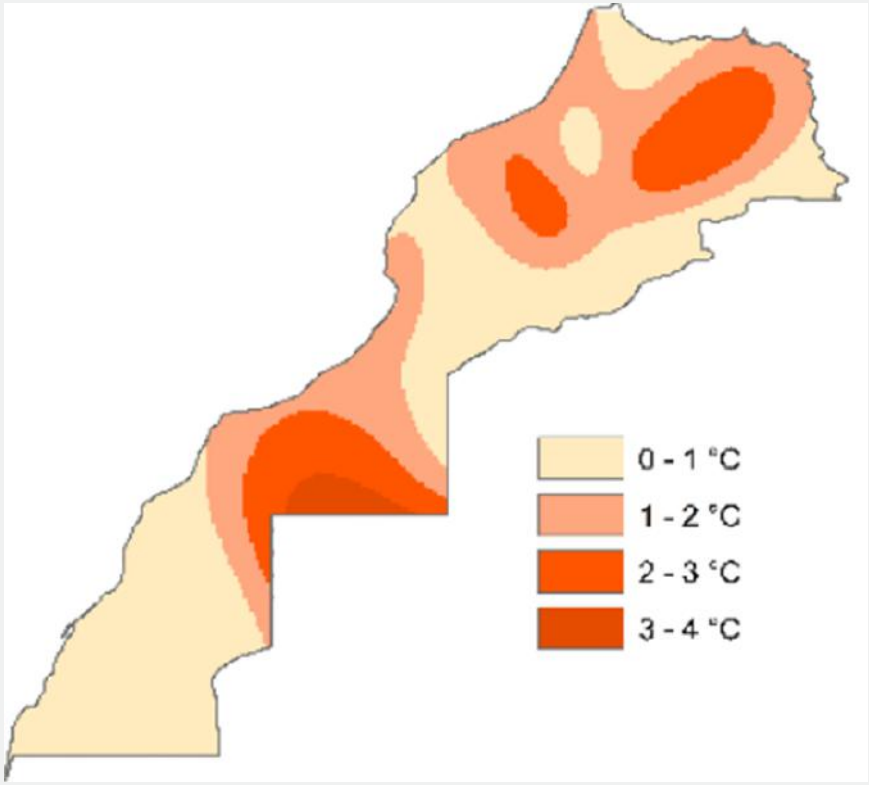
Dryness now characterizes the Moroccan climate:

- Average annual temperatures have increased by 0.16°C per decade since the 1960s.
- Spring rains have decreased by over 40% and the maximum duration of dry spells has lengthened by 15 days.
- Extreme phenomena such as storms, showers, heat waves and cold snaps have intensified; droughts have been severe and frequent in recent decades.

According to Germanwatch, an international organisation which ranks countries based on the quantitative impact of extreme weather events, Morocco has lost over 110 places between 2004 and 2014 in the international ranking* of the global index of climate risks. This fall can be ascribed to a series of natural disasters that generated significant economic losses (USD 708 billion at purchasing power parity, according to Germanwatch).

(*) The higher the rank, the better.

Mean temperature variation (1998-2007 versus 1971-1980)

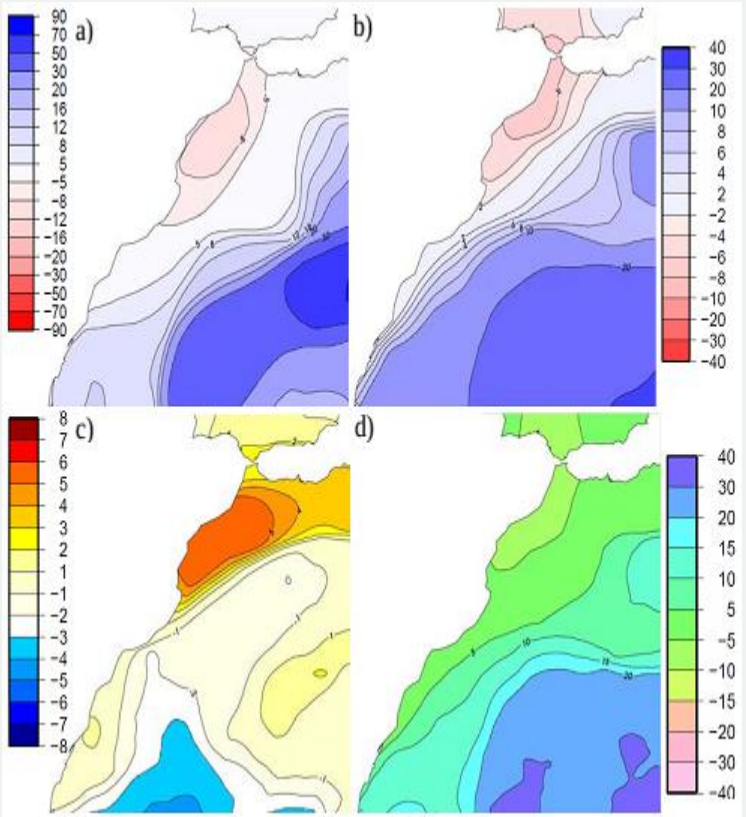


Source : Morocco's Third National Communication (2015)

OUTLOOK TO 2050

- 1 to 6°C temperature rise by 2100, depending on the region, as compared to the 1960-1990 baseline.
- 20-50% fall in precipitations on average by the end of the century relative to the baseline (Moroccan weather agency).
- Rising sea levels may cause low-lying coastal areas to be submerged by 2050. This could lead to the disappearance of nearly half the beach areas (72% by 2100), the salinization of estuaries as well as biogeochemical transformations.
- 1 to 2.2°C temperature rise in oasis areas, with more summer heat wave days (15 to 25 days per year).

Expected changes under A1B scenario in:
a) average precipitation (%), b) number of wet days (%), c) maximum number of consecutive dry days (days), d) number of heavy rainfall events (%). Extended winter, 2021-2050, compared to 1971-2000.



Source : Case study on regional climate projections, Direction de la Météorologie Nationale, 2014.

2015-2050 IMPACTS

Water resources per person per year went from **4 074 m³ in 1950 to 670 m³ in 2010**, whereas population was only multiplied by **3.6** during that time.

Food security is threatened by agriculture's shrinking productive base and a heftier food bill.

The resurgence of water-borne diseases and the development of emerging diseases represent significant risks to health security.

Coastal areas are more vulnerable, with potential impacts on economic security.

Morocco is exposed to the impacts of climate migration, with the rural exodus and Sub-Saharan immigration both intensifying.

Biodiversity faces serious threats posed by the overexploitation of natural resources, habitat fragmentation and loss, and pollution.

2 015-2050 IMPACTS

Based on the work of the IRES study programme “Climate change: global adaptation options”, if no action is taken, the following is to be expected:

- **Heightened water stress**: with water capital forecasts ranging from 465 to 520 m3/person/year by mid-century in the pessimistic and optimistic scenario respectively, Morocco would face water shortages. This would lead to increasingly higher production and water use costs.
- **Lower crop yields**: if no action were to be taken, climate change would result in a decline in crop yields. Such deterioration would be more pronounced for rain-fed agriculture and crops for which technological progress would fail to reverse the trend. In addition, water needs for irrigated crops are expected to rise. As a result, the country’s food security would be affected, and it would grow more dependent on food imports.
- **Intensified climate migration**: heightened rural exodus and amplified Sub-Saharan immigration.
- **Biodiversity damage:**
  - **Retreating forests**: growing temperatures in the country’s various regions would shift bioclimatic zones toward the North. In consequence, 22% of plant life and several species of birds and mammals could disappear by mid-century.
  - **Excessive fragility of coastal areas**: rising sea levels and increased salinity would modify flora and fauna, accentuate erosion of Moroccan beaches and threaten habitats and infrastructure along the coast.
  - **Growing vulnerability of oasis areas**: these would face risks of drought, locust infestations and fires. Tourism would be affected by climate extremes.

Atlas Lion or Barbary Lion (Panthera leo leo),
An extinct in the wild species, but available in the Zoo Parc of Rabat

Source : Zoo Parc of Rabat, Morocco

Chapter 3

STRATEGIES IN RESPONSE TO CLIMATE CHANGE

INTRODUCTION

There are three main types of strategies to face climate change:

- **Mitigation** – the effects of which will not be felt before mid-century – is a long-term strategy aiming to reduce the causes of climate change. Its main goal is **decarbonisation**: reducing greenhouse gas emissions, developing renewable energies and sequestering CO_2.
- **Adaptation** consists in inventing, rediscovering or adopting, then implementing processes (know-how, behaviour, production or distribution chains...) and products (goods or services) helping to deal with ongoing changes.
- **Anticipation** seeks to prepare populations and territories to changes to come, not only to limit damage but also to continue to ensure, or even develop, their prosperity. Hence the close link with the **positive economy** (see opposite).

Pursued strategies can be classified based on three criteria:

- Objective (mitigation, adaptation, anticipation),
- Geoeconomic scale (world, developed countries, developing countries),
- Type of player behind the strategy: international, national or local.

The positive economy brings together, by definition, all entities producing goods or services, commercial or non-commercial, public or private, that wish to be useful to future generations. The positive economy seeks to reconcile democracy, the market and the long-term; to make the urgency of the short-term compatible with the importance of the long-term. The positive economy considers the world to be a living entity, which one must protect and add value to, and where humankind is but one dimension.

Jacques ATTALI, For a positive economy, Fayard, 2013

THE NOTION OF VULNERABILITY

The notion of **vulnerability** does not just refer to the objective impact of an event on a population, but more importantly to the lack of preparation of this population to such an event. Anticipation should therefore lead to **risk prevention**.

A country's degree of vulnerability depends on the combination of two criteria:

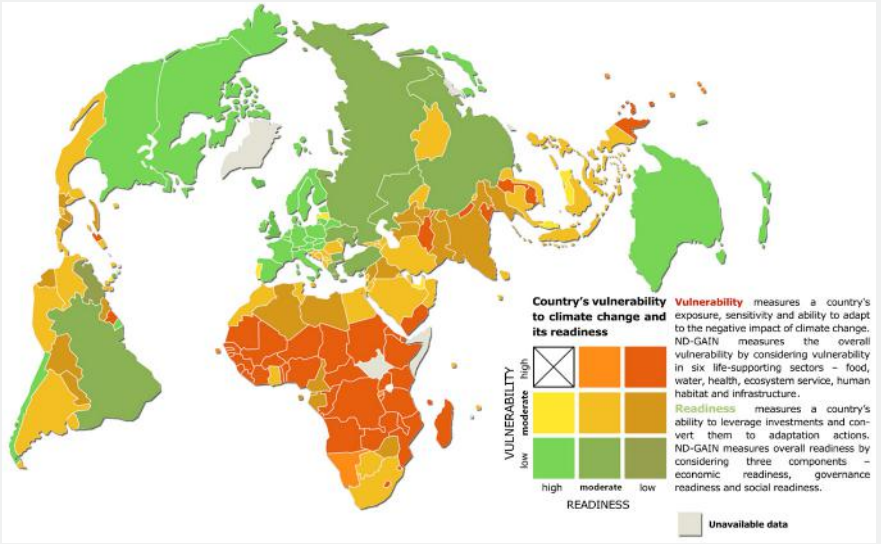
- **the impact of climate change on the country's biotope** and, consequently, on human activities (agriculture, mobility, habitat...),
- **preparedness** to these impacts (energy transition, sustainable development, policies for risk prevention, adaptation or anticipation).

The **level of economic development** is not systematically correlated to the degree of vulnerability. In fact, before economic development, the cultural factor plays a significant role in awareness of climate change and its local impacts.

Among developed countries, some, such as Finland which is affected by thawing permafrost, the Netherlands and the United Kingdom by rising sea levels, France by droughts and Australia, have already started to prepare themselves to compensate for their geographic vulnerability.

On the contrary, fossil fuel-rich countries, particularly in the MENA region, are relatively unconcerned by adaptation, despite a stronger climate change impact.

The hardest hit African countries are also those that have the least resources; they are the least prepared to take necessary measures, hence the importance of local initiatives which sometimes compensate for national shortcomings.



Source : Data from Notre Dame Global Adaptation Index (ND-GAIN), 2014 _ IRES processing.

MITIGATION STRATEGIES - WORLD

By the 1st of October 2015, 147 countries, representing 38.42 billion tonnes of carbon equivalent ($GtCO_2$) according to World Bank data for the year 2010, published their commitments to mitigate their greenhouse gas (GHG) emissions.

These Intended Nationally Determined Contributions (INDCs) cover 85.37% of global emissions.

According to the Climate Action Tracker (CAT) estimate on 1 October 2015, these commitments would lead to global warming of 2.7°C by the end of the century, that is to say 0.3°C less than the previous evaluation.

From Philippe COLLET, Environnement & Technique n. 353, December 2015

International initiatives (COP) : global stakes.

Because each country tends to determine their real engagement in mitigation policies based on their neighbours or even their "competitors", a common global stance seems impossible to reach in the near future, particularly as:

- OPEC countries are missing
- The difference in baseline periods for emissions reduction objectives sometimes leads to allowing to emit more than current levels
- While industrialised countries pledged $100 billion/year of financial support to countries of the South by 2020, this does not seem on track to materialise within 4 years
- Mitigation cannot be limited to reducing GHG emissions; it must also involve carbon sequestration and efficiently organise a planet-wide shift toward a low-carbon economy.

The acceleration of climate change is indifferent to political dithering. Its exponential progression by 2050 should guide response strategies. These should no longer be restricted to the mitigation of GHG emissions, but must also systematically include adaptation to climate change and risk anticipation.

MITIGATION STRATEGIES - WORLD

The following examples show the diversity of ongoing initiatives:

Projects

- Methane: after several research studies (France, Morocco) on reducing bovine methane emissions by adjusting cattle feed, multiple experiments are being carried out, particularly in Europe[20].
- Since the 1980s, China has successfully encouraged the use of biogas as a source of household energy. In 2002, the strategy became one of the main components of a six-year project, funded by IFAD (International Fund for Agricultural Development), which aimed to improve and support the livelihoods of poor rural populations while preserving natural resources[21].
- The Lower Zambezi REDD+, a project launched in Zambia by BioCarbon Partners (BCP) and funded by the United States Agency for International Development (USAID), seeks to reduce deforestation-related emissions and mitigate environmental degradation. Its actions help to minimize local dependence on deforestation, and improve local livelihoods and land use systems (infrastructure, security, fire management and biodiversity monitoring).

Actions

- RE100, a network of the world's most influential companies, has committed since 2014 to switching as soon as possible to 100% renewable power (the private sector consumes 50% of global power production).
- MICCA, a programme launched in 2010 by the FAO, aims to make agriculture more climate-smart by enhancing databases, factual tools, knowledge and know-how.

Source : BP Target Neutral, Treadle Pumps, India

Treadle pumps reduce CO_2 emissions by 477 kg per year per pump compared to diesel pumps.

ADAPTATION STRATEGIES - WORLD

The locational dimension: a thorny but important issue

- **2006** : the Stern Review is published, demonstrating the need for appropriate policies to deal with the inevitable consequences of climate change, or 1% of world GDP/year to stabilise CO_2 emissions at 550 ppm/year. But the 2008 financial crisis and the ensuing economic decline took priority over adaptation concerns.
- **2015** : under pressure from developing countries, the **Paris agreement** establishes the balance between adaptation and mitigation. But the issue of implementation is crucial in more ways than one:
  - **Costs** : the locational dimension of adaptation raises the question of its financing, unlike a globalised mitigation strategy. Each country should mobilise its own resources for adaptation, but the poorest are also the hardest hit. (The United Nations Environment Programme, in "the Adaptation Gap Report" (may 2016), estimates that **an annual 280 to 500 billion dollars** would be needed by 2050 to finance adaptation in developing countries.) **New financial engineering** remains to be invented[22].
  - **Approach** : meta-risk should lead us to imagine **meta-governance** – one that is multi-dimensional, multi-sectoral and multi-scale, well beyond traditional sector-led approaches: water, food, health, infrastructure, energy, forests, human development...[23]

Highly differentiated public policies

- **Developed countries** : adaptation strategies focus on anticipation and management of climate risks, and are closely linked to mitigation strategies. These strategies revolve around the notions of climate security and green growth, and rely on technological and industrial innovation to reconcile environmentalism and development. The concept of **bio-economy**, promoted by the OECD and the EU, embodies this approach: placing biological cycles (renewal) at the heart of economic reasoning.
- **Developing countries** : strategies are very local, and aim to build the population's capacity and the resilience of vital sectors (agriculture, fisheries, water, energy, forests). They are part of sector- and territory-based projects (rural areas, protected areas...), and as such, they remain subject to financial and technical support from the international community.
- **Citizens' initiatives (still little-known)** : from Canada (New Brunswick) to Africa and South America, civil society and private sector associations are gathering to work on adaptation at the local level (NAZCA portal), but their visibility is low.

ADAPTATION STRATEGIES - WORLD

Beyond the issue of cost and governance of adaptation strategies, is that of the trade-off between the **short and the medium term**. For instance, in the case of water resource management:

- Short-term strategy: setting up more collection devices (e.g. pumps),
- Long-term strategy: reducing consumption and losses (25 to 30% of global drinking water is lost in supply networks), rainwater harvesting, desalination, aquifer monitoring and management.

Best practice in public policy:

- Taking climate change into account in national or local planning processes (European Union, Asia, Australia, North America)
- Setting up a structured and coherent institutional and regulatory framework dedicated to climate change, creating synergies between sector-based measures (Europe, North America)
- Developing relatively elaborate information and weather intelligence systems, associated with effective natural risk warning and management systems (West, Asia)
- Building capacity of local populations (Africa, North America, Asia)

Agriculture must play a major role in climate change adaptation policies. Selecting species by hybridization or rediscovering endemic species is becoming **a necessary and urgent adaptation measure to ensure that there will be enough food for all 9 billion people in 2050**.

Research conducted at the International Rice Research Institute (IRRI) in the Philippines led to the development of a rice variety (Swarna-Sub1) that can resist to long periods of submergence in stagnant seawater. Starting in 2009, it was sold in India and Bangladesh. Repeated river floods affect several Asian countries; in the future, they will concern all countries impacted by rising sea levels, regardless of their level of development (USA, Europe, delta countries, islands...).

Since this hybrid selected for flood tolerance was put on the Asian market, crop yields have increased 1 to 3 tonnes per hectare.

This improved variety is set to replace Swarna rice on 5 to 6 million hectares of rice fields in eastern India and Bangladesh. It is currently being introduced in several other countries, such as Cambodia, Indonesia, Laos, Myanmar, the Philippines, Thailand and Vietnam[24].

ADAPTATION STRATEGIES - WORLD

Protecting the coastline against rising sea waters is all the more important since aggravating factors tend to be underestimated, in particular melting ice. However the **timeline is not well taken into account**, if at all – possibly because of the divergence between the various IPCC scenarios.

All maritime countries are concerned, but few significant measures are being adopted, such as relocating inhabited areas inwards, or moving farmland likely to be salinized.

Some advanced countries and regions can serve as an example:

- The Netherlands' strategy for rising sea levels rests almost entirely on the construction of dykes and dams. Damages of nearly 3 billion euros per year are thus prevented for an annual investment of 560 million euros[25].
- 3/4 of Florida's 18 million inhabitants live in coastal cities and concentrate 4/5ths of its economy. Because the sea level is estimated to rise by 0.6 to 1.8 m by 2060-2100, local private players have gathered to implement adaptation strategies, without having to wait for State measures that are getting bogged down in discussions.
- In Australia, special emphasis is placed on systemic adaptation of small coastal cities to climate change, through an integrated regional approach (South East Coastal Adaptation Project) and by helping decision-makers to prepare and manage climate risks (NCCARF).

Most adaptation strategies :

- **Remain sector-based**, as for instance in the health sector: early warning systems for extreme events (heat waves); protecting water, wastewater treatment and hygiene services against floods and droughts; epidemiological monitoring and health risks management; research and evaluation programmes on the link between climate change and the dynamics of human pathogens (*Emerging Diseases in a Changing European Environment* project in the EU)
- Or are **conflated with mitigation strategies**, particularly in the area of energy and transport, where there is much confusion between working toward a low-carbon economy (mitigation) and striving for energy security in countries that do not produce fossil fuels.

weADAPT, a collaborative platform supported by the Stockholm Environment Institute, identifies adaptation projects and actions since 2007. Its goal is to enable professionals, researchers and decision-makers to get in touch and to provide them with credible, quality information.

ADAPTATION STRATEGIES - AFRICA

The African Development Bank incorporated climate change adaptation to its action plan. Designed in partnership with the GCA, it includes:

- Project financing facilities, particularly in sectors vulnerable to climate change: agriculture, infrastructure, energy and water
- The *Climate Safeguards System*, a scalable system that assesses climate vulnerabilities and identifies adaptation measures that can be integrated in the project life cycle
- Country fact sheets with climate projections and national indicators
- An information base providing access to sources on adaptation

"We invest a great deal in Africa and we need to see what effects climate change has on the livelihoods of communities. If this isn't addressed, then it isn't worth investing"

Dr Mbarack Diop, Chief Safeguard Policy Officer at the African Development Bank, 2011

The Intra-ACP programme of the Global Climate Change Alliance+ (GCCA+) focuses on the COMESA-EAC-SADC area where climate change translates to higher frequency of extreme weather events (floods, tropical cyclones, severe droughts), threatening food security and civil safety.

Focusing on small farmers, this programme aims to make agriculture climate-compatible and to encourage the adoption of conservation agriculture and sustainable soil management practices. It involves research and capacity building, as well as vulnerability assessments and analyses. The programme thereby contributes to building the resilience of the agriculture sector to the impacts of climate change.

More broadly, the programme contributed to the development of a **common African position** for international climate negotiations.

Adaptation Learning Programme for Africa (ALP) seeks to help vulnerable Sub-Saharan households to adapt to climate variability by pursuing specific strategies. It relies on community-based adaptation (CBA) and emphasizes gender equality and diversity in the process. Several countries got involved: Ghana (8 communities), Niger (20), Kenya (6) and Mozambique (10).

ADAPTATION STRATEGIES - MEDITERRANEAN

The new 2016-2025 **Mediterranean Strategy for Sustainable Development** (MSSD), adopted in February 2016, concerns 21 countries of the Mediterranean and the EU. Its purpose is to achieve greater coherence between national sustainable development policies, and to lay the groundwork for an effective partnership to meet environmental and development challenges in the Mediterranean region.

This strategy, which is a **response to the region's sources of vulnerability to climate change**, rests on the three objectives of sustainable development: economic development, social equity and preserving environmental balances.

In its environmental component, the strategy sets out priority objectives to do with protecting the sea, coastlines, the climate and air quality, as well as water resources, soils and biodiversity.

The distinctive feature of this strategy is that it gives crucial importance to **local governance**, as a key driver of environmental and socio-economic development policies.

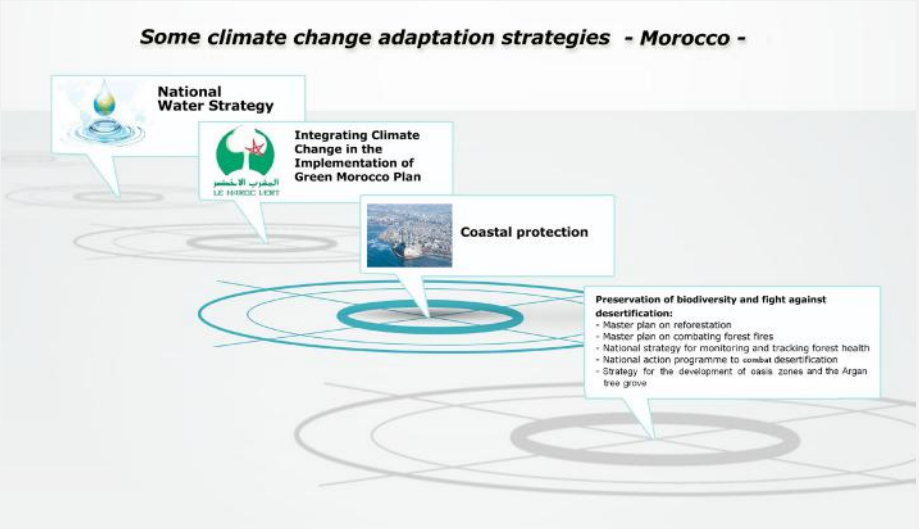
"Mainstream the concept of adaptation to climate change in national policies. Develop plans to anticipate risks and adapt the most exposed Mediterranean areas, especially islands, deltas and arid agricultural zones, to climate change."

See MSSD 2016-2025

ADAPTATION STRATEGIES - MOROCCO

Public policy tools in Morocco are the following:

- **The National Water Strategy**: internationally recognized for its expertise in mobilising water resources, Morocco has pursued a national strategy regarding flood risk prevention, incentives to save water, converting spray irrigation systems to localized irrigation, adapting water infrastructure management tools to the effects of climate change and mobilising non-conventional water resources.
- **The "Integrating Climate Change in the Implementation of the Plan Maroc Vert" programme** gives priority to 9 key tools:
  - A large-scale proactive programme to save irrigation water
  - Use of non-conventional water resources, in particular through seawater desalination
  - Incentives for farmers to adopt climate-resilient best practices in farming through an agricultural development fund
  - An ambitious programme to switch from cultivating cereal to fruit trees on 1 million hectares
  - Developing agricultural insurance (comprehensive and multi-crop)
  - GEF and FAO support for the climate change and sustainable development components of Pillar II of the Plan Maroc Vert; creditor assistance for the implementation of projects under Pillar II
  - Developing agronomic research, generalizing territorial maps of optimal agricultural use and establishing a large gene bank.



ADAPTATION STRATEGIES - MOROCCO

The High Commission for Water, Forests and the Fight against Desertification steers several measures to preserve forests and biodiversity and to combat desertification, through:

- A master plan on reforestation
- A master plan on combating forest fires
- A national strategy for monitoring and tracking forest health
- The national action programme to fight desertification

Coastal protection is also one of the Kingdom's concerns, as reflected in:

- The adoption, in June 2015, of a law on the coastline, ensuring integrated management of coastal areas and adapting them to rising sea levels
- The creation of the National Coastline Agency

Oasis protection: a national strategy to develop oases and argan tree areas is currently being implemented, under the supervision of the agency created for the purpose.

Multiple actions are currently being carried out. Indicatively, it should be noted that:

- Morocco intends to apply the national strategy for sustainable development at the territorial level, with extended consultations. It is preparing a national adaptation plan, and looks to develop regional climate change adaptation plans.
- Morocco will be launching, on the occasion of the COP22, an initiative called triple A (by analogy with the rating agency grade): Adaptation, Africa, Agriculture. This initiative was designed in partnership with OCP Group and is supported by a number of international NGOs.

MITIGATION STRATEGIES - MOROCCO

The Kingdom set itself the goal of **42% renewable energy** in total installed power capacity by **2020** and **52%** by **2030**.

The Noor Ouarzazate facility is among the major achievements of Morocco's energy strategy. The first unit of this mega-complex, which will have a capacity of 580 MW in 2018, was inaugurated in February 2016 by His Majesty the King Mohammed VI.

Solar power capacity will reach 2000 MW by 2020, contributing to reduce greenhouse gas emissions by 3.7 million tonnes of CO_2 each year.

Noor I is the first phase of the Noor Ouarzazate complex. This unit has a 160 MW capacity, using Concentrated Solar Power (CSP) technology with parabolic troughs, and has a thermal storage capacity of 3 hours at full load. Noor I spreads on a surface area of about 450 ha.

Source : Moroccan Agency for Solar Energy

CONCLUSION OF PART 1

The global climate change outlook points to:

- two lasting trends: **climate extremes and irreversible phenomena** (40 cm sea level rise during the 21st century, permafrost…),
- two decisive factors with lethal consequences: **ocean acidification and melting of polar ice**,
- two distinct but correlated impacts: **biodiversity loss and threats to human populations** (famine, health, migration…).

Mitigation: Given that humankind has already used 68% of its emission rights to limit the global temperature increase to 2°C, if emissions were to continue unabated, the 2°C would be reached before mid-century. Hence the dual necessity:

- of achieving **carbon neutrality** by the second half of the 21st century
- of **making environmental priorities consistent with economic ones**: ensuring financial flows (450 billion dollars per year of global fossil fuel subsidies, between 2007 and 2014) are compatible with low greenhouse gas emission scenarios.

(*) World Energy Outlook – International Energy Agency

Adaptation: Climate change is a continuous process. Therefore, the question is not how to adapt to a "new" climate, but how to adapt to a constantly changing climate, and at what cost?

Adaptation must be understood as a **very long-term permanent transition policy**. An adaptation plan that spans just a few years is merely a step in this process.

It is too expensive or technically impossible, in some countries, to adapt "on the side", while existing activities or services remain unchanged, and in the same locations. There must therefore be a **shift** toward other activities and/or locations.

The issue of transition between activities and/or regions becomes a central one. It implies that:

- adaptation policies must be designed and implemented in a cross-sectoral manner
- future impacts of climate change must, from now on, be factored in to land use choices and urban planning.

Mitigation and adaptation are inseparable: whereas mitigation seeks climate stability, adaptation strengthens political and social stability.

IN FAVOUR OF BREAKING AWAY FROM CURRENT PUBLIC POLICIES

The issue of **cost is at the heart of climate change strategies** and considerably hampers them, especially where they are most needed.

To break the deadlock, **climate change must absolutely be made a driver of growth**, by showing that its related changes are opportunities waiting to be seized to **create added value and jobs**.

Such is the purpose of the **positive economy** that springs up in different parts of the world; but also of the **green economy** (waste management) and G. Pauli's **blue economy** (circular economy and biomimetics).

3.3 billion jobs should be created by 2050 in order to absorb unemployment worldwide. According to the ILO, the green economy could contribute to job creation in the following sectors: agriculture (+4%), forestry (+20%), transports (+20%). The shift toward a low-carbon economy could generate an additional 60 million jobs globally by 2030.

The **Netherlands**, for instance, are pioneers in the preservation of low-lying areas: the 450 companies that work in this sector produce 4% of GDP.

The second obstructing factor today is that **medium and long-term effects fail to be taken into consideration**, whether it possible drivers of change (development strategies) or the impacts of mitigation and adaptation measures. Among these effects, the following should be pointed out:

- substituting biomass for fossil fuels (mitigation) actually contributes to deforestation (removing a carbon sink) and to pollution
- catching up on electrification in Africa (development): countries are tempted to use local hydrocarbon sources (coal, gas, oil) at the expense of necessary investment in low-carbon power sources
- the demographic boom and economic growth in emerging countries exert significant pressure on the livestock farming sector (meat consumption), leading to additional methane emissions.

Therefore, it becomes urgent to **develop a global strategy to combat and adapt to climate change,** one that is:

- globally coordinated,
- mindful of systemic and long-term effects,
- perceived as a driver of growth and implemented as such.

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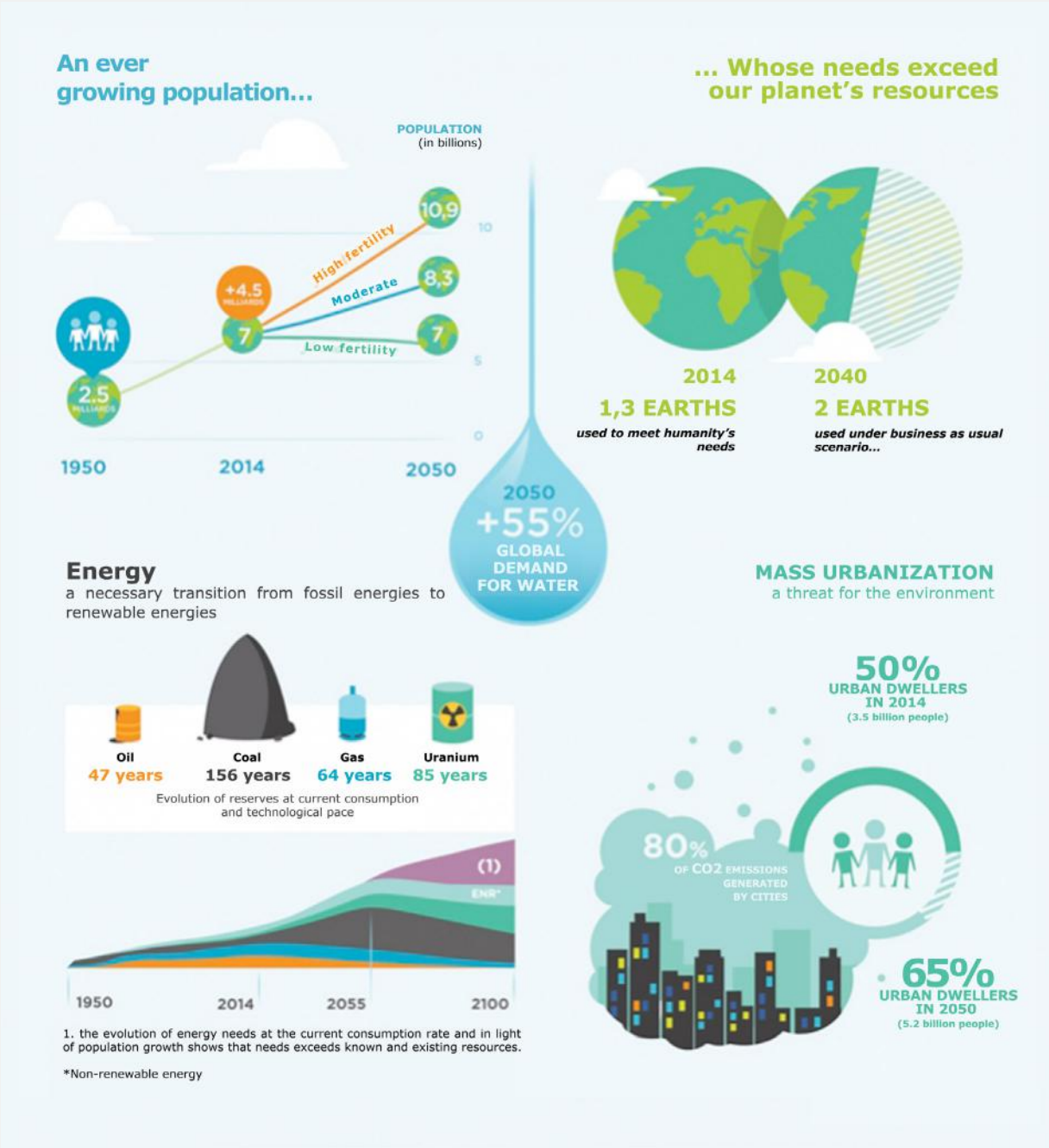
Part 2

ECOLOGICAL FOOTPRINT

SUMMARY OF PART 2

Chapter 1

ISSUE AT STAKE



Source : Manicore ; OECD ; United Nations Population Fund _ IRES reprocessing

OVERVIEW

The result of an unsustainable development model, current production and consumption patterns in most of the world have significantly altered the environmental balance, thus affecting the planet's biological reproductive capacity.

Accelerated globalization, socio-economic catch-up by developing countries and significant population increase are key factors for an unprecedented level of natural resource consumption and of volumes of waste produced.

This trend has significantly expanded the human footprint on the environment, reaching the two physical boundaries of the sustainability of production systems: those of resource reproduction and absorption of waste.

Today, ecosystems that provide people with the resources they need, while absorbing the waste they generate, are no longer able to keep up with the pace imposed by human activity.

In the absence of any change, humanity could each year consume the equivalent of the annual output of 2.8 planets by 2050, against 1.5 planets in 2015.

It is, however, possible to reduce the environmental footprint rapidly and dramatically if we choose to act, particularly with regard to overexploitation of natural resources and global pollution: air, soil and sea.

Accelerating the energy transition by increasing the share of renewable energy and promoting energy efficiency would reduce both reliance on polluting fossil fuels as well as the number of deaths caused by air pollution (6.5 million people in 2015). In this regard, the International Energy Agency is of the view that an increase of only 7% of energy investments by 2040, especially in clean technology, would reduce by 1.7 million the number of premature deaths worldwide due to air pollution in the world[1].

THE ECOLOGICAL FOOTPRINT CONCEPT

❖ Two centuries of warning…

As early as 1798, the economist Thomas Malthus showed that «the power of population is indefinitely greater than the power in the earth to produce subsistence for man[2]».

From the 1960s on, many thinkers started wondering, in turn, about the sustainability of economic growth, given the natural resources available[3]. That concern was compounded by the 1973 oil crisis which gave rise to ecological movements.

The **predominant development model**, based on both sustained increase in production and consumption and unequal globalization, is one of the major obstacles to resolving the dichotomy between population growth and natural resources. Because of the fundamental principles underpinning this model, malnutrition is, on average, responsible for 9 million deaths per annum worldwide, even though agricultural production capacity is sufficient today to eradicate hunger on earth[4].

❖ Some tentative answers

In 1979, the philosopher Hans Jonas raised the issue of the imperative of responsibility[5], particularly vis-à-vis future generations; he recommended **knowledge of things before they happened** so that progress can be well thought-out.

It was not until the Brundtland Report came out in 1987 that the concept of **sustainable development** appeared and was accepted as such at the Rio Summit in 1992. Sustainable development aims to restore the nature/culture relationship which should no longer be a domination/destruction relationship, namely by simultaneously taking into consideration the needs of society, the economy and the environment.

Finally, it was in 1996 that Professor William E. Rees, who came up with the concept of the ecological footprint, published his book *Our Ecological Footprint*, which revealed the fundamental incompatibility between continued economic material growth and ecological security. He reopened the debate on the "carrying capacity", which means the optimum or maximum population of a given species a territory can support without permanently irremediably impairing the soil or productivity of that habitat[6]».

THE ECOLOGICAL FOOTPRINT CONCEPT

«The ecological footprint is a concept that calculates the area of land and water needed to sustain a defined human population, based on the population's use of energy, food, water, building material and other consumables (...) it is a useful accounting tool whose purpose is to demonstrate the effect of human consumption on the productive capacity of the Earth» (Source : www.greenfacts.org)

The ecological footprint is spread across six land use categories: forests to absorb human emissions of CO_2, forests for wood production, cropland, grazing land, productive marine and lake areas and built-up areas.

«Overshoot» of the regenerative capacity of the planet has been made possible by the consumption of the resources available: trees cut at a rate higher than the one needed for their growth, more animals taken from the wild than those born and more emissions - including carbon - in the atmosphere than the biomass can absorb and degrade.

The global pressure on land and marine ecosystems increases as the world population grows since there has yet been no disconnect between economic growth and environmental impact.

The human ecological footprint has exceeded the planet's biocapacity since the 1970s. The ecological deficit has been growing year after year, like a debt. According to the Global Footprint Network - August 13, 2015 - in less than eight months, humanity has used up all of the resources produced by nature in one year.

In 2015, it took nearly 1.5 Earths to provide the biocapacity needed to support humanity's footprint. Although the structure of humanity's ecological footprint is carbon-dominated today due to the consumption of fossil fuels (59% of the total footprint), we must not be distracted from the bigger picture : land degradation, drinking water supplies and the destruction of biodiversity are just as serious for the future of humanity.

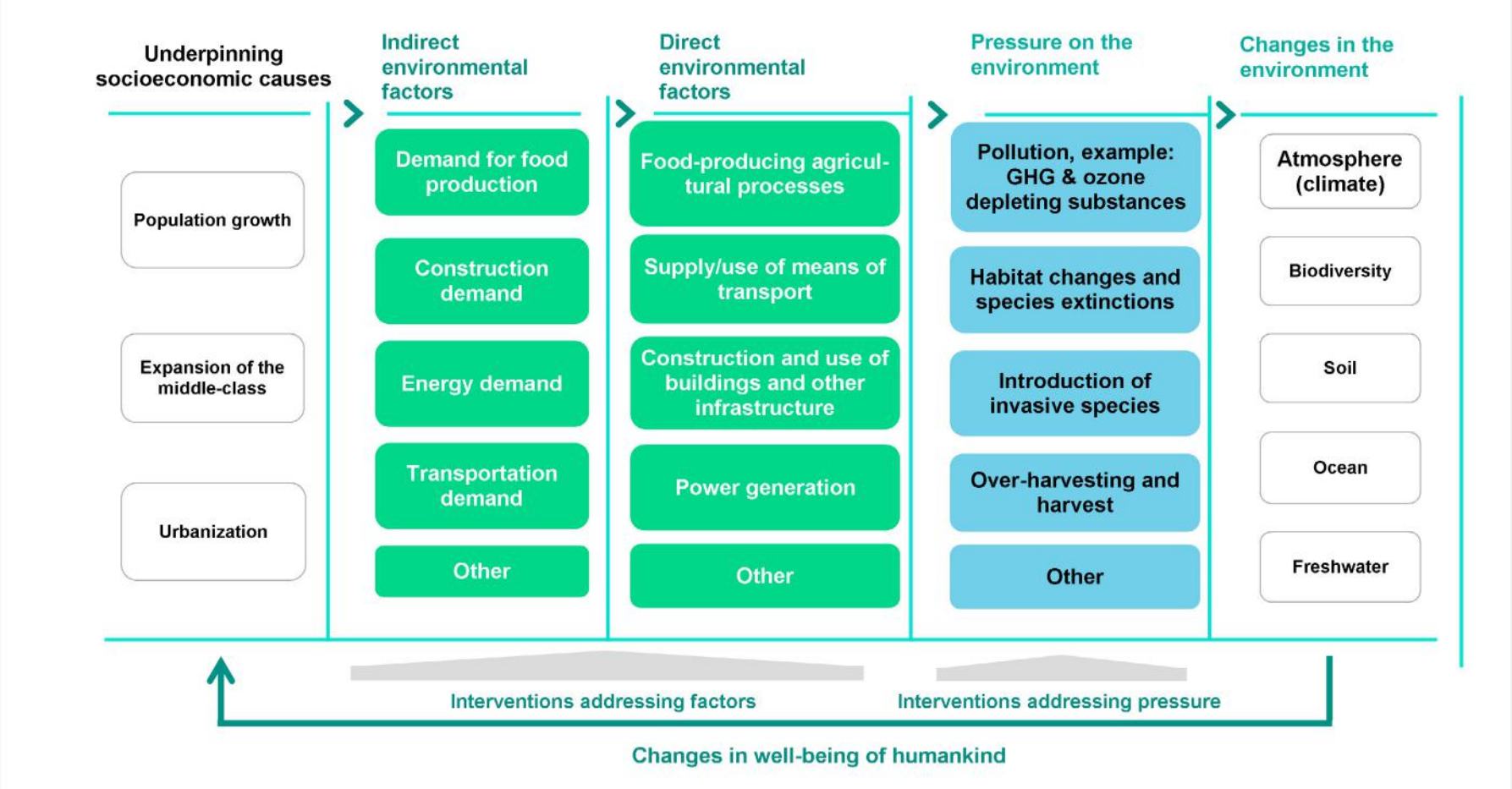
FACTORS LEADING TO

Several concurrent factors contribute to the growing ecological footprint, including the following :

- **strong increase of the world population** which led to significant socio-economic needs to be met. The world population stands at 7.3 billion people today and could exceed 9 billion by 2050, according to UN projections,
- **a larger global middle class**, with daily per capita consumption between 10 and 100 dollars. In 2009, the total number of people falling under this social category stood at approximately 1.8 billion; that figure could jump to 5 billion people by 2030 according to the Organization for Economic Cooperation and Development,
- **unsustainable development patterns** that prevailed in developed countries and that were, until recently, presented as the exclusive model for growth,
- **accelerated catching-up by emerging countries** whose demand for natural resources has increased significantly to support the development of their productive systems. According to the IMF, the share of large emerging countries in the global GDP rose from 12% in the early 1990s to 32% in 2015 and is expected to stand at 45% in 2030,
- the effects of **climate change**, including alteration of the agricultural production base and threats to biodiversity. According to the Global Environment Fund, the total agricultural area worldwide will increase by 20% by the year 2020, compared to 2000.
- the **strong growth of international trade** makes it possible for ecological deficit countries to import natural resources from abroad in order to meet their needs.

THE GROWING ECOLOGICAL FOOTPRINT

Cause-effect chain for the degradation of biocapacity and the growing ecological footprint



Source : Global Environment Facility, 2015 _ IRES reprocessing

EVOLUTION OF THE GLOBAL CONTEXT

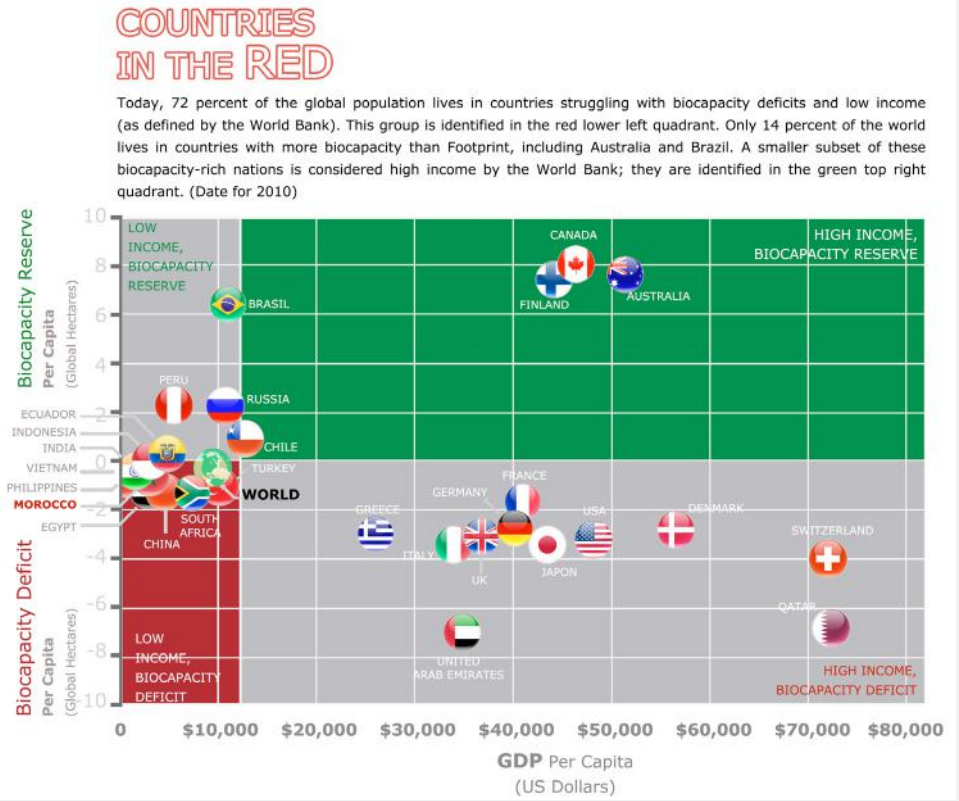
The issue

The survival of human beings hinges on meeting their basic needs for water, food, ground and under-ground products.

The quasi-generalization of the Western development model has encouraged the development of societies characterized by mass consumption, including in emerging and developing countries known for their population increase and economic catch-up process. As a result, new, less vital needs have emerged that have, in fact, more to do with overconsumption. Overconsumption:

- unduly depletes non-renewable resources,
- generates a large amount of untreated waste, including non-biodegradable substances: concrete, nuclear products, chemicals ...
- pollutes the global environment such as air, land and sea: inputs, fine particles, plastics ...

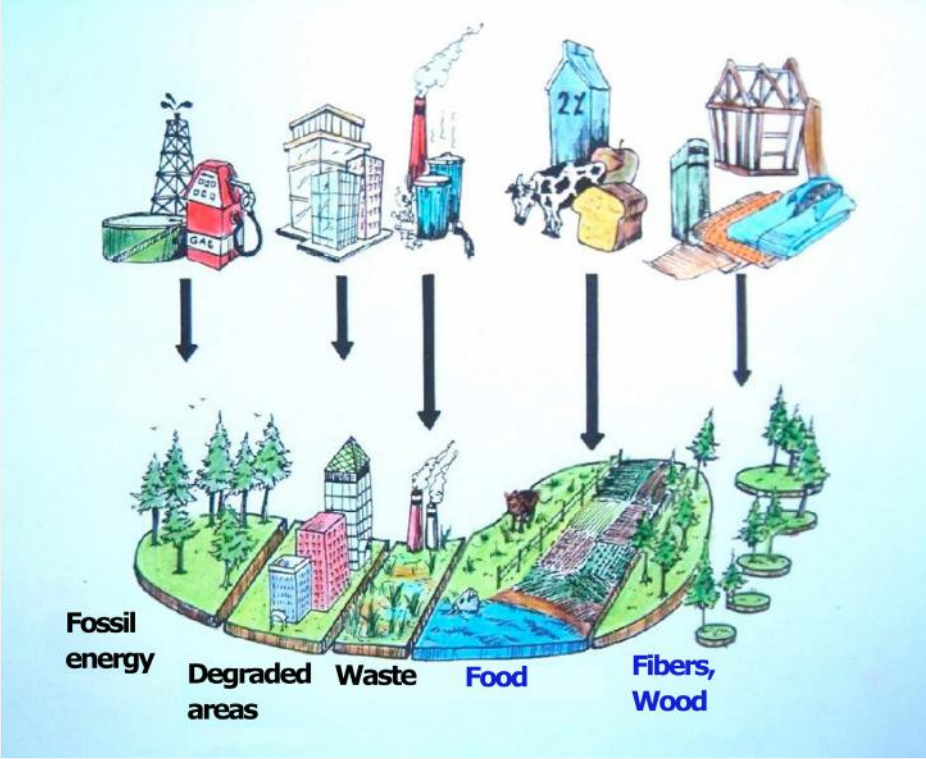
Overconsumption is compounded by the growing access by a larger number of people to the western lifestyle and by population on the one hand, and by the fact that product recyclability is not taken into account when determining product cost. This hinders the development of a circular economy, which is more respectful of the environment.



Source : Global Footprint Network _ IRES reprocessing

EVOLUTION OF THE GLOBAL CONTEXT

Various footprint perspectives
in a given territory



Source : Global Footprint Network _ IRES reprocessing

Consequences of the quasi-generalization of the Western development model

- A gradual destruction of natural resource stocks, reducing spontaneous biocapacity.
- A deterioration of biodiversity, which affects the consistency of the food chain.
- Environmental degradation affecting the production of biomass: reduction of the utilized agricultural land.
- A significant contribution to climate change and to amplification of its effects.
- Increased geographical and socioeconomic disparities among different populations: water stress, deforestation, poverty ...
- A deterioration of health conditions: hunger, obesity and diseases due to an unbalanced diet (diabetes), diseases from pollution (lead poisoning ...), chronic diseases (asthma ...).

GROWING AWARENESS

Biodiversity

Deep concern about fast, irreversible loss of biodiversity and the growing awareness of the importance of its role for humanity led to the adoption, in 1992, of the **Convention on Biological Diversity**.

This legally binding global treaty has three main objectives: the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising out of the utilization of genetic resources (source: www.greenfacts.org).

Near-universal participation has been achieved through this agreement, to which 195 countries are currently signatories.

The tenth **Conference of the Parties in Nagoya**, held in 2010, decided the following:

- combat biopiracy : better access to genetic resources, more equitable sharing of benefits arising from their use ...
- adopt a 2011-2020 strategic plan, comprising 20 quantified sub-goals advocating the elimination, by 2020, of subsidies that are harmful to biodiversity
- set up a scientific and political intergovernmental platform on biodiversity and ecosystem services, the equivalent of the IPCC for biodiversity; its first report was published in February 2016.

Waste

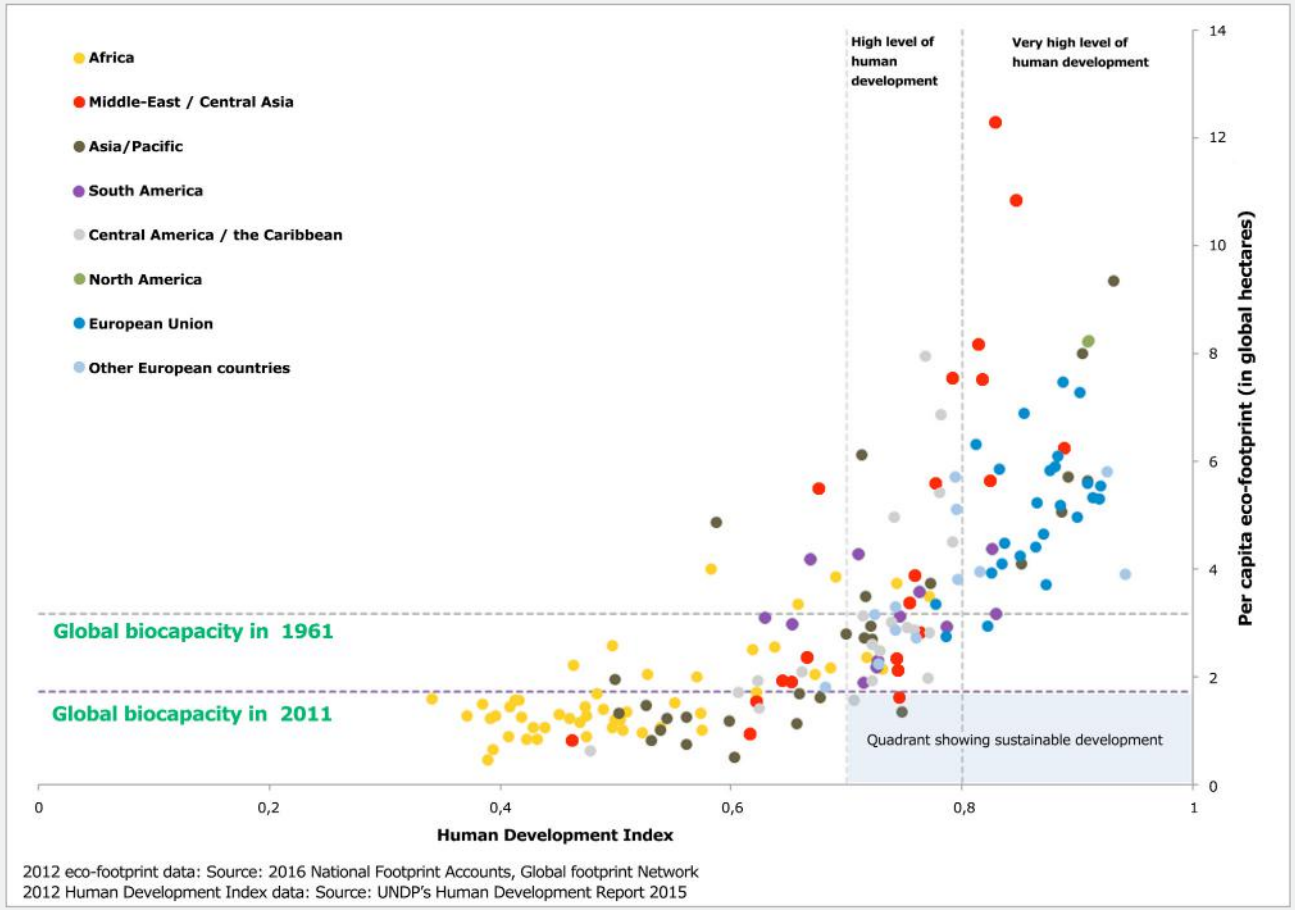
To tackle the waste problem, several conventions[7] were concluded under the aegis of the United Nations, including the following:

- the **Basel Convention**, which was adopted in 1989 and which entered into force in 1992, deals mostly with the regulation of cross-border trade of hazardous waste. This agreement also insists on the full implementation of treaty commitments.
- the **Rotterdam Convention**, which was adopted in 1998 and which entered into force in 2004, regulates the information and communication system on the management of hazardous waste.
- the **Stockholm Convention**, which was adopted in 2001 and which entered into force in 2004, aims to limit the production of chemicals and reduce the release of persistent organic pollutants, including pesticides and dioxins.

GROWING AWARENESS

The graph on the right shows how the UN human development index compares with population demand for resources. It reflects the challenge of ensuring a high level of human well-being that can be replicated globally without harming the planet's ecological resources.

Ecological footprint and level of human development (2012)



Source : National Footprint Accounts, Global Footprint Network, 2016 edition _ IRES reprocessing

THE ALIEN GENERATION : A DECISIVE FACTOR

The *Alien Generation* includes not only the so-called «digital» generation, born in the 1990s, but also all those who share the values embraced by this generation, namely:

- access to rather than ownership of things, hence the increase in rental or leasing modes,
- the techie character of this generation: the digital technology allows them to be more effectively mobile (e-commerce and networks)
- "globality" trumps nationalism,
- 'enoughism': rejection of excessive consumerism, including food waste,
- the particular care given to well-being and health (balanced diet)
- agility (more adaptable, more flexible, more autonomous) and transparency are the source of its resilience,
- accepting to slow down one's pace if this benefits the environment (example: Solar Impulse)
- the Jugaad innovation, Kaizen mindset and positive economics as the new watchwords,
- constant connection to the Internet increases empathy and a sense of belonging to one humanity.

This generation will be, from 2030, the majority of assets in the world. First to share common values around the world, it will have a significant influence on the behavior and lifestyles. This could result, ultimately, the development of:

- the circular economy, whose values it shares: recycling, barter, attention to the environment ...
- the local economy: locavores ...
- protein substitution: vegetarianism, food products made from insect/ jellyfish powder ...
- new solutions for the environment, such as ridding the continent of plastic ...

This generation's appetite for new technology could foster and accelerate the development of autonomous management systems, controlled by artificial intelligence systems, including in agriculture.

The price, however, could be an exponential increase in the use of resources required to develop new technologies which the Alien Generation craves.

Chapter 2

STATE AND CONSEQUENCES OF BIOSPHERE DETERIORATION: 2015-2050

STATE AND CONSEQUENCES
OF BIOSPHERE DETERIORATION
2015-2050
IN THE WORLD

2015-2050 BIOSPHERE DETERIORATION

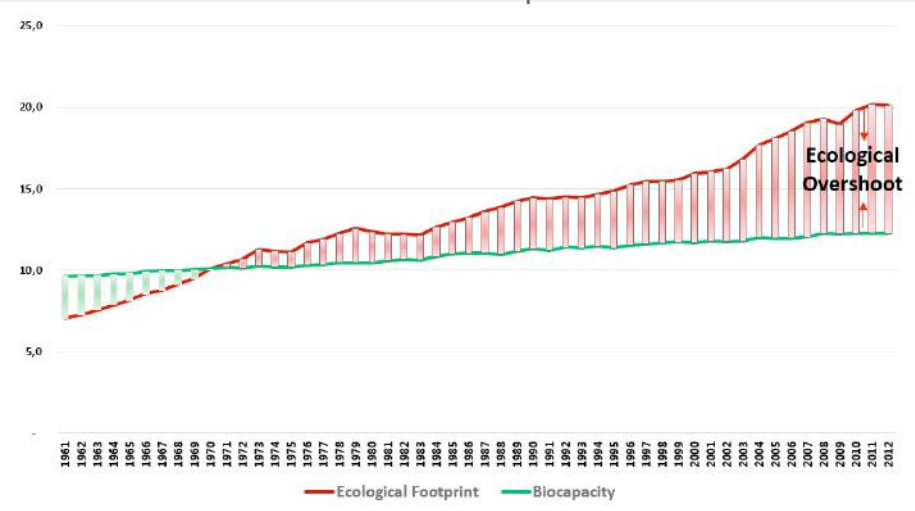
In 2012, the ecological footprint for the world was 20.1 billion global hectares, or the equivalent of 2.84 global hectares per capita whereas the planet's biocapacity is 12.25 billion global hectares, or 1.73 global hectares per capita.

This overshoot of the average global per capita biocapacity now concerns 128 out of 187 countries studied by the Global Footprint Network.

In 2012, 5 countries accounted for approximately half[8] the global ecological footprint: China, the United States of America, India, Russia and Japan.

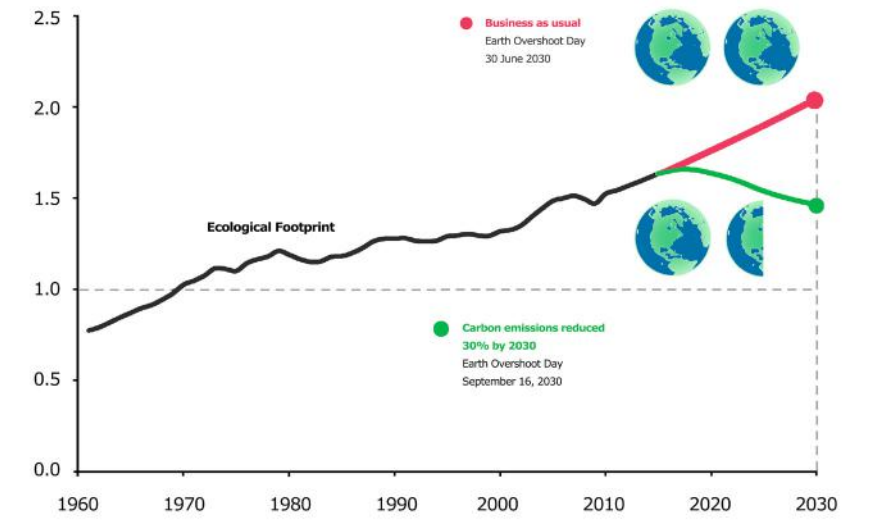
The largest component of the ecological footprint is carbon, in the form of CO_2 emissions, the main emitters being China, with 27%, and the US, with 16%.

Evolution of the global ecological footprint and biocapacity (in billions of global hectares) for the 1961-2012 period



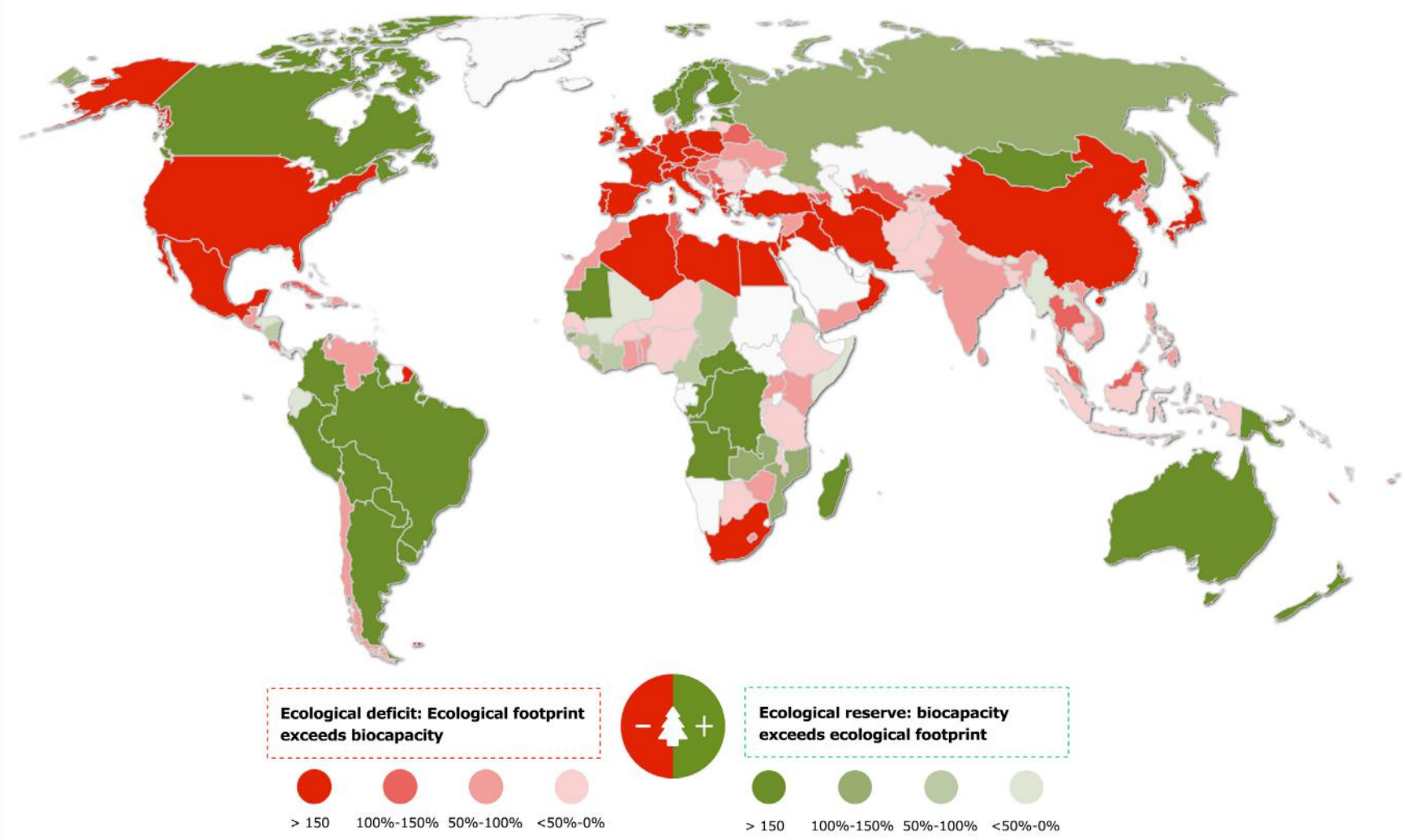
Source : Global Footprint Network data _ IRES processing

Number of Earths it takes to support humanity by 2030



Source : Global Footprint Network data _ IRES reprocessing

Ecological Deficit / Reserve (2012)



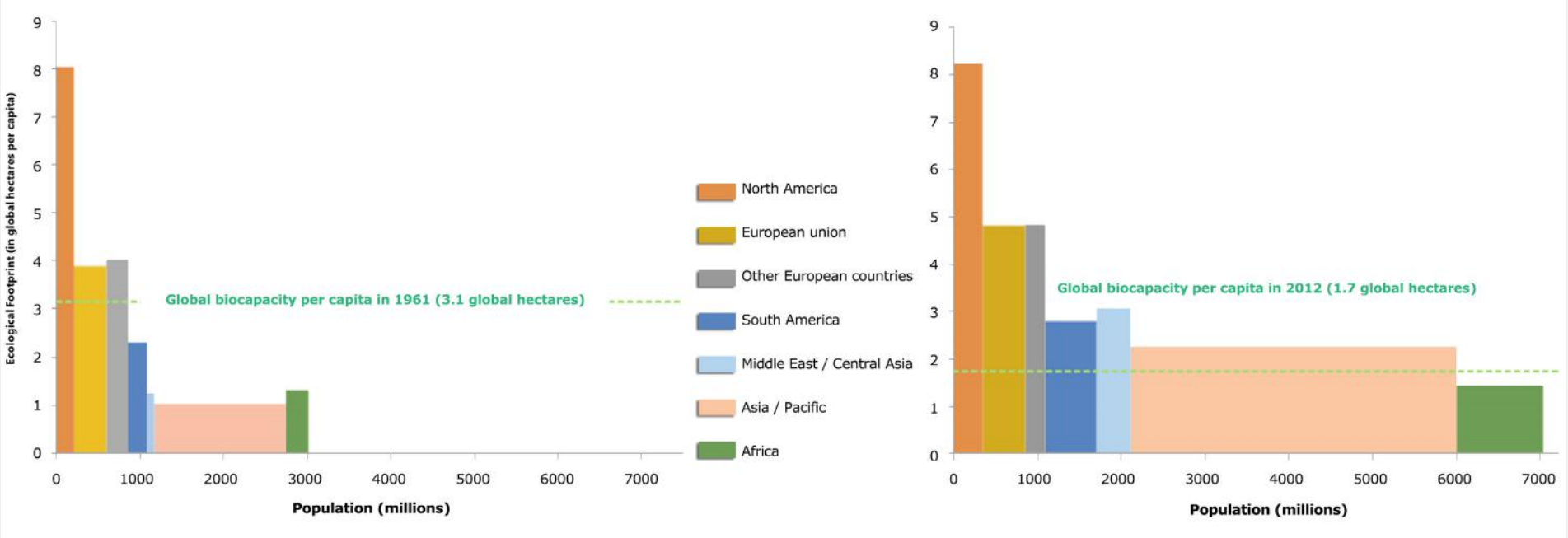
Source : Global Footprint Network_National Footprint Accounts, 2016 edition _ IRES reprocessing

SITUATION IN 2015

In most regions, the ecological footprint exceeds biocapacity. Asia's ecological footprint per capita is now nearly the same as that of Europe and has even exceeded the global biocapacity per capita.

Although its population has considerably increased over the last 50 years, Africa maintains a steady ecological footprint per capita. It remains lower than global biocapacity per capita. However, Africa's environmental impact has been increasing with population growth.

Evolution of population and ecological footprint per capita, by major world regions for the 1961-2012 period



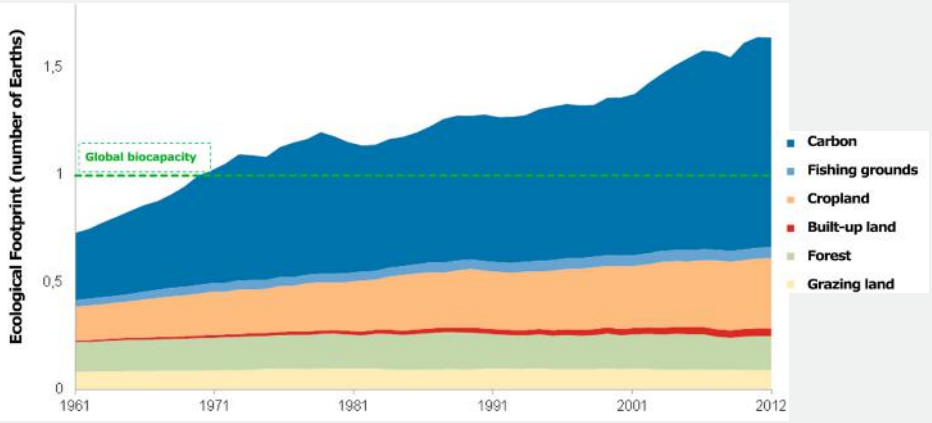
Source : Global Footprint Network data_ IRES reprocessing

SITUATION IN 2015

The increase in carbon dioxide emissions is attributed to increased use of fossil fuels; they are the primary component of the ecological footprint. According to the Global Footprint Network[9], the carbon footprint increased from 36% in 1961 to 59.5% in 2012. The carbon issue is discussed in the first part of this report in Chapter 3 on climate change mitigation strategies.

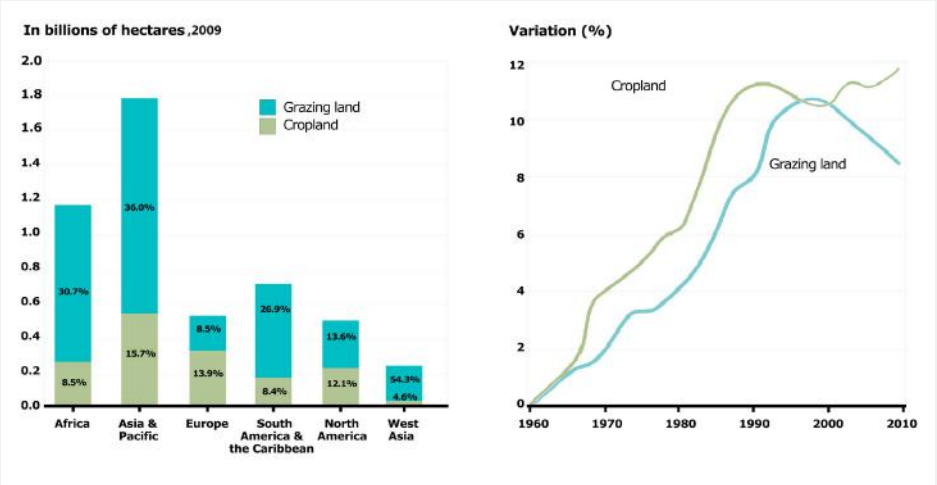
The use of intensive **farming** methods, coupled with pressure on water resources, affect the status of agricultural land. Soil erosion in agricultural systems using pesticides and chemical fertilizers is more than three times that observed in sustainable agriculture systems, and more than 75 times that of natural vegetation systems[10].

Global Ecological Footprint breakdown



Source : Global Footprint Network, 2012 _ IRES reprocessing

Status by region and evolution of total cropland and grazing land in 2009 for 1960-2010 period



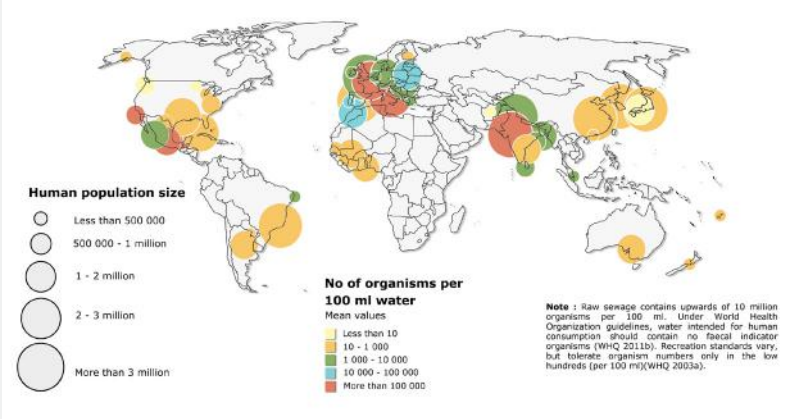
Source : FAOSTAT, FAO, 2011 _ IRES reprocessing

SITUATION IN 2015

There has been continuing degradation of **aquatic ecosystems**, imperiling many ecological functions, including the security of food supply and the sustainability of biodiversity. In the 20th century, 50% of wetlands were lost (up to 95% in some areas). Moreover, two-thirds of all large river systems in the world are now moderately to highly fragmented by dams and reservoirs[11].

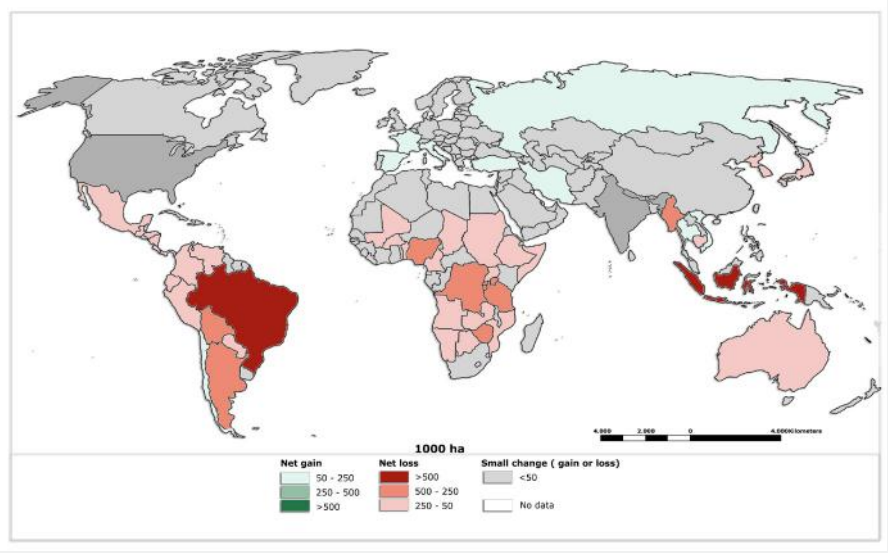
Forests are under severe pressure. According to FAO, between 2010 and 2015, there was an estimated net loss of 6.6 million hectares per year of natural forest, which represents 93% of global forest areas. Moreover, according to research by the World Resources Institute, 30% of global forest cover has already been cleared, another 20% has been degraded, the rest has been fragmented, and only 15% of the forest cover is intact. Deforestation is continuing at a faster rate than reforestation due, in particular, to arson, acid rain, logging and the conversion of forests to cropland and grazing land. This phenomenon exists in the entire planet, but more so in tropical areas in South America and in Africa[12].

Concentration of faecal coliforms in rivers near large cities 1990-2011



Source : UNEP – GEMS/Water Programme 2008

Average annual variation of forest area between 1990 and 2015



Source : Global Forest Resources Assessement, FAO, 2015

SITUATION IN 2015

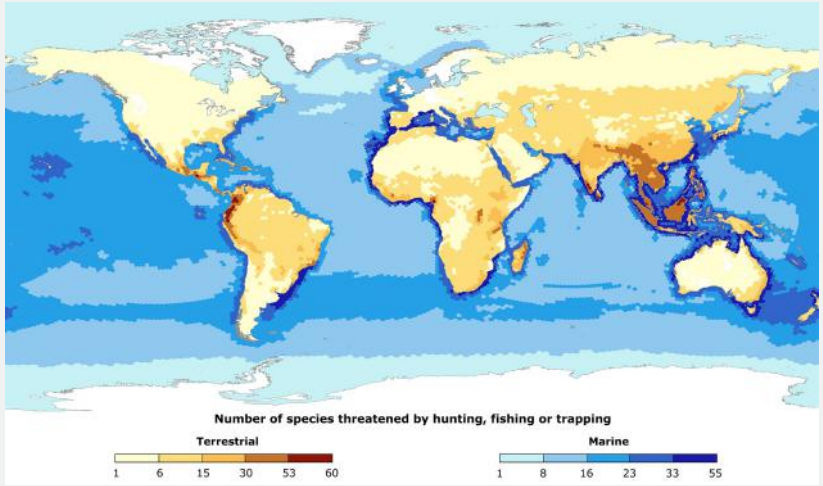
Global biodiversity has significantly deteriorated. According to the World Wildlife Fund (WWF), the Millennium Development Goal aimed at reducing the rate of biodiversity loss could not be achieved. Nearly half the wildlife populations are in danger of becoming extinct.

- According to the WWF's Living Planet Index, vertebrate species populations declined 52% between 1970 and 2010, and in 2015 20% of these species were in danger of becoming extinct,
- The Living Planet Index for freshwater species shows a decline of 76% between 1970 and 2010.

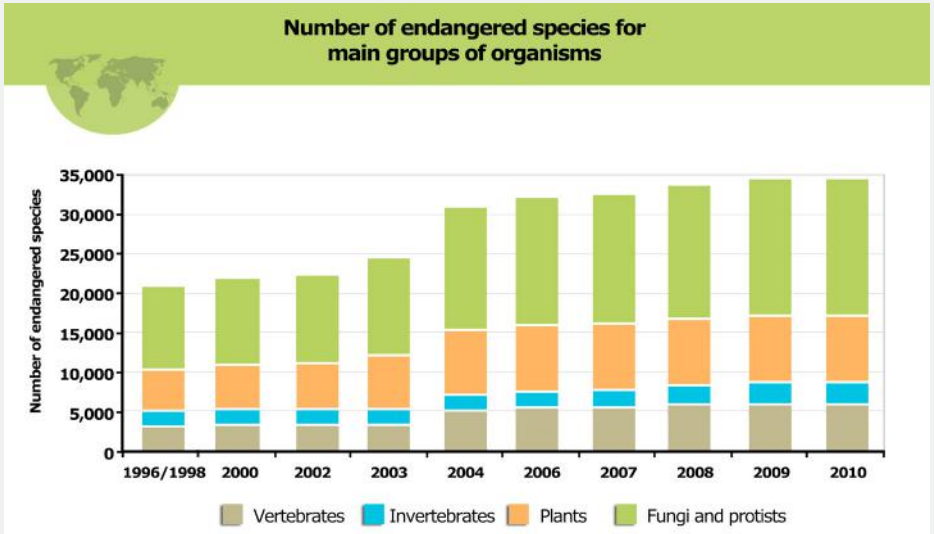
Among the most crucial factors - both in terms of increasing intensity and the threat of extinction they pose to the species – are the following, in descending order:

- destruction of natural habitats due to deforestation (agriculture, logging): almost 50% of the Earth's tropical forest has been destroyed over the last 40 years,
- overexploitation of natural resources (flora and fauna)
- invasive species that hunt native species through competition or predation,
- pollution: soil and water contamination has weakened or even destroyed many species
- population growth compounds all of the above factors (7.4 billion in May 2016).

Number of vertebrate species threatened by overexploitation - 2010



Source : International Union for Conservation of Nature _ IRES reprocessing

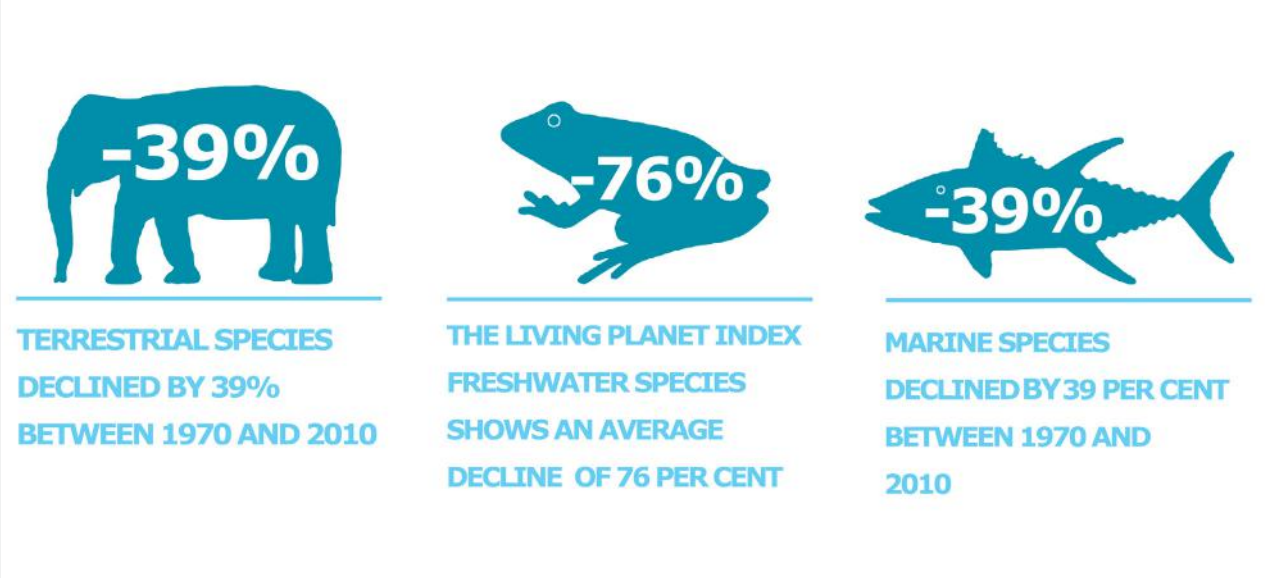


Source : International Union for Conservation of Nature, 2010 _ IRES reprocessing

SITUATION IN 2015

In addition to the alarming threat to corals, the threat of extinction for freshwater species is almost twice as high as that for terrestrial and marine species.

The decline for vertebrate populations is faster in tropical regions and in freshwater habitats.

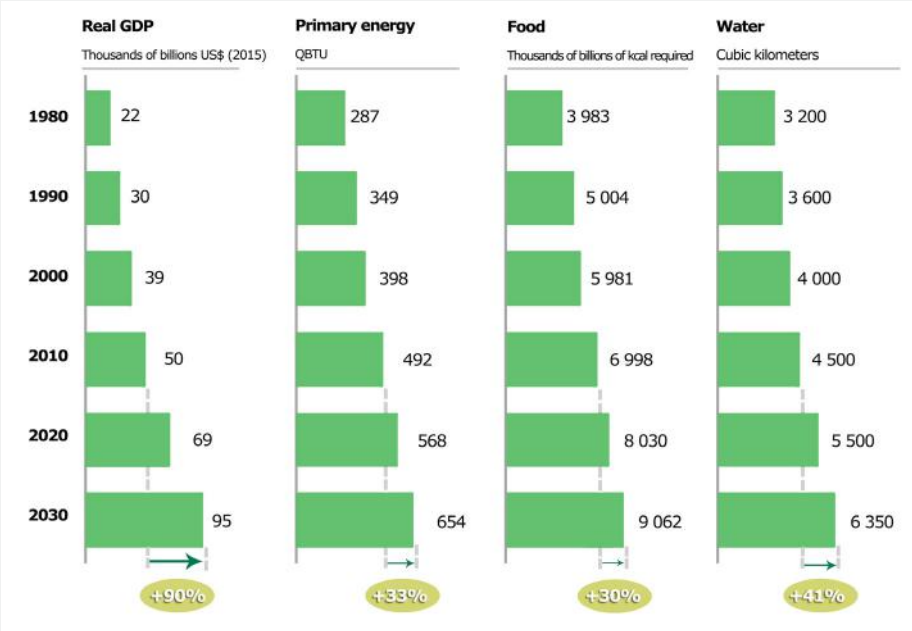


Source : Living Planet Index, World Wildlife Fund _ IRES reprocessing

OUTLOOK TO 2050

Nearly 2.8 planets will be required in 2050 to meet the growing global demand for resources. Between 2010 and 2030, demand could increase by 33% for primary energy, 30% for food and 41% for water, for a real GDP increasing by 90%.

Growth of global resource demand under business-as-usual scenario - 2010 / 2030



Source : Creating a Sustainable Food Future, World Resources Institute, 2013 _ IRES reprocessing

Prospects for the development of the ecological footprint by 2050 (baseline scenario) include the following:

- increased pressure on freshwater resources[13] compared to 2015 :
  - 55% increase in global water demand due to population growth and intensification of human activities,
  - Up to 66%[14] decline in the volume of freshwater available in cities
- a loss of 10% global biodiversity compared to 2014, particularly in Asia, Europe and southern Africa: human encroachment, pollution ...
- loss of 289 million hectares of tropical forest compared to 2014 – a size equivalent to India[15].

In a not-too-distant future:

- in 2025, a loss of productivity for half the irrigated land due to salinization;
- in 2030, land and water resources available would be insufficient to feed the world population.

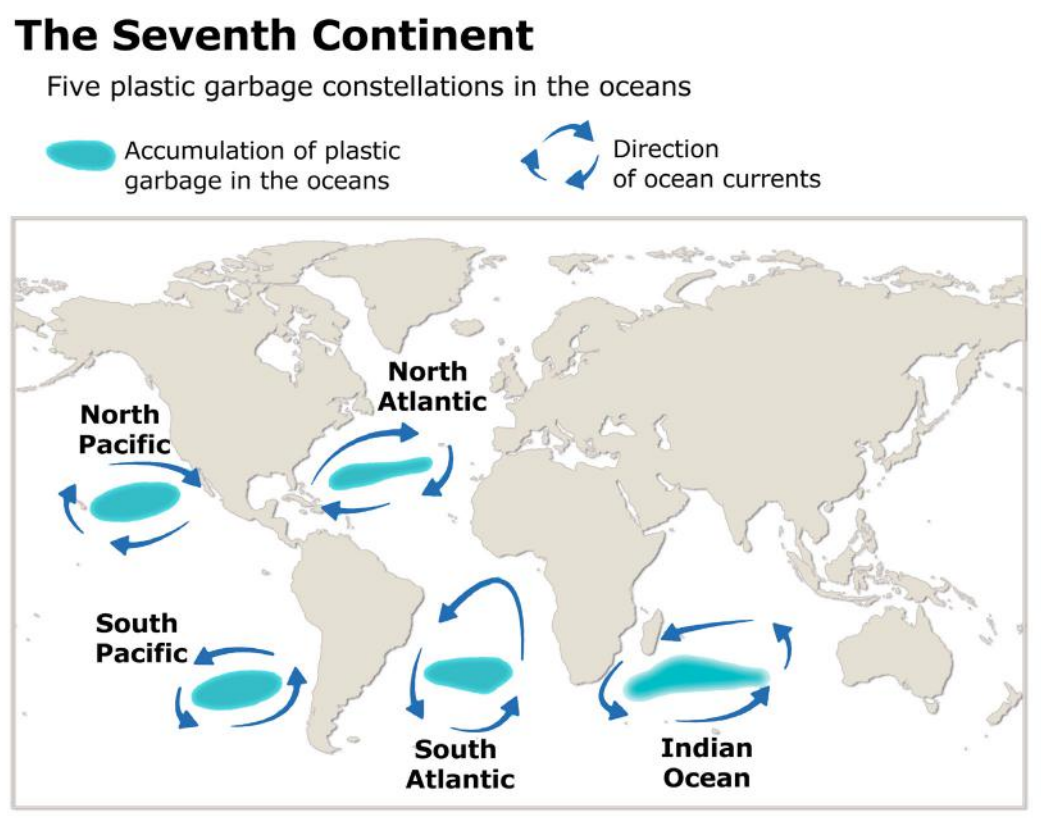
OUTLOOK TO 2050

The destruction of aquatic ecosystems could continue. Asia, Africa and South America (especially Brazil) would be most affected: by 2050, 20% increase in the number of lakes affected by harmful algal blooms compared to 2000[16].

The Congo Basin's rainforest and 40% of the Amazon rainforest could be lost by 2050. The most endangered forests are in South America, Russia, Canada, Southeast Asia and Africa[17].

The amount of plastic found in the oceans would be multiplied by 5 between 2014 and 2050. By weight, the plastic to fish ratio would be 1:1 by 2050[18].

Plastic garbage gyre distribution in the world



Source : Expedition 7th Continent, 2014 _ IRES reprocessing

2 015-2050 IMPACTS

The growing ecological footprint problem is already raising a double issue which will only get worse in the next 35 years if nothing is done (business-as-usual scenario):

- **Reproduction of resources** (flows) and the disappearance of stocks[19]: Using 16 tons of natural resources per capita in the world in 2050, compared to 9.2 tons in 2009 and an annual average of 4.6 tons a century earlier.
- the **management of growing waste volumes** which are not absorbed by nature due to their toxicity:
  - In rural areas: 900 million tons of solid waste expected to be generated worldwide by 2050, compared to 500 million tons in 2013.
  - In urban settings: 2.72 billion tons of solid waste expected to be generated in 2050, compared to 1.3 billion tons in 2030[20]

The complexity of **impacts resulting from the degradation of natural resources** partly explain the ineffectiveness of certain measures taken as well as the lack of action. Illustrating this complexity as well as the risks involved in the **water-deforestation-pollution nexus**.

Definitions

The planet's resources

Finite resources: resources that are the product of geological phenomena (minerals, crystals) or evolution over millions of years (hydrocarbons, deep sedimentary aquifers); non-renewable stocks on a human scale

Renewable resources: regenerated resources: free groundwater, vegetation, wildlife; their regeneration is the biocapacity of the planet.

Waste and pollution

recyclable waste : biodegradable (biomass) or reusable (metals, plastics, building materials).

waste to be eliminated or buried : final waste (which cannot be recycled), hazardous waste (toxic or radioactive) and special waste (hospital, agricultural, military, electronic).

municipal solid waste (MSW / DSU): anything that is not sewage, agricultural waste, industrial, medical or radioactive waste

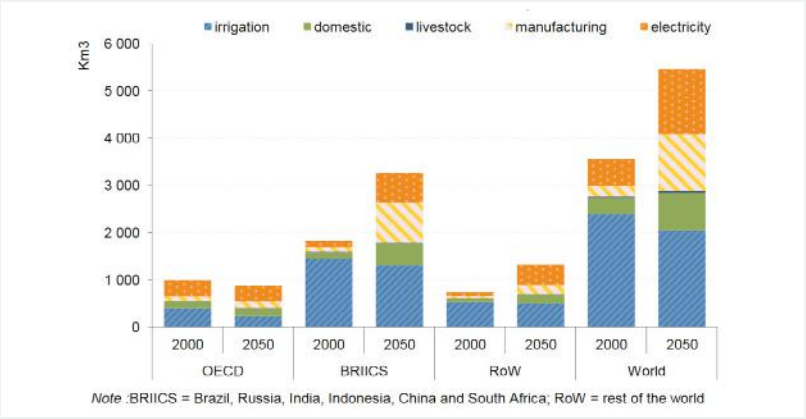
2 015-2050 IMPACTS

First nexus: decreasing water resources

Water consumption exceeds biocapacity, which means the need to tap into reserves which are unevenly distributed (glaciers, aquifers) and which are shrinking due to climate change (melting glaciers), contamination resulting from human activity and leaks in distribution networks; hence a triple impact on:

- **ecosystems and species balance** resulting from the food chain: declining biodiversity, extinction, proliferation of certain harmful species...
- **economic development capabilities**, given the water needs of some sectors such as agriculture, energy, industry ... and the increasing cost of water,
- **the survival of human beings**, since a decrease in the quality and availability of water affects:
  - food, because of the high cost of agricultural products (higher cost of water, reduced soil productivity, competition for naturally irrigated land) and increase in water-stressed areas,
  - health and hygiene: dehydration, diseases related to contaminated water. According to the World Health Organization, in 2015 two million deaths were caused by unsafe water and inadequate sanitation and hygiene in the world,
  - security: populations that are particularly vulnerable to floods (1.6 billion, compared to 1.2 billion people today)[21], competition for access to water (individual conflicts and otherwise).

Global demand for water in case of inaction : 2000 - 2050

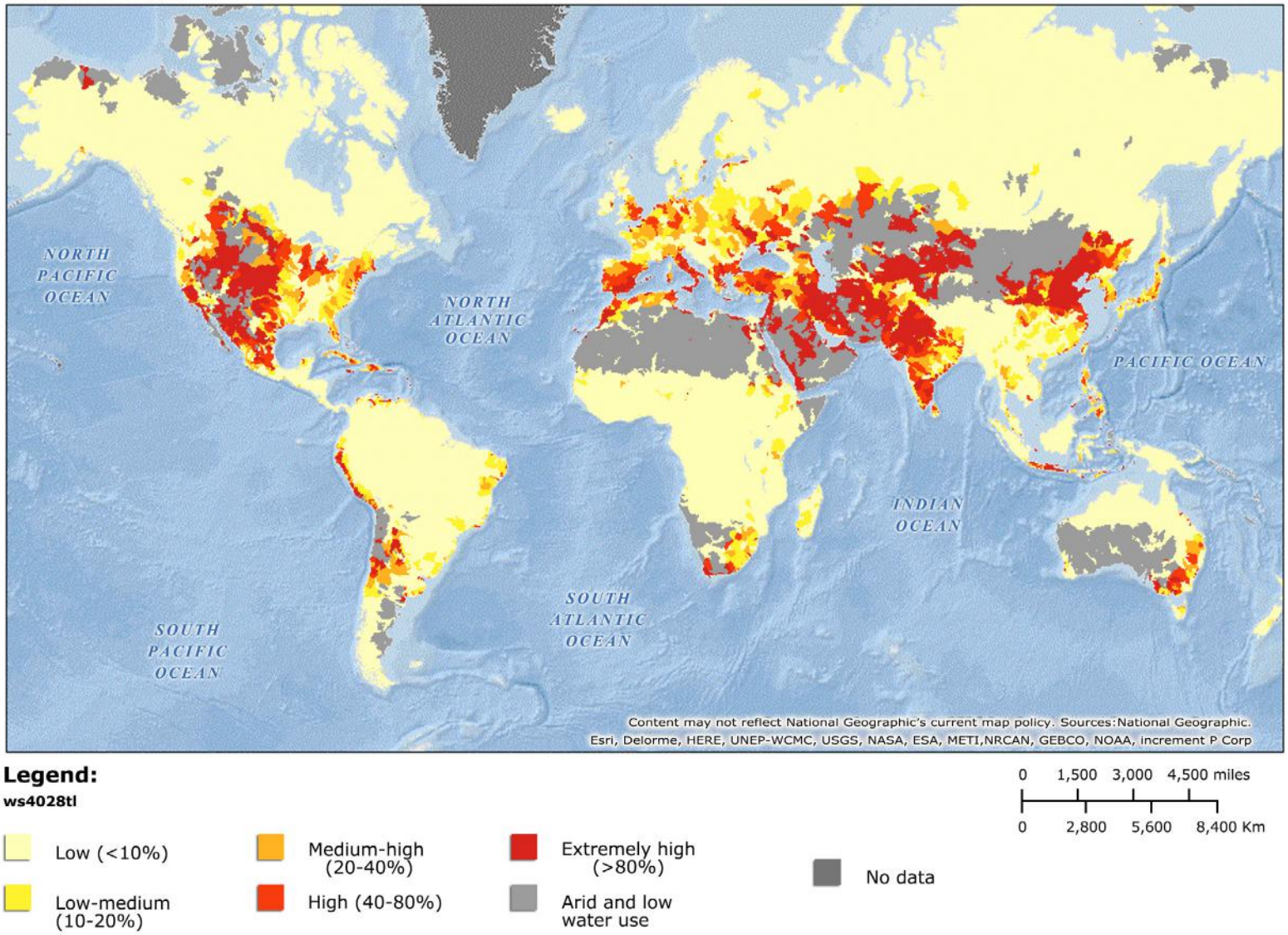


Source : OECD Environmental Outlook to 2050 : The consequences of inaction

Global demand for water is expected to increase by about 55% in 2050 due to the increasing demand of the industrial sector (+ 400%), thermal electricity generation (+ 140%) and domestic use (+ 130%). In 2050, more than 240 million people will still be without access to a source of clean, safe water[21], according to the OECD.

→How can we, from now until 2050, continue to ensure water security and food production at a time when drinking water supplies are rapidly shrinking and there will be more than a 25% increase in world population?

Projected change in water stress (2040)
(business as usual)



Source : World Resources Institute, Aqueduct measuring and mapping water risk, 2015
_ IRES reprocessing

2 015-2050 IMPACTS

Second nexus: deforestation

The reduction of the plant cover has an impact on :

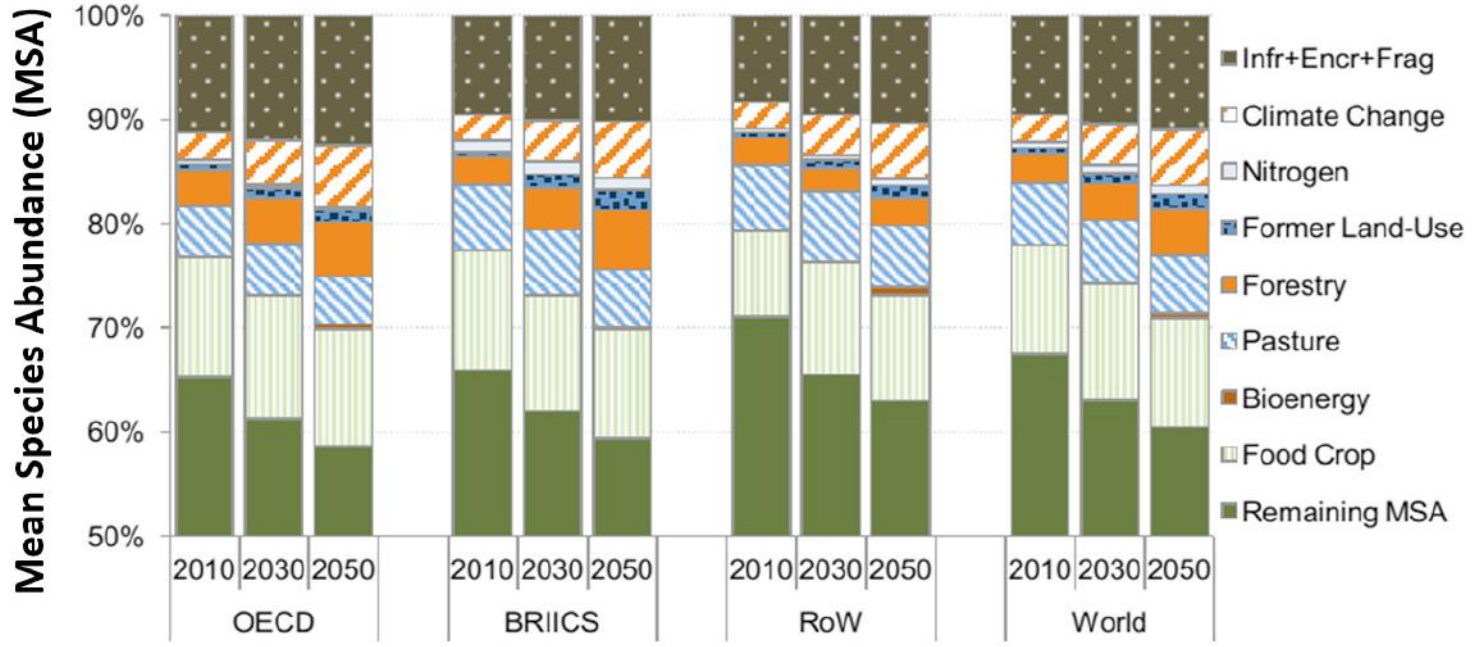
- **climate change**: 169 gigatons of CO_2 will be released into the atmosphere by 2050[22]; reduced production of oxygen and carbon dioxide storage,
- **biodiversity**: half the world's biodiversity and 80% of terrestrial biodiversity are found in tropical forests[23],
- **survival of people** who make their living from forests: out of the 1.6 billion people who make a living from forest-related economic activities, 50 million indigenous people could be forced to migrate by 2030[24],
- **soil degradation**: desertification in sensitive areas and water and wind erosion affect soil productivity (nomadic tropical farming)
- **Pharmacopoeia**: a quarter of active substances of the drugs sold comes from primary forests[25].

This reduction of the plant cover was necessary to:

- **feed a growing world population** (global demand for food commodities will double by 2050); it is a demanding population (global meat consumption will double by 2050)[26].
- **extension of built-up land** for accommodation in cities and greater mobility thanks to infrastructure development,
- **help meet growing energy needs** through logging and bioenergy. By 2030, the use of biofuels in Europe could lead to the destruction of 70.2 million hectares of natural areas[27].

→ How to combat climate change (reducing emissions and CO_2 storage) without causing a deterioration of the conditions for the survival of local populations today, and without affecting the survival prospects of future generations?

Effects of different pressures on terrestrial Mean Species Abundance (MSA) : Baseline, 2010 to 2050



Note: Infra+Encr+Frag = infrastructure, encroachment and ecosystem fragmentation. BRIICS: Brazil, Russia, India, Indonesia, China, South Africa. RoW: Rest of the world.

Source : OECD Environmental Outlook to 2050 : The consequences of inaction _ IRES reprocessing

2 015-2050 IMPACTS

Third nexus: proliferation of pollution

Human activity is responsible for the generation of **different sources of environmental toxicity** :

- generation of solid urban, industrial, and agricultural waste...
- water contamination by sewage, industrial and agricultural waste water discharged into soils, rivers and oceans;
- particulate emissions: heavy metals, gases, toxic products;
- interfering with ecosystems: dams (soil salinization, deterioration of freshwater fauna and flora), infrastructure and urbanization (disruption of ecological corridors ...).

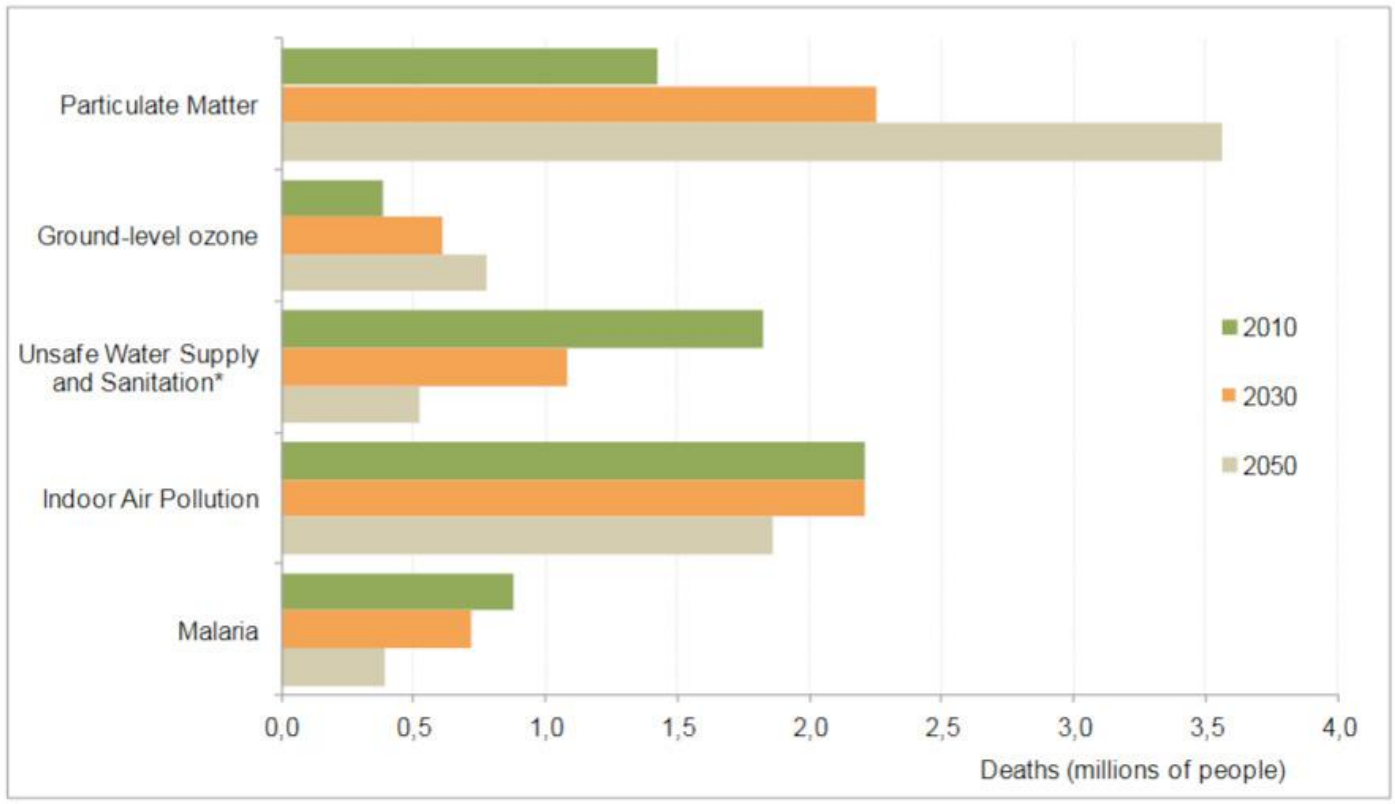
The overall toxicity generated by humanity today is greater than the planet's absorption / degradation capacity.

According to the United Nations Environment Programme[28], there may be more than 2 million contaminated industrial and urban sites which contain hazardous substances, like heavy metals, in Europe, the USA and the Russian Federation.

The multiple impacts of the proliferation of pollution impedes a proper understanding of this phenomenon which is already overshadowed by concerns about climate change.

With regard to health, for example, in 2050 more than 3.5 million premature deaths would be caused by contamination by particles, compared to 1.4 million deaths in 2010. Similarly, the number of ozone-related premature deaths could double between 2010 and 2050.

Global premature deaths from selected environmental risks :
***Baseline*, 2010 to 2050**



(*) Child mortality only.

Source : OECD Environmental Outlook Baseline, 2012 ;
output from IMAGE

2 015-2050 IMPACTS

Waste management

Frantic consumption of goods and services produced by humanity raises the acute problem of absorption of the ensuing waste.

There is marked difference in waste generation, according to the level of development:

- According to the World Bank, in low and middle-income countries, organic waste represents 40 to 85% of all generated waste.
- In high-income countries, it is paper, plastic, glass and metal fractions that predominate in the generated waste, with a much greater impact on the environment.

There is uneven waste distribution:

- 44% of global waste is generated by OECD countries.
- 76% of waste exchanges originate in OECD countries
- Africa and South Asia are the least waste-generating regions, collectively as well as on a per capita basis.

Between 2012 and 2025, the increase in waste generation in developing countries (+ 152% in East Asia and the Pacific, + 161% in Africa), coupled with the uneven distribution of waste processing capacity, are likely to heavily affect these countries' biocapacity.

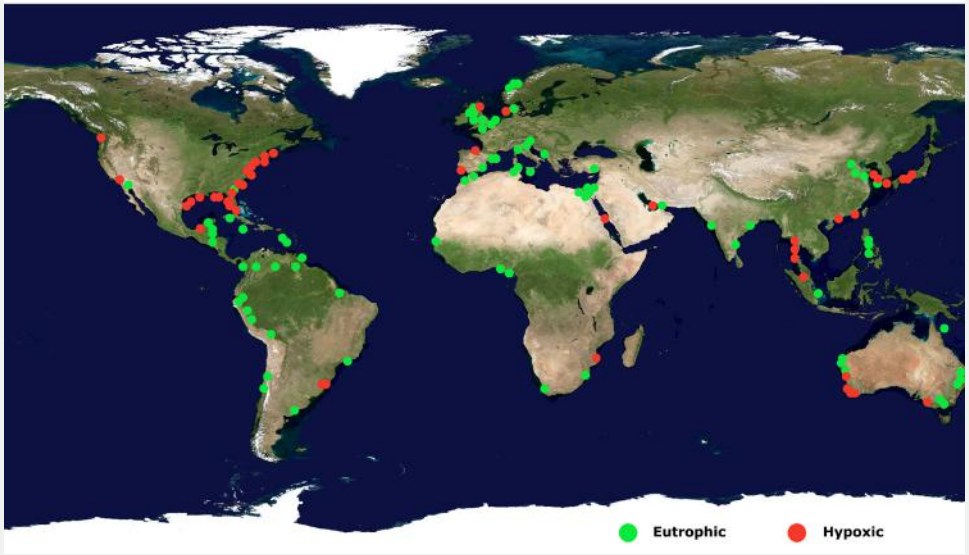
With the exception of the 1989 Basel Convention governing international trade in hazardous waste, importing countries do not generally have a regulatory framework to protect their economic interests and their natural assets.

The export of electronic waste to certain developing countries is on the rise due to the low cost of labor and the lack of strict standards for health and environmental protection. People working in the informal electronic waste recycling sector are exposed to heavy metals, endocrine disrupters and other hazardous health-effecting materials.

THE DEGRADATION OF THE OCEAN SYSTEM :

Serious risks of mass extinction and total climate disruption hang over the planet due to the disruption of oceanic water masses and a reduction of oxygen levels required for life because of human activities.

Coastal areas impacted by eutrophication and/or hypoxia



Source : Eutrophication-and-hypoxia/interactive map, World Resources Institute _ IRES reprocessing

Chain reactions

Ocean degradation is caused by human activity: overfishing, intensive fishery practices, pollution and damage to sea, coastal development, release of contaminants (fuel, fertilizers, industrial waste water) through watershed ...

It affects the **termohaline circulation** of water masses in the ocean (gulf stream ...) which, in turn, affects the role of oceans in regulating atmospheric temperature, CO_2 absorption ...

Responses may differ markedly at local level, and this is not reflected in global averages which are traditionally used to assess the state of the ocean.

At the end of the chain, the **global human footprint in the ocean** affects the nutrient supply in the maritime environment and the related biological productivity:

- Eutrophication of marine areas: the planet now has 405 'dead' ocean zones, covering 246,000 sq km (oxygen levels too low to support life)[29]
- Moving fishing grounds to deeper waters: 40% of fishing grounds are now more than 200m deep[30].
- Threat to coral reefs by 2050; they are home to a third of documented marine species[31] and, in the longer term, the risk of marine animals shell dissolution (aragonite) because of acidification ...

A DECISIVE FACTOR

The chain reactions, however, do not end at the ocean :

- **Food**: The decline of fish stocks and the increase in relative consumption (protein source) are mitigated by the growth of aquaculture production (50% of global consumption, 80% in China) which is one of the causes of ecosystem pollution (excrement). According to FAO, fish farming produces an enormous amount of concentrate-waste[32].
- **Health**: Almost all marine organisms - from plankton to whales - are contaminated by chemical pollution (pesticides, chemicals, plastics, copper ...). The effects of consuming these products, which are not adequately assessed, will probably have consequences for the health of humans over the more or less long term (cancer, infertility ...)[33].

  Since 2003, scientists have highlighted the risk of growing health problems resulting from marine toxins, such as red or green tides[34].
- **Habitat** : impaired ocean conditions will inevitably have an impact on the quality and living conditions for the 200 million people living in coastal areas less than 5 meters above sea level (2009)[35].
- **Economy** : In 2007, over 275 million people lived within 30 km of a coral reef, from which most of these people were making a living or which constituted their habitats (coral islands)[36].

Oceans are a major disruption factor for the terrestrial ecosystem; however, the main reason for this is not climate change, but human activity, through the discharge of industrial effluents, the emptying of tanks out at sea, the discharge of untreated wastewater (80% of wastewater discharged into the Mediterranean is not treated)[37].

Better awareness of the role of the terrestrial water mass is needed to understand its impact both on the biosphere in general and on humans, who have strong links with the ocean (thalasso-tropism).

The resilience of nature gives hope for reversing the current situation if immediate action is taken to curb pollution. However, population growth is a serious hindrance to curbing overexploitation of marine resources for food.

Whether we act or we do not, the activities which will be most heavily affected by the deterioration of the ocean environment, in the North as well as in the South, will be seaside tourism, agriculture, aquaculture, fisheries, maritime transport, port activities, mining and forestry[38].

Source : Global Footprint Network

STATE AND CONSEQUENCES
OF BIOSPHERE DETERIORATION
2015-2050
IN AFRICA, IN THE MEDITERRANEAN AND IN MOROCCO

AFRICA

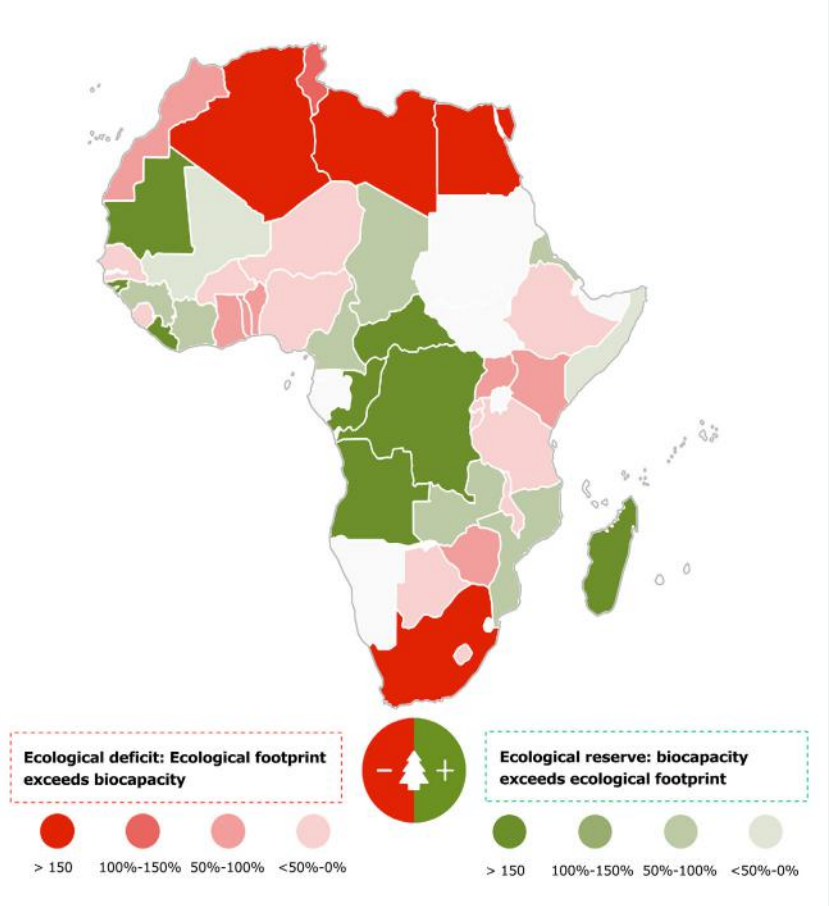
Ecosystems in Africa are under an increasingly strong pressure and are experiencing unprecedented change.

By and large, Africa's ecological footprint per capita is below the global average. However, African countries' convergence process is straining ecological balances that are already precarious in several African countries. Of particular concern is the situation in North Africa and in some countries in Southern and Eastern Africa.

According to the Global Footprint Network[39], the African ecological footprint has more than tripled between 1961 and 2012 due to a 277% population increase[40], as well as a high urbanization rate, which went up from 19% to 40% during the same period.

In 2012, Africa's ecological footprint per capita was 1.4 GHA, which is almost equivalent to the continent's biocapacity.

Ecological deficit / reserve per African country - 2012



Source : Global Footprint Network _ National Footprint Accounts, 2016 edition _ IRES processing

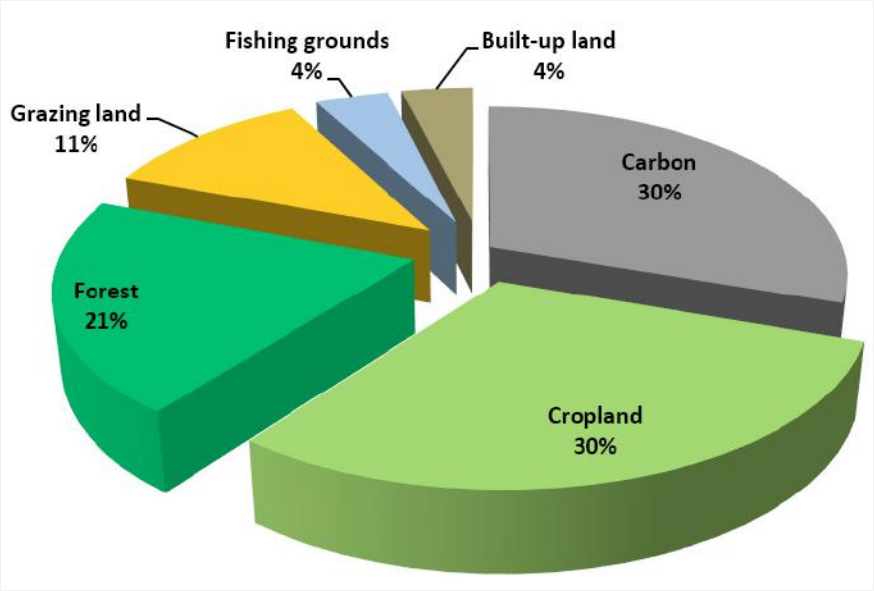
AFRICA

Forest products account for 21% of Africa's ecological footprint, against a world average of 9%, thus highlighting the problem of deforestation afflicting Africa. Indeed, during the 2010-2015 period, the highest net annual loss was recorded in Africa, compared to other regions, with 2.8 million hectares.

Carbon emissions represent 30% of Africa's ecological footprint, compared to a global average of 59.5%. Besides the fact that Africa is economically lagging behind, this can be explained by the fact that 60% of the continent's population still has no access to electricity, according to the International Energy Agency.

Whereas there is room for leeway to contain the carbon footprint - thanks to the development of renewable energy – in the carbon footprint for agricultural products, which accounts for almost 30% of the overall footprint, compared to a global average of 20%, there is the question of meeting the considerable needs of African populations in terms of food supply, at a time when desertification is affecting 46% of the African continent and about 485 million Africans[41].

Ecological Footprint breakdown in Africa – 2012



Source : Global Footprint Network _ National Footprint Accounts, 2016 edition _ IRES processing

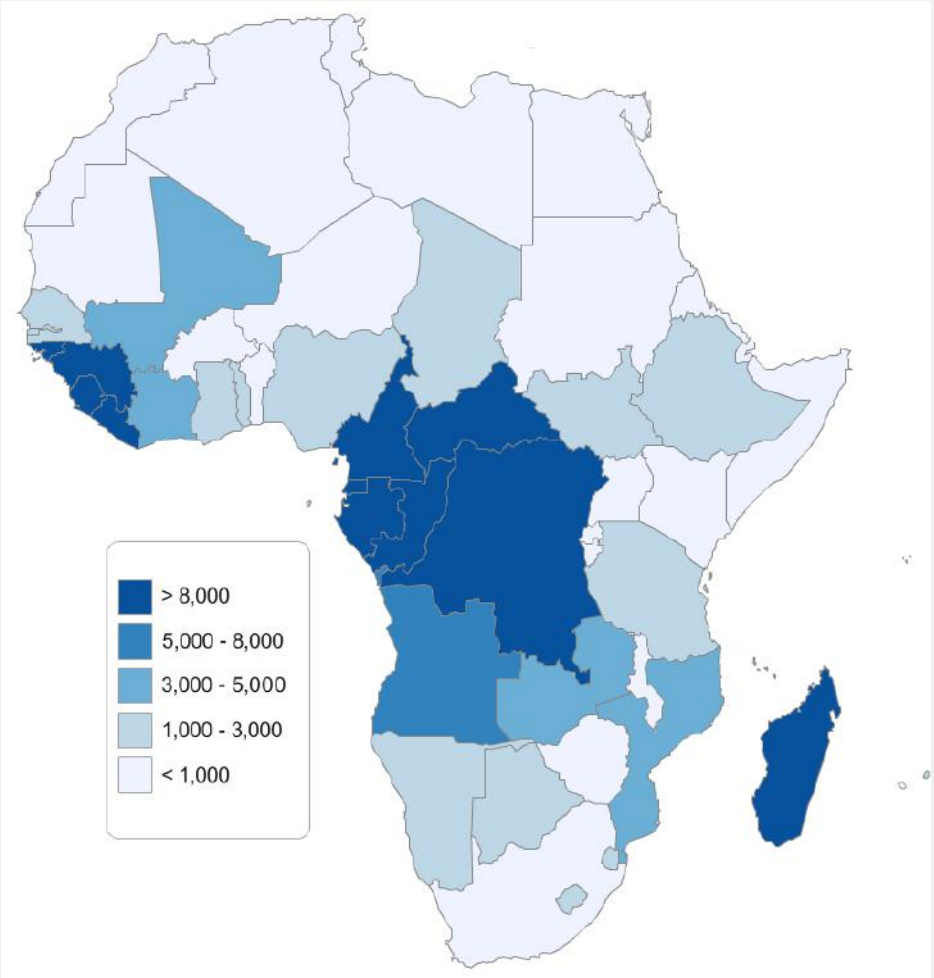
AFRICA

The problems of water resource availability, loss of biodiversity and waste absorption will affect the future of the African continent.

❖ Water availability

Africa is home to 10% of the globe freshwater resources[42]; these resources are unevenly spread across the continent. In 2012, nearly 400 million people living in the 36 largest African river basins experienced water shortages at least one month a year. The percentage of African countries suffering a shortage of water, which in 2014 was 37%, could reach 65% in 2025, according to the United Nations Environment Programme[43]. Moreover, by 2050, according to the OECD, water demand in the continent would increase by 83%.

Renewable freshwater resources per capita in Africa (in cubic meters per year) - 2014



Source : FAO AQUASTAT Platform
data _ IRES processing

AFRICA

❖ Loss of biodiversity

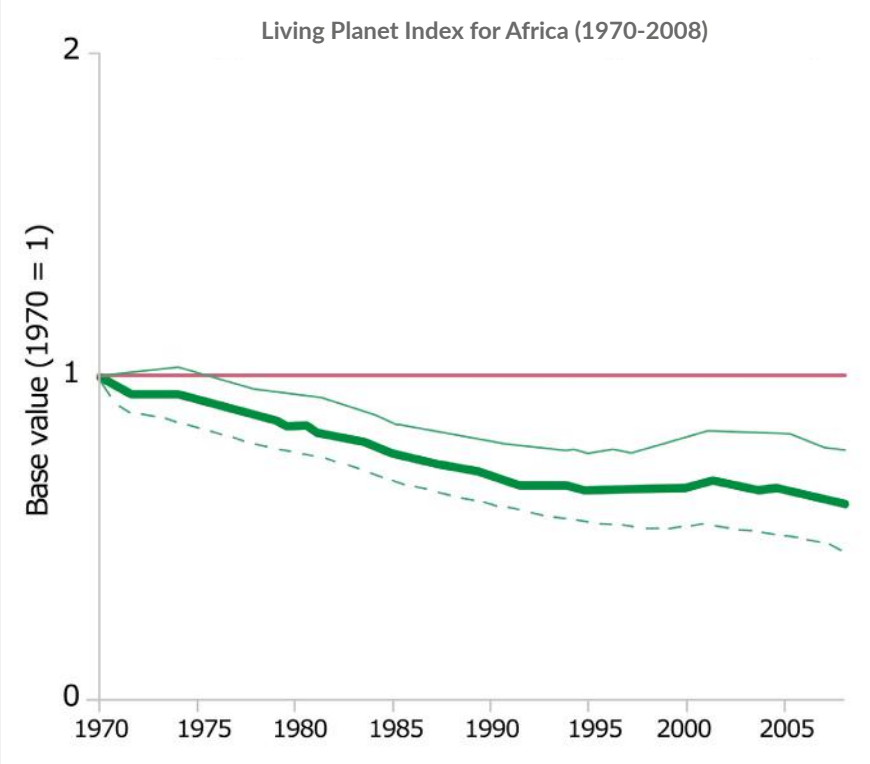
The Living Planet Index for animal populations in Africa fell 39% between 1970 and 2008.

Today, about 1,780 African vertebrate species are considered in critical danger of extinction, endangered or vulnerable, according to the Red List of the International Union for the Conservation of Nature.

❖ Waste absorption

Waste absorption is a major concern for Africa even though the continent accounts for only 5% of the total waste generated in the world.

Solid waste, which is almost 60% organic[44], is expected to increase by 161% between 2012 and 2025 due to economic catch-up in Africa. The management of this waste is a challenge to which African cities would have to rise.



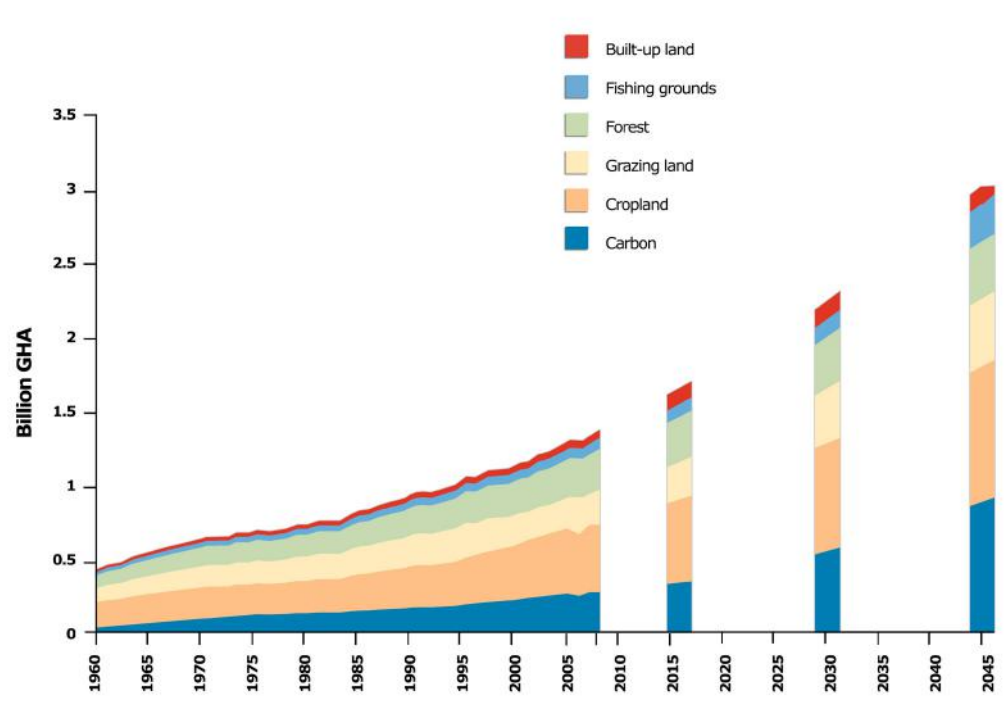
Source : Report on Africa's ecological footprint (World Widlife Fund/African Development Bank -2012)_ IRES reprocessing

AFRICA

According to the Global Footprint Network, Africa's ecological footprint could double by 2045, accelerating the continent's ecological deficit. The ecological deficit of many African countries is set to become more significant.

Africa is expected to experience sweeping changes in terms of land use and exploitation of natural resources due to the fact that it will be home to an additional one billion inhabitants by 2050 and would have an urbanization rate of 56 %, against 40% currently, according to UN projections.

Ecological footprint by land use category (1961-2008), with projections for 2030 and 2045 (billion GHA) -Africa
- Baseline scenario -



Source : Global Footprint Network, 2012 _ IRES reprocessing

THE MEDITERRANEAN

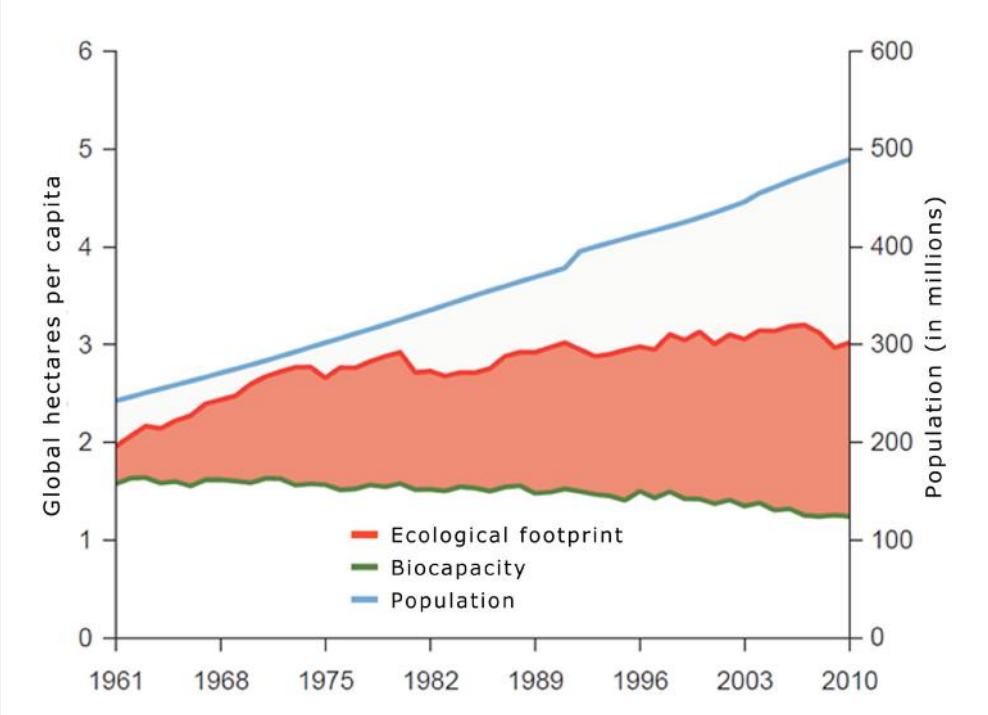
A leading destination in the world and a hub for trade between Europe, Africa and Asia, the Mediterranean is a unique eco-region with many specific features. It is home to 10% of flowering plants in the world on only 1.6% of the Earth's surface and has about 13,000 endemic species.

But the Mediterranean is also one of the most vulnerable regions of the biosphere. Moreover, it is exposed to the major causes of current anthropogenic alteration. The pressure on resources – which is already very high (limited water resources, overexploited fish stocks, air pollution ...), makes the Mediterranean one of the planet's most sensitive regions.

In 1961, Mediterranean countries were already using a large part of their natural resources, which exceeded the reproductive capacity of their ecosystems.

This situation means the countries of the region are dependent on ecological assets outside the Mediterranean basin. According to the Global Footprint Network, food and energy products imported by Mediterranean countries accounted for 30% of the region's ecological footprint in 2010.

Evolution of the ecological footprint and of biocapacity per capita in the Mediterranean 1961-2010



Source : Global Footprint Network, 2015 _ IRES reprocessing

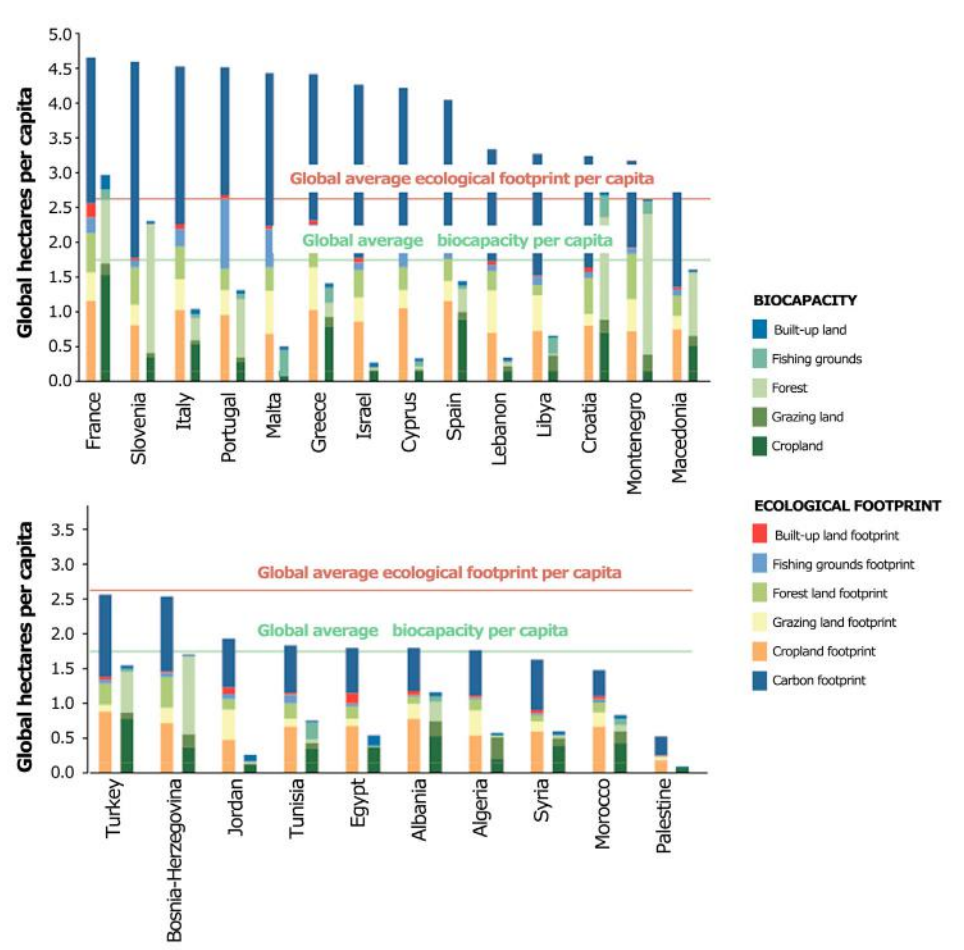
THE MEDITERRANEAN

Between 1961 and 2010, the ecological footprint per capita in the Mediterranean basin increased by 54%, according to the Global Footprint Network, and biocapacity per capita declined 21%[45]. The ecological footprint is currently more than twice higher than biocapacity per capita.

The ecological footprint exceeds biocapacity in all Mediterranean countries. On a per capita basis, it far exceeds the global average, with the exception of North Africa, Jordan, Albania and Syria.

The structure of the ecological footprint varies depending on the level of development of the Mediterranean country concerned. The ecological footprint per capita shows a ratio of 1 to 9, depending on the size of the carbon footprint.

Distribution of ecological footprint and biocapacity per capita in the Mediterranean basin, by component - 2010



Source : Global Footprint Network, 2010 _ IRES reprocessing

THE MEDITERRANEAN

The main factors causing the increase of the ecological footprint in the Mediterranean are:

- **Demographic pressure and accelerated urbanization**: According to the United Nations, the seashore population of the Mediterranean has more than doubled between 1961 and 2015, rising from 251 to 515 million inhabitants[46]. The average urbanization rate in Mediterranean countries went up from 41.7% in 1961 to almost 69% in 2015.
- **The development of industrialization**, especially in the North, with an industrial added value representing nearly 30% of the Mediterranean GDP[47] according to the World Bank. Naturally, this industrialization causes additional damage, both direct, through physical destruction, and indirectly, through pollution from different types of coastal ecosystems.
- **Intensive farming** represents a threat for communities living in the Mediterranean region, especially in coastal areas, due to the growing use of pesticides and chemical fertilizers, which increasingly pollute soil and water.
- The **use of unsustainable consumption patterns** over the past five decades has significantly contributed to increasing the ecological deficit in the Mediterranean region.

THE MEDITERRANEAN

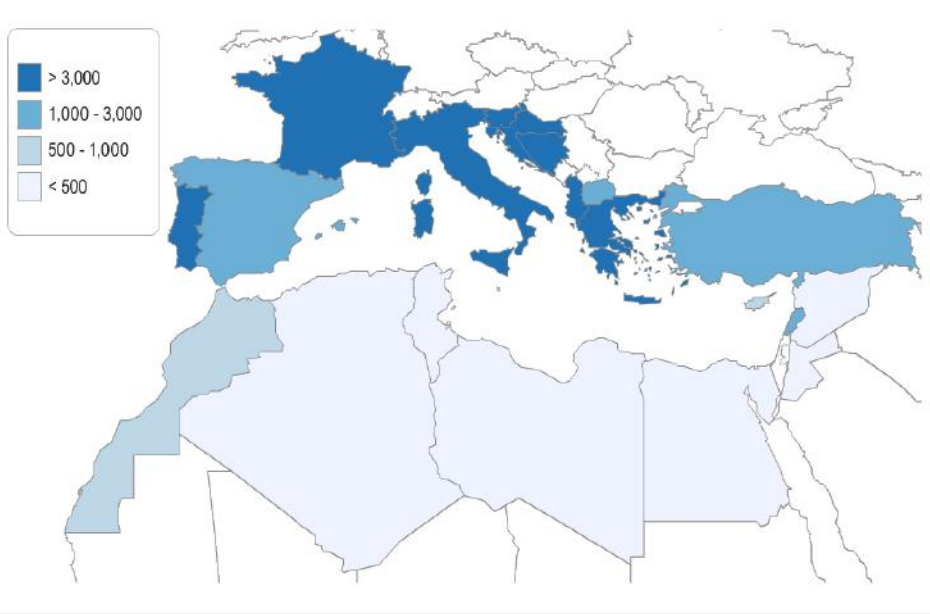
Water scarcity, loss of biodiversity, alarming pollution levels, land degradation and accelerated waste generation are critical issues for the Mediterranean.

Water: a scarce resource, particularly in southern Mediterranean countries

With only 3.4% of the world's renewable freshwater resources and an unequal distribution between the two shores, the Mediterranean region is home to 60% of the world population of the so-called water-poor countries (less than 1,000 cubic meters per capita).

The Mediterranean population classified as "water-poor" will increase from 180 million in 2010 to 250 million in 2025, 80 million people will be in an environment characterized by water scarcity (less than 500 cubic meters / year), according to the European Institute of the Mediterranean[48]. According to the same Institute, demand for water in the Mediterranean basin could increase by nearly 20% in 2025.

Renewable freshwater resources per capita in the Mediterranean (in cubic meters per year) - 2014



Source : FAO AQUASTAT Platform data _ IRES processing

THE MEDITERRANEAN

❖ Declining biodiversity

Despite plant endemism in the Mediterranean, almost 70% of the original habitat has been altered by human action and only 5% of the vegetation is in perfect condition, according to the United Nations Environment Programme[49].

Today, most Mediterranean marine habitats are endangered. According to the International Union for the Conservation of Nature, there are at least 81 endangered animal marine species, such as the monk seal, the dusky grouper and the loggerhead turtle. The space covered by some ecosystems, such as the Posidonia meadow, which plays a crucial role in the Mediterranean ecological balance, has been increasingly shrinking. (Source: www.cybellemediterranee.org).

According to the Mistrals program, in which several scientific missions are involved, the Mediterranean Sea could become progressively more acid, which would lead to major disruption in the movement of water masses.

❖ Alarming levels of pollution

The Mediterranean is one of the most polluted seas in the world. It suffers from daily pollution from sewage and chemical spills in a context marked by inadequate coastal development regulations.

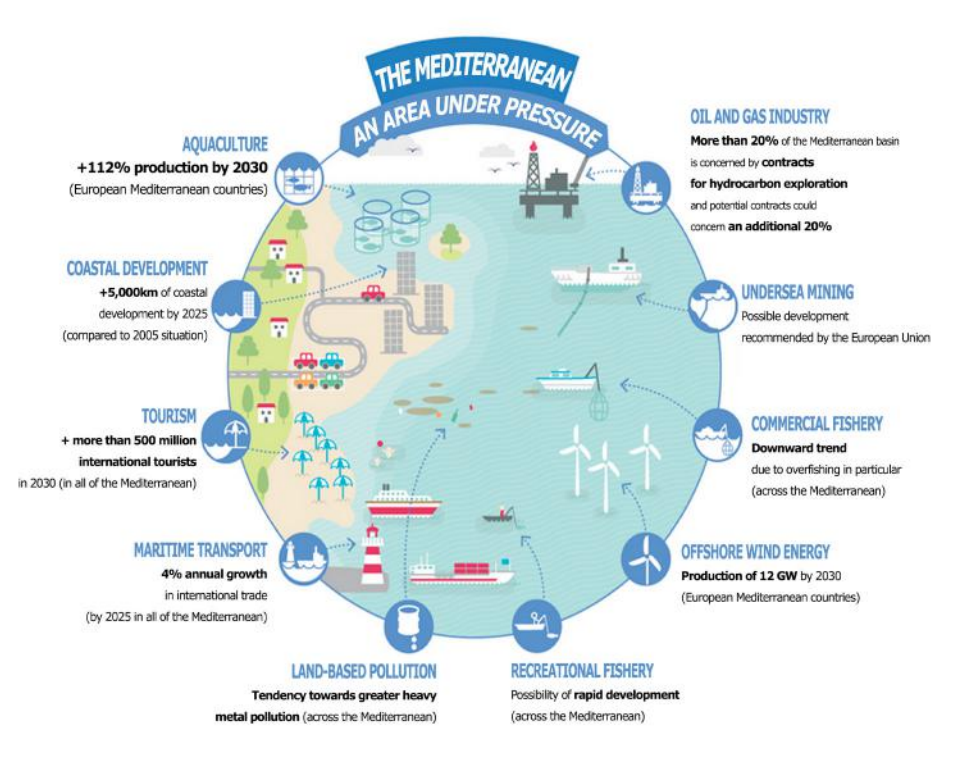
Intense merchant traffic in the Mediterranean (a third of world traffic) causes pollution from oil spills. Almost 16% of oil discharges at sea takes place in the Mediterranean, which represents less than 1% of ocean space in the world[50].

Moreover, half the goods transported by sea are somewhat dangerous; some hazardous chemical products are more dangerous than oil.

THE MEDITERRANEAN

The alarming pollution situation in the Mediterranean is likely to get worse in the future because of several concomitant factors, including:

- **the development of tourism**, with a 50% increase in the number of tourist arrivals in the region by 2030, to reach 500 million tourists,
- **accelerated urban development**, leading to increased coastal development, with 5,000 kilometers of additional coastline which could be developed between 2005 and 2025. This situation would get worse given the inadequacy of sewage networks: 44% of cities with more than 10,000 inhabitants do not have sewage networks in the southern Mediterranean, against 11% in the northern shore[51],
- **the intensification of oil and gas exploration** at sea could grow by 60% in 2020, according to the World Wildlife Fund[52].



Source : World Wildlife Fund _ IRES reprocessing

THE MEDITERRANEAN

❖ Soil deterioration

Urbanization, population growth and the unsustainable use of resources are leading to worrying soil degradation and to loss of arable land. As a result, agricultural productivity is declining and essential ecological balances are disrupted.

From 1992 to 2009, according to FAO, the supply of arable land decreased by 7 million hectares in the northern Mediterranean countries (-13%) and 4 million hectares in the southern Mediterranean countries (-9%).

These phenomena result in erosion, compaction, loss of organic matter, salinization, landslides, acidification, desertification ...

❖ Growing waste generation

In 2000, the volume of solid waste generated in the Mediterranean region was 174 million tons. It could reach 396 million tons by 2025.

In the southern and eastern Mediterranean, municipal waste includes twice as much organic waste and half the paper and cardboard waste compared to Europe. As far as waste characteristics are concerned, they reveal an abundance of packaging and advertising paper.

Furthermore, plastic waste is growing rapidly, due to changing patterns in the packaging of foodstuffs in supermarkets. The pollution caused by this type of waste is a major concern for Mediterranean countries. In 2014, the Tara Expedition found that there were 5 kg of plastic per sq. km in the Mediterranean, from watersheds in the 22 countries around the Mediterranean[53].

THE MEDITERRANEAN

The already serious environmental situation prevailing in the Mediterranean could become even worse due to:

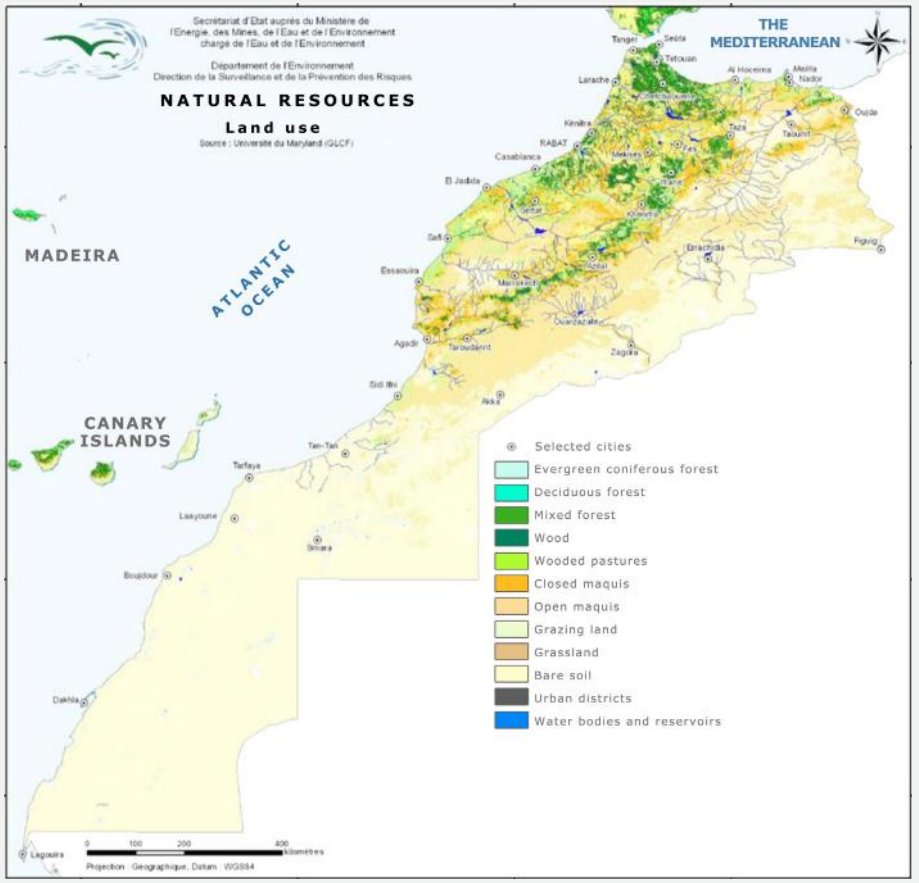
- population growth, especially in the southern Mediterranean, coupled with increasing urbanization. According to UN projections, the population of the Mediterranean would increase from 515 million in 2015 to 650 million in 2050. The urbanization rate, which currently stands at 69%, would be 78.2% in 2050,
- catching up the gap in terms of improving people's living standards and creating jobs for a young population, especially in the southern Mediterranean,
- global warming, which exacerbates water stress,
- the consequences of unsustainable use of resources in the region, possibly causing irreversible environmental degradation, with the risk of instability and fracture lines crossed,
- the need to modernize agriculture which, in southern Mediterranean countries in particular, is facing difficult natural conditions, especially rainfall: the development and diversification of agricultural areas lead to the expansion of irrigation and also the use of pesticides.

MOROCCO

Morocco has a privileged geographical location offering a varied range of bio-climates, ranging from humid and sub-humid to a Saharan desert climate and arid and semi-arid areas.

Morocco features significant bio-ecological diversity as well as a diverse range of natural environments: wooded formations, pre-Saharan and Saharan formations, steppe, matorrals, coastal regions... The result is a great species and genetic diversity which can be classified in three major types of ecosystems: terrestrial, inland, marine and coastal ecosystems. These ecosystems contain a unique and specific microbial population as evidenced by recent discoveries of new bacteria[54].

Overview of habitat diversity in Morocco



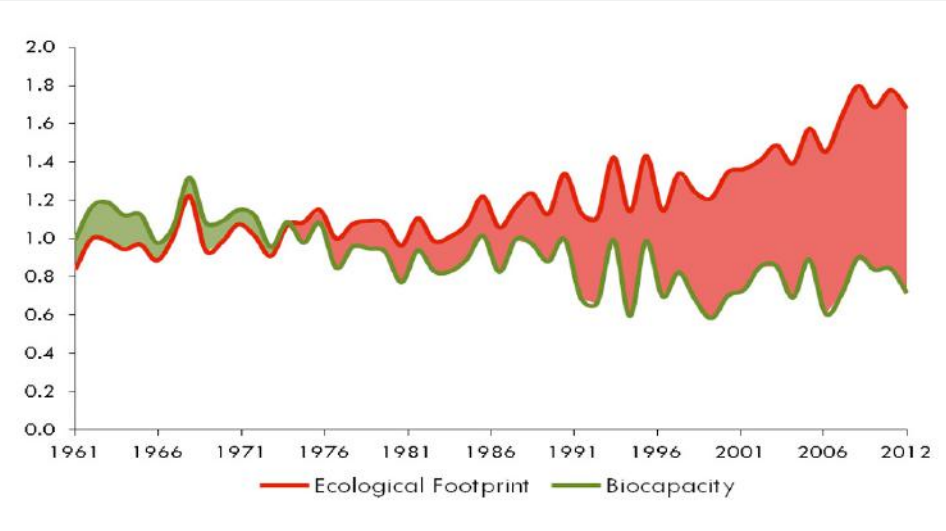
Source : Fifth national report on the implementation of the Convention on Biological Diversity, Department for the Environment, Morocco, 2014 _ IRES reprocessing

MOROCCO

Morocco's ecological footprint and biocapacity vary from year to another, reflecting fluctuations in agricultural output, which itself still depends to a large extent on rainfall.

Between 1961 and 2012, the ecological footprint per capita has more than doubled. Although the latter is still below the world average, the continuous widening of the ecological deficit, which started in the mid-1970s, is a major concern, particularly as Morocco aims to speed up its economic and social development.

Evolution of the ecological footprint and biocapacity per capita in Morocco (in global hectares), 1961-2012



Source : Global Footprint Network _ National Footprint Accounts, 2016 edition

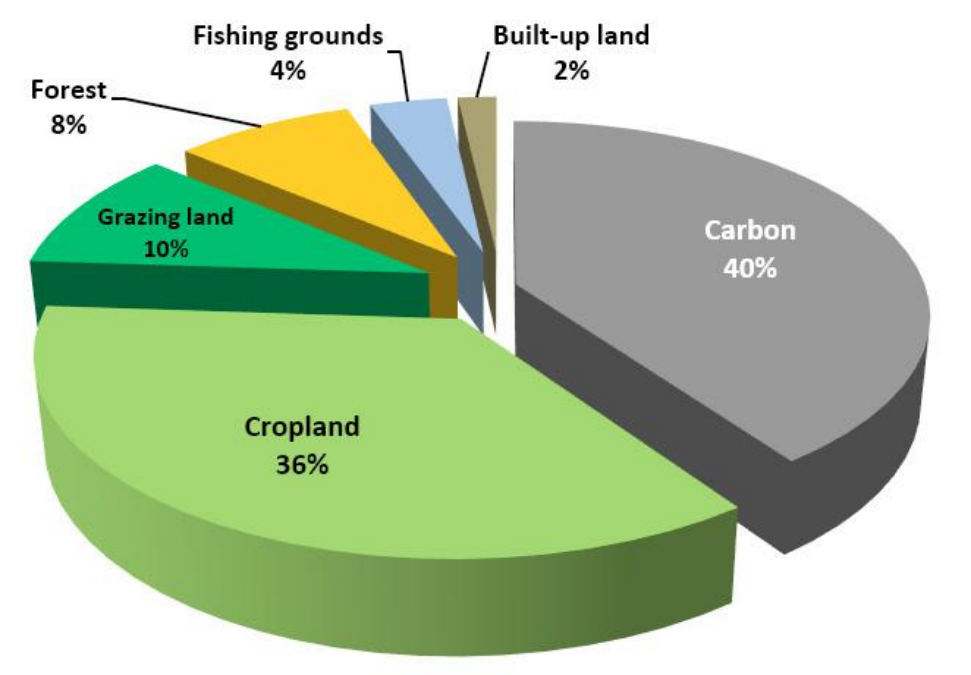
MOROCCO

Morocco's ecological footprint is dominated by the carbon and cropland components.

The carbon component accounts for 40% of Morocco's ecological footprint, compared to a global average of almost 60%. The Kingdom's ambition to develop renewable energy and its commitment to reduce GHG emissions by 32% by 2030 will make it possible for the country to continue to keep its carbon footprint under control.

The cropland component accounts for nearly 36% of the Kingdom's ecological footprint, against a global average of 20%. This high level reflects the pressure on Morocco's agricultural production due to population increase and the effects of climate change. Agricultural land per capita was cut in half between 1961 and 2013, going from 0.54 to 0.24 hectares. Morocco intends to implement the ecological footprint concept to rigorously assess how the Green Morocco Plan will accelerate the transition to a sustainable agricultural development model[55].

Ecological Footprint breakdown in Morocco - 2012



Source : Global Footprint Network _ National Footprint Accounts, 2016 edition _ IRES processing

MOROCCO

Like other Mediterranean countries, Morocco is facing problems in connection with water scarcity, soil deterioration, loss of biodiversity and waste management issues.

- **Increasingly scarce water resources** : With 600 cubic meters per capita per year, Morocco is a water-stressed country. In 2050, under the medium case scenario, water availability per capita per year could fall well below 500 cubic meters due to demographic pressure and climate change[56].
- **Soil deterioration** : Soils are particularly vulnerable to erosion, including in arid zones. They are facing strong pressure, due in particular to the demands of the agricultural sector. Soil deterioration is illustrated by deforestation, land clearance, land cover changes... In addition to some inefficient agricultural practices, population growth and poor control of urban development, soil degradation could reduce the agricultural area per capita to 0.22 and 0.15 hectares by 2025 and 2050 respectively, against 0.24 today.
- **Real risk of loss of biodiversity** : At the end of December 2012, nearly 1,200 species in Morocco were on the International Union for the Conservation of Nature's Red List, of which 9% are near threatened with extinction, 7% are vulnerable, 7% are vulnerable and 7% are endangered or critically endangered, a minor concern for 70%. Moreover, forecasts indicate a risk of extinction for nearly 22% of national biodiversity by the year 2050[57].

  The state of biodiversity could worsen due to the effects of climate change. According to the High Commissioner for Water, Forests and the Fight against Desertification, although forest ecosystems are generally characterized by significant climatic tolerance thresholds, about 22% of Morocco's flora could disappear by 2050. Terrestrial wildlife is particularly impacted by drought.

MOROCCO

- **Endangered fish stocks** : Fish stocks are already being degraded due to inefficient management of coastal areas, home to a wide range of activities. Those activities, together with other anthropogenic factors, are exerting pressure on ecosystems and are affecting the biological stability of fish stocks. Polluting discharges are affecting fishery productivity of as well as the reproductive capacity of species, which leads to a progressive reduction of fish resources and adverse impacts on marine environments.

Further compounding the situation is the issue of overfishing. Among the regularly monitored stocks, 16 are believed to be overexploited and 4 are under-exploited[58].

Moreover, checks performed by the Moroccan Ministry of Territory Planning, Water and Environment showed that over 50% of fishing boats were docked for fishing in prohibited areas, for fishing during biological rest periods or for using prohibited fishing gear.

MOROCCO

- **Waste accumulation** : According to the World Bank[59], the economic cost of environmental degradation in Morocco due to poor solid waste management is estimated at nearly 0.5% of GDP.

  The difficulties relating to the collection, evacuation and disposal of household and similar waste are such that this waste is often dumped directly in landfills, in 'black spots' or in rivers, without any sort of treatment or control.

  Despite the efforts made by Morocco, waste recycling remains limited, not exceeding 10% nationally.

As for medical and pharmaceutical waste, it is estimated at 21,000 tons a year[60]. The emergence of new diseases and, in turn, of new drugs to treat them, could lead to an increase of this type of waste, requiring the adoption of appropriate mechanisms and tools.

The question of waste treatment is likely to become more of an issue in the future. As early as 2020, the volume of waste could reach 12 million tons, almost double the figure in 2014[61].

Morocco would benefit from strengthening national capacities in terms of waste treatment and recycling and making this a key sector in the development of the circular economy.

Chapter 3

CURRENT STRATEGIES

STRATEGIES AT THE GLOBAL LEVEL

Given the challenge of deterioration of natural assets, reducing the ecological footprint is, more than ever, an urgent imperative.

In addition to continuing to implement the Basel, Rotterdam and Stockholm conventions on waste and pollutants, several strategies have been adopted at the global, regional or national levels with a view to preserving and safeguarding the planet's natural resources. These strategies are introduced in this chapter which sheds light on certain initiatives by some countries.

Protecting the ozone layer: an unfinished task

It is widely accepted that actions to combat the deterioration of the ozone layer constitute a real success for the entire international community. The Montreal Protocol, signed on 16 September 1987 and ratified by 190 countries, has achieved its goal.

This multilateral decision led to the phasing out of aerosols and other domestic use cans that contained chlorofluorocarbons and constituted the main threat to the ozone layer.

At the time, the task seemed insurmountable. Although the mission is still incomplete, it should be noted that the ozone layer is recovering, and experts believe it should regain its 1980 status in 2055.

The Global Water Partnership strategy

The Global Water Partnership strategy 2014-2019 constitutes a novel solution to emerging challenges with regard to the sustainable management of water resources in a context of climate change, rapid urbanization and growing disparities. Three objectives have been set for this strategy: to catalyze change in policies and practice, to generate and communicate knowledge and to strengthen partnerships[62].

STRATEGIES AT THE GLOBAL LEVEL

The Strategic Plan for Biodiversity 2011-2020

This plan was adopted by the Parties to the Convention on Biological Diversity in Nagoya in 2010 under the auspices of the United Nations Environment Programme. The aim was to enhance and protect biodiversity and conserve the ecological services provided by ecosystems.

Recognizing the urgent need to act, the UN General Assembly also declared the 2011-2020 period the United Nations Decade on Biodiversity.

The Plan for Biological Diversity includes 5 strategic objectives, namely:

- take into account biodiversity in the implementation of public policies;
- reduce direct pressures on biodiversity and promote the sustainable use of ecosystems services;
- safeguard ecosystems, species and genetic diversity;
- restore degraded ecosystems.

The outcome of the first evaluation in 2014 showed significant progress in terms of awareness of the importance of biodiversity. It also highlighted the need to significantly step up efforts, particularly in terms of raising financial resources.

The 2011-2020 global strategy for plant conservation

This strategy falls under the UN Convention on Biodiversity which aims «to halt the continuing loss of plant diversity» in the world.

It insists on the need to make sure plant diversity is well understood, documented and recognized, that it is preserved urgently and effectively and that it is used in a way that is sustainable and equitable.

The strategy insists on promoting education and awareness about plant diversity, about their role regarding sustainable livelihood and their importance regarding all forms of life on Earth.

The capacities and public engagement needed to implement the strategy were developed[63].

STRATEGIES AT THE REGIONAL LEVEL

In Africa

Wildlife strategy

In June 2015, Africa adopted a wildlife strategy. It aims to encourage African countries to react in a concerted manner to combat illicit trade in flora and fauna. The strategy revolves around four main objectives:

- promote political commitment to protect wildlife and combat illegal exploitation;
- improve governance at the regional and inter-regional levels;
- enhance engagement with major consumer states to reduce demand, supply and transit of illegal products of wild fauna and flora;
- promote the participatory approach with economic development and community livelihoods through the sustainable use of wild fauna and flora.

Project of the Central Africa Forests Commission

This project, which concerns Cameroon, the Congo, Gabon, the Central African Republic and the Democratic Republic of Congo, has three general objectives:

- improve decision-making support tools in forest management by setting up a network of monitoring sites for forest activity as well as a database to provide useful summary information to decision-makers;
- promote scientific and technological knowledge on forest dynamics. The project aims to make a quantitative assessment of the effects of logging on the environment;
- engage stakeholders to improve management practices and set up a network of actors involved by providing assistance for the use of tools to promote new development rules, and widely disseminate the results obtained through workshops, conferences and all types of documents.

STRATEGIES AT THE REGIONAL LEVEL

In the Euro-Mediterranean region

In the Euro-Mediterranean region, and in addition to the afore-mentioned Mediterranean Strategy for Sustainable Development 2016-2025, two initiatives deserve to be mentioned: *Horizon 2020 and Innovating for Sustainable Growth: A Bioeconomy for Europe.*

The Horizon 2020 initiative

This initiative aims to promote coordination between various actors in the Mediterranean and improve activities relating to the environment. It seeks to contribute to the implementation of the Barcelona Convention to De-Pollute the Mediterranean. The initiative includes a series of projects, started since 2006, to combat pollution in the Mediterranean as well as in some countries of the region.

Innovating for Sustainable Growth: A Bioeconomy for Europe

Adopted in 2012 by the European Union under the Europe 2020 project, this strategy aims to promote an innovative economy that ensures sustainable development in agriculture and fisheries as well as the sustainable use of renewable biological resources for industrial purposes.

It targets three strategic objectives:

- To promote research and innovation in bio-economy;
- To enhance markets and competitiveness in the bioeconomy;
- To strengthen policy coordination and engage the actors concerned through the setting up of a Bioeconomy Panel and a Bioeconomy Observatory[64].

SOME COUNTRY INITIATIVES

The initiatives introduced below concern forest conservation, improving river water quality, financial incentives for environmental protection and waste recycling.

Forest conservation

Brazil – Pilot Program for the Conservation of Brazilian Rainforests

Launched jointly, in 1992, by the Brazilian government, civil society and the international community, this program aims to maximize the environmental benefits of the vast Brazilian forest and reduce deforestation.

It revolves around the following objectives:

- adoption of methods to protect rainforests in order to ensure their sustainable exploitation;
- conservation of the natural resources of tropical rainforests;
- promotion of scientific research and publication of scientific results.

The results achieved to date have made it possible to :

- protect 45.4 million hectares of indigenous territories and create 2.1 million hectares of community-managed extractive reserves;
- fund 200 community projects putting to practice new models for the conservation of tropical rainforests;
- train thousands of community leaders in combating forest fires[65].

The results achieved under this pilot program also include strong civil society involvement.

SOME COUNTRY INITIATIVES

Costa Rica : Payments for Ecosystem Services

This payment program for environmental services, implemented since 1997, consists in paying landowners to encourage them to conserve forest ecosystems and to safeguard the beauty of nature. Program funds come mainly from a national fuel tax and contributions from local businesses involved in water supply and the food sector.

It is likely that incentives to preserve forests contributed to the improvement of 26% of Costa Rica forest cover in 1983 and up to 45% in 2002. However, it is difficult to determine the impact of this program relative to other economic factors involved.

Central African Republic : the national strategy for non-wood forest products

These biological products, which are a source of income generation for some households, are being informally exploited.

To address the situation, the Central African government launched a strategy in 2012 with FAO's support to ensure profitability as well as the sustainable management of non-wood forest products, the aim being to enhance food security.

SOME COUNTRY INITIATIVES

Improving water quality

British rivers are the healthiest for 20 years

The UK has made significant efforts to rehabilitate British rivers. Several natural habitat restoration projects have been implemented. The success of the rehabilitation of part of the Thames illustrates the impact of these endeavors. Now the Thames is home to over 125 species of fish after it was declared «biologically dead» in 1950s.

The success of this project is due to a combination of strict rules to improve and preserve water quality with efforts to create the habitats needed to accommodate plants, fish and wildlife.

Financial incentives for environmental protection

California: energy efficiency via the decoupling of revenue from energy sales

The California Public Utilities Commission introduced financial incentives to protect the environment. The main innovation was to decouple energy sales from profits, defining income public utilities can collect in advance from customers. Under this scheme, distribution companies are not under pressure to sell more energy to customers, but rather to secure financial returns offered by the regulator to reward them for efforts with customers to make them reduce their energy consumption.

Improvements in energy efficiency at customer level are achieved through direct investment efforts by electricity companies.

This model could be extended to water resources and other public services that are provided by private companies.

SOME COUNTRY INITIATIVES

Management and treatment of waste and residue

Capannori, the Zero Waste Municipality

This small town, located in the Tuscany region is a pioneer in waste reduction. In the late 1990s, after the refusal to build an expensive incinerator which was also going to be harmful to health, people in Capannori, supported by the municipality, decided to deeply transform the way they generated and treated waste at source. Thus, between 2004 and 2013, the city managed to reduce by 40% the generation of household and similar waste.

The strategy used in Capannori was to combine traditional approaches with new ideas: door to door collecting to promote source separation, establishment of incentive pricing to encourage waste recovery (recycling and composting) and, finally, widespread reuse within the community, and the opening of several centers to recover and repair textiles, furniture, bicycles and used electrical appliances.

Spain: European leader in the management of waste oils

In 2007, Spain set up a not-for-profit organization which holds a 90% share in the market for the re-refining of waste oils.

Using an extensive collection network, this organization is in charge of the whole process: from recovery to the final processing of waste oils across the country. It is financed through contributions by manufacturers, in the form of a tax on lubricants sold on the Spanish market.

Through the establishment of an integrated waste oil management system, economic gains were made possible, especially with respect to the use of raw materials, such as oil, and environmental preservation has been promoted by reducing discharges and GHG emissions[66].

NATIONAL STRATEGIES

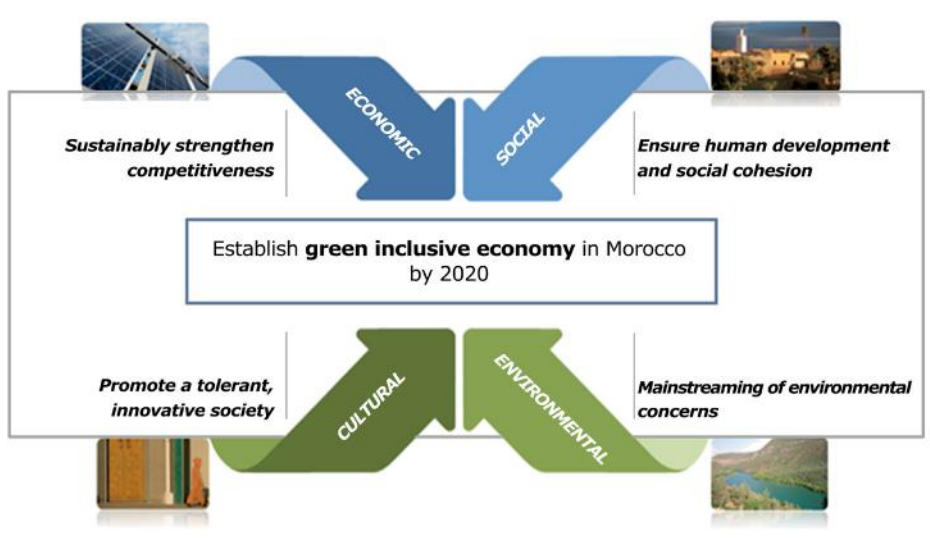
The strategic decisions made by Morocco are in line with the requirements of sustainability and the preservation of environmental balances. The implementation of these decisions, in a context of climate change and rapid urbanization (close to 69% of Morocco's population in 2050, according to the High Commissioner for Planning), calls for significant financial resources that are commensurate with the scope of these projects.

The Speech delivered by His Majesty The King Mohammed VI to the nation on the occasion of the 10th Throne Day announced the development of a national environmental charter to protect "the country's natural resources and nature reserves as part of a sustainable development policy".

The framework law for the implementation of this national charter includes:

- a frame of reference to streamline state action with regard to environmental action and sustainable development;
- public policy guidelines;
- a contribution towards mainstreaming environmental concerns into all public policies,

National Sustainable Development Strategy



NATIONAL STRATEGIES

Morocco has launched several programs to promote environmental protection, including:

The national program for liquid sanitation and wastewater treatment

It aims to bring the connection rate to the sewerage network in urban areas to 100% in 2030 and the wastewater treatment rate to 60% in 2020 and 100% in 2030.

Among the program's achievements, up to the end of 2014, is the increase to 90% in the rate of connection to the liquid sanitation network in urban areas. The wastewater treatment rate stood at 39%, against 8% in 2005.

The national program for the management of household and similar waste

It aims to bring the professional collection rate to 90% in 2022 and the recycling rate to 20%.

Among the program's achievements, up to the end of 2013, is an increase to 85% in the collection rate, against 44% in 2008, the development of 22 landfills and recycling centers, i.e. a 53% handling capacity for household and similar waste, and the rehabilitation of 25 uncontrolled landfills.

The national waste recycling program

It aims to promote integrated, sustainable waste management, to organize waste recycling and recovery streams, to reduce resource wastage, to minimize human and industrial impacts, to promote investment and to create jobs. Several value chains are being developed under this program, including those relating to batteries, tires, paper and cardboard, waste, including plastic waste...

Banning plastic bags

Morocco has adopted legislation prohibiting, as of 1st July 2016, the manufacturing, import, marketing and use of plastic bags.

«Zero Mika» operation

This civil society-led initiative was launched in June 2016, through an awareness-raising campaign, via the national media, to draw attention to the negative effects of plastic waste on health and the environment. The second phase consisted in a plastic waste collection operation across the country.

NATIONAL STRATEGIES

The 2009-2020 Halieutis Plan

In addition to continuing the practice of biological recovery period to promote the reproduction of fish stocks, Morocco started implementing the *Halieutis Plan* in 2009. The aim is to ensure resource sustainability, to ensure optimum product quality and to build the sector's competitiveness on solid foundations, through optimal development of fishery resources.

The *Halieutis Plan* also provides for the development of aquaculture to achieve 200,000 tons per year by 2020, or 11% of fisheries production[67], compared to an insignificant rate today. However, to enable this sector to grow quickly, sustainable farming methods are needed to mitigate adverse effects on the marine environment, including eutrophication due to fish excrement.

The 2015-2024 forest program

This program targets the following objectives:

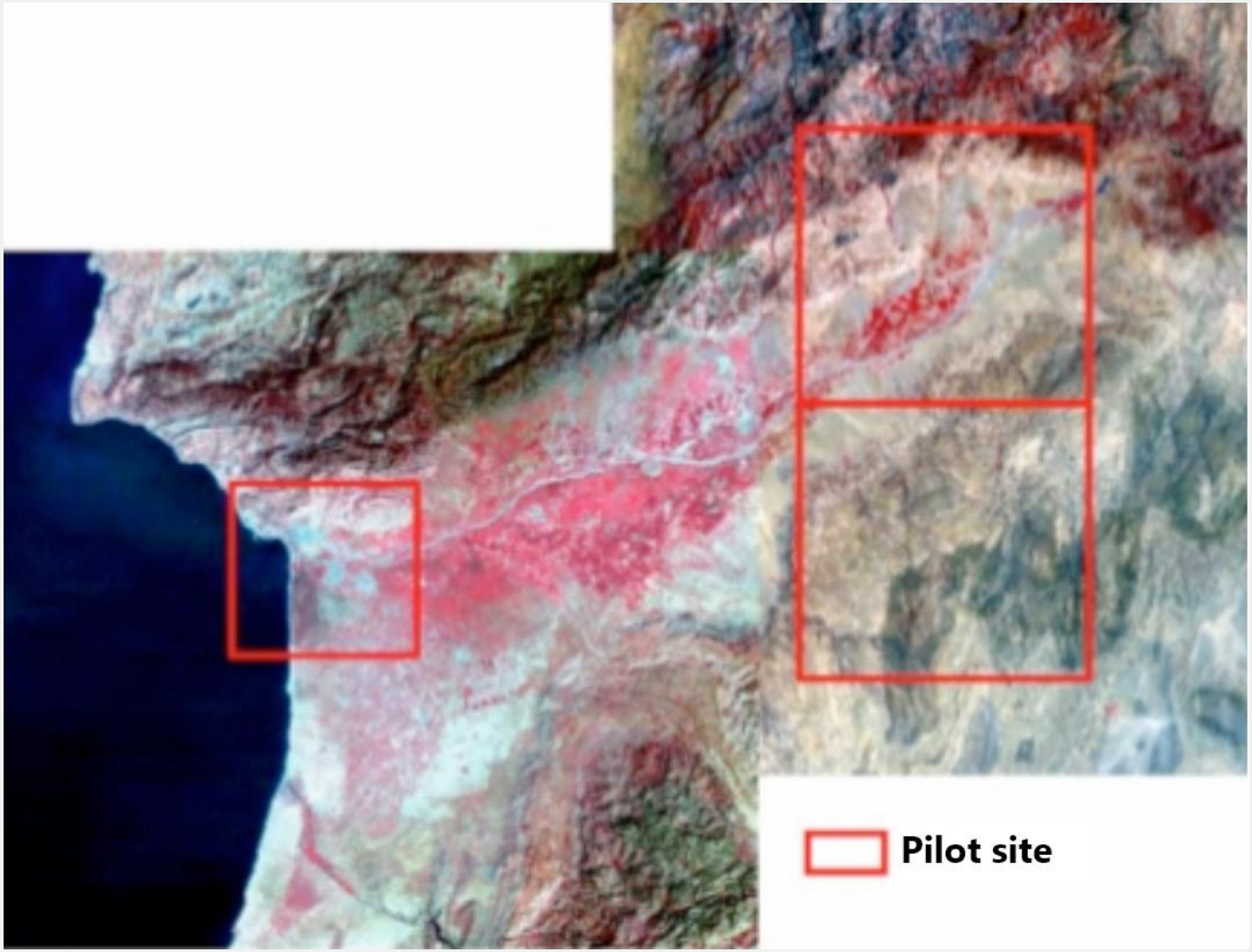
- the restoration of forest ecosystems (reforestation, forest regeneration, forest-pasture development);
- the fight against desertification and sand encroachment; sand dune fixation and watershed development;
- conservation and promotion of biodiversity,
- the fight against fires;
- the economic valuation of forest ecosystem goods and services;
- support for governance.

The development of remote sensing

It allows regular observation of the territory, the monitoring of space and time evolution and impact assessment. It provides relevant, recurrent information on the management of natural resources. In Morocco it is used in connection with the management of:

- **agricultural resources**, through the development of land-use maps, the assessment of the impacts of urbanization on agricultural land, control of rural housing ...
- **forestry and forest-pastoral resources**, through the monitoring of space and time changes in forest areas and the forecasting of forest fires at national and / or local levels
- **marine and coastal areas**, through the definition and monitoring of upwelling, the identification of areas suitable for aquaculture and coastal zone mapping.

Integrated water resource management in the Souss-Massa basin



Source : The Royal Centre for Remote Sensing (CRTS), Morocco

CONCLUSION OF PART 2

The degradation of the biosphere is caused by the overexploitation of resources and also by pollution, through untreated releases.

The planet has a certain resilience that allows it to absorb toxins through degradation of matter and adaptation of the habitat to the changes affecting it.

However, beyond a certain threshold and pace of change, ecosystems are no longer able to adapt. That is when **chain reactions** are triggered. They accelerate the disruption of the entire biosphere, with the risk of mass extinction of living species and the total disappearance of certain resources.

The «boiling frog syndrome» shows the low reactivity of humans to issues developing over a long period of time. But the latter's remarkable biological adaptation ability does not apply to the artificial systems they create: urban systems, production systems, transport, governance and trade systems...etc.

At the dawn of this 21st century, humanity stands at a crossroads:

- either it opts for the artificial development of the universe surrounding it and of its organism, as suggested by transhumanism, at the expense of nature, and in that case it must be prepared to use its space environment: the solar system,
- or it decides, now, to change its modes of production and consumption and establish a new relationship with its natural environment: the biosphere that gives it life.

Whether a choice is made or not, change will take place during this century because of the seriousness of the situation and the multiple impacts involved - all of which mean inaction is not an option.

The more we wait, the quicker and more drastic the changes will be, and a significant part of humanity will be left on the sidelines.

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Part 3

TOWARDS AN EFFECTIVE ADAPTATION AND ANTICIPATION STRATEGY

SUMMARY OF PART 3

INTRODUCTION

The first part of this 2017 Panorama was devoted to **climate change**. The second part concerned the **ecological footprint**, a little-known question about which the lack of scientific research on a global scale is quite obvious, as evidenced by the difficulty to obtain comprehensive, prospective data.

The third part aims to combine prospective ideas with strategic guidelines to inform the action of policy-makers and that of stakeholders in general.

The purpose is to show that an **integrated approach to climate change and the ecological footprint** is the only approach likely to help face up to the magnitude of changes underway.

Two chapters make up this part:

- The first explains the different **worldviews** that reflect concepts such as sustainable development and the blue economy.
- The second, through the **food situation**, underscores the inevitable interdependence of public policy in dealing with this nexus.

Chapter 1

WORLDVIEWS

IS THE ANTHROPOCENE UNDER CONTROL?

In two centuries, the scale of human activity, especially in the industrial sector, and technological power have made mankind a major «geological» force in the planet, that is to say one that is capable of geologically transforming the biosphere. This is the **Anthropocene Age**.

The reference here is to a **radical break** whose full consequences are hard to fathom at this stage: an impoverished and artificialized atmosphere imbued with synthetic chemical molecules which adversely affects health, probably fertility as well. A warmer biosphere, with higher seas, disrupted and unstable climates and reduced biodiversity. A world over which risks, not to say disasters, are looming.

The concept Anthropocene rallies scientists studying different Earth systems, researchers involved in environmental humanities (philosophy, history, anthropology ...) and actors involved in socio-ecological fields who **think together about this age in which humanity has become a major geological force, causing a profound and comprehensive ecological crisis**[1].

Therefore, the degradation of the biosphere is not an environmental crisis from which humanity could recover through a «back to normal» scenario. This is a **planet-wide human-induced geological mutation**. There are no turning back prospects in the coming decades, or even a possibility to rapidly stop the spread of the phenomenon, given the profound changes that would be required in production and consumption patterns.

It is possible, however, to **avoid worsening** the situation exponentially and to mitigate damage, especially that caused to the poorest populations, who are also the hardest-hit.

IS THE ANTHROPOCENE UNDER CONTROL?

For that to happen, we must stop believing that the Anthropocene is a normal, natural or purely physical evolution of the biosphere. We must be aware of the historical and human dimension of this phenomenon. In fact, it is the natural result of the **choices made** and of the policies and lifestyles adopted.

These choices have not always been as rational as they may seem. Thus, the history of energy use is not one of transition from one energy source to another, but of accumulation of several new primary energy sources[2] that ultimately **hamper progress toward alternative sources of abundant, clean energy**.

Moreover, the enthusiasm for hi-tech products imposed sometimes illogical choices at the expense of **low-tech solutions** that are just as effective but less harmful to the biosphere.

Finally, 20th century (mass) consumption, together with the relinquishing of traditional recycling practices deemed obsolete, is altering the cycle of matter. Concrete, plastics and various composite materials are permanently embedded in the biosphere, and their **particles contaminate living beings**.

Il est plus It is high time long-term strategies were adopted - **remedial as well as preventive ones** – to help humans forge a **new relationship with nature**.

SOME BASIC CONCEPTS

Introduction : General principles

According to the Stockholm Resilience Centre, there are nine «planetary boundaries», beyond which the systems that support life on earth could collapse. Four of these planetary boundaries may have already been reached: climate change, loss of biosphere integrity, land system change, and biogeochemical cycles (phosphorus and nitrogen). Hence the need to develop a worldview that reliably underpins public and private policies.

By the end of WWII, growing awareness of environmental degradation emerged. New schools of thought began to take shape, advocating a new, more balanced relationship with nature[3].

Following the success of the concept of «sustainable development» in the 1990s and the feeling that its implementation has been limited, new visions for alternative development models have emerged, which are more inclusive and precise in terms of implementation, and are also free from political bias.

They have in common a desire to seek better ways to reconcile economic and social development, on one hand, and respect for the biosphere, on the other. Preservation, restoration and sustainable use are the three conditions for preservation of the biosphere.

At the global level, the commitment of the various stakeholders concerned led them to support the new United Nations global program (2015-2030) «Transforming Our World: The 2030 Agenda for Sustainable Development».

17 Sustainable Development Goals

1 «End poverty in all its forms everywhere,
2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3 Ensure healthy lives and promote well-being for all at all ages,
4 Ensure inclusive and quality education for all and promote lifelong learning,
5 Achieve gender equality and empower all women and girls,
6 Ensure access to water and sanitation for all as well as sustainable management of water reources,
7 Ensure access to affordable, reliable, sustainable and modern energy for all,
8 Promote inclusive and sustainable economic growth, employment and decent work for all,
9 Build resilient infrastructure, promote sustainable industrialization and foster innovation,
10 Reduce inequality within and among countries,
11 Make cities inclusive, safe, resilient and sustainable,
12 Ensure sustainable consumption and production patterns,
13 Take urgent action to combat climate change and its impacts,
14 Conserve and sustainably use the oceans, seas and marine resources to achieve sustainable development,
15 Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss,
16 Promote just, peaceful and inclusive societies for sustainable development, the provision of access to justice for all, and building effective, accountable institutions at all levels
17 Revitalize the global partnership for sustainable development»

Source : United Nations Development Program)

SOME BASIC CONCEPTS

Sustainable dvelopment : it is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[4].

There is a problem with the notion of 'needs'. Today, indeed, needs vary according to culture and the extent of vulnerability. But what about needs tomorrow?

However, this concept has the advantage of showing the interdependence that exists between the economy, society and the environment (the three «pillars») and of demonstrating the unsustainability of the current development model, given the planet's biocapacity. However, the vagueness of this concept makes it difficult to implement, and its political and marketing exploitation has led to «greenwashing».

Green economy: it is sometimes considered as the actual implementation of sustainable development; in fact, it mainly concerns promotion of waste treatment and pollution control.

Zero growth: «infinite growth in a finite world being impossible, all economic activities should aim at a stable state of equilibrium»[5].

Based on a systems approach that highlighting the close interdependence between the components of the world system, this concept advocates strong regulations as the only means to sustain economic progress while preserving natural resources:

- rigorous birth control to limit population growth,
- control of production volumes to avoid over-supply.
- pollution control and fight against wastage ...

This approach is criticized for two reasons:

- the development aspirations of the countries of the South are not taken into account,
- it is impossible to implement this program in countries where the number of unemployed people will increase as a result of aging or birth rates, and in countries where the number of unemployed will increase due to automation.

SOME BASIC CONCEPTS

Circular economy: It is a restorative industrial economy in which material flows are two distinct types[6]:

- biological nutrients meant to safely return to the biosphere, provided their volume can be absorbed,
- technical entrants, meant to be continuously recycled while remaining at a high level of quality, without going into the biosphere.

This approach has the advantage of clearly reorganizing activities (recycling) and of promoting recovery (secondhand market); it can be immediately applied, which is already the case in some countries.

Since it does not question industrial growth, it may not be radical enough to initiate an overhaul of the economic system.

Blue economy: Inspired by nature (biomimetics), its aim is to forge a new business model, using a minimum of natural resources and a maximum of the local resources available[7].

This new «blue» paradigm is to be compared with the current industrial model (red) and that of sustainable development (green), which is deemed insufficient and superficial. It involves a full re-engineering of activities to avoid wastage, to reuse waste in order to generate new products and to promote local development.

It aims to produce healthier, more affordable products for all (accessibility), which are also more environment-friendly.

It is based on an attractive holistic approach:

- resorting to traditions, cultures and local know-how;
- considering water, air and soil as common assets;
- adaptation and change seen as operating principles of an ecosystem economy.

SOME BASIC CONCEPTS

Collaborative economy[8] : Under this economic model, human activity revolves around the collective production of value and is based on new forms of organization: horizontal, mutual (sharing), community (networks) that are often backed by internet platforms.

This is a radical perception of development that includes, in particular, circular economy and economy at zero marginal cost[9]. Labor, production, consumption and mobility are reorganized from a proximity and sharing perspective, emphasizing access rather than ownership. Thus, the same number of objects is useful to more people, thus reducing pressure on the environment.

The rise of carpooling, couchsurfing, crowfunding, coworking or fablabs, not to mention knowledge communities (e.g. Wikipedia) shows how widespread this model has become.

However, critics have pointed out a number of soft spots:

- trust and respect are core elements of sharing, but social tensions are undermining them,
- the crisis has created certain windfall situations which are likely to disappear, with a return to growth (local agriculture for example).
- its mode of financing, for the time being, reproduces the capitalist model (BlaBlaCar, Uber), although other approaches are being developed, such as cooperatives platforms.

Conclusion

For half a century, a new vision has been taking shape, through different currents of thought and basic references.

After having been first general and sector-specific, the latter have become increasingly inclusive, comprehensive and systemic. Action has become the main concern. “How” has replaced “Why?”.

This vision heralds the end of a crude form of capitalism, centered on money as a commodity (speculation) and ever yawning gaps.

It reflects an enduring desire for a world where there is more equality and empathy – a world in which life means more than just unbridled consumerism. Beyond keen awareness of the environmental situation, it involves an acute sense of urgency in the face of sluggishness by many governments: citizens, businesses and various social groups are taking their destiny into their own hands and want to influence the future of the planet[10].

Based on this vision, a final, decisive approach needs to be developed that takes into account all of the above concepts: the sustainability of development, waste management and pollution control, smart monitoring of activities that are harmful to the biosphere, implementing recyclability, drawing inspiration from nature to promote smarter processes, encouraging local approaches, proximity and low-tech solutions, frugal innovation, mutualization, sharing ...

KEY STRATEGIC FACTORS

- **Working together** : across-the-board stakeholder awareness is necessary because combating climate change and halting the degradation of the biosphere do not concern public authorities alone.
  - Whereas the private sector is mobilized concerning mitigation, a business plan is yet to be developed as far as adaptation is concerned. Among the questions that are yet to be answered: how to make adaptation projects attractive to private businesses? What governance should be put in place? What barriers need to be removed to ensure the implementation of adaptation projects? Who will bear the cost of resilience?
  - Costs and insurance for climate change risks have been rapidly increasing in the past 30 years. What needs to be done to reduce those costs while expanding coverage to all risks?
  - While public authorities focus on physical impacts and biophysical vulnerability at national and sectoral levels, non-governmental organizations take greater interest in socio-economic and environmental considerations as well as social vulnerability at regional and local levels.

→ Partnerships – including public-private partnerships – coordination and, more generally, governance of biosphere reparation require special attention as well as an inclusive, systemic approach to simultaneously take into account the ecological, scientific, institutional, economic, social dimensions.

- **Better knowledge** : Both scientific (planetary weather system, oceanic mechanisms) and statistical (biodiversity, at-risk populations); knowledge must be quickly and significantly improved to better understand current as well as future changes (anticipation).
  - The IPCC report on adaptation, expected in 2018, could make up for the **lack of scientific data** on this issue and on sectors which must be given priority;
  - **Vulnerability studies** on climate change and the degradation of the biosphere should also be undertaken to help determine priorities;
  - Innovation is also part of R&D and needs to be accelerated, particularly **frugal innovation** which is accessible to the poorest countries.

→ Therefore, it is imperative to promote the development and sharing of knowledge with all countries. Priority research programs should be decided and funded globally. Prospective reflection should be fostered.

KEY STRATEGIC FACTORS

- **To adapt**: As we face the degradation of the biosphere as well as climate change, the first thing to do is to adapt, pending possible mitigation or improvement:
  - To adapt means to reduce current and future damage by revisiting procedures and changing practices and structures. Ideally, countries could benefit from opportunities created by the new situation;
  - Above all, this involves a state of mind to be shaped through educational programs for all age brackets, taking into account the cultural background.

Three types of adaptation measures[11] are listed hereunder:

- **Anticipatory adaptation**: this process is started before environmental and climate change impacts are visible.
- **Autonomous (or spontaneous) adaptation**: it results from ecological changes in natural systems, or from changes in market conditions or from the state of well-being in humans, according to the IPCC.
- **Planned adaptation**: it results from a conscious policy decision based on a clear determination that conditions have changed or are about to change, and that measures should be taken to achieve a particular goal, according to the IPCC.

- **Anticipate** : There are no natural disasters: disasters only results from human unpreparedness for natural events[12]. Hence the need for greater awareness of the risks involved:
  - **Risk anticipation**: the ability to detect advance warning signs (tsunamis sensors for example) or modeling to allow for fairly reliable prediction (meteorology).
  - **Risk assessment**: good knowledge about areas and communities that could potentially be impacted and assessment of direct and collateral damage.
  - **Proactive and systematic risk management** to increase resilience, minimize crises and turn risk management into development opportunities[13].

Anticipation is demanding by nature: it requires measures to be taken although the event has not occurred yet. This probably explains why it is only rarely taken into account although we know what the consequences are:

- reckless land planning (urban development in flood-prone areas);
- inadequate preparedness of reaction forces (police, emergency units, hospitals ...);
- deforestation for biofuel development purposes...

Chapter 2

FEEDING THE PLANET

ISSUE AT STAKE

To better understand what this new worldview represents and how to implement it, we have decided to address the food issue.

This issue is more complex than it seems: feeding hungry people today and produce food for those who will be born in the coming decades will certainly accelerate the degradation of the biosphere (soil, water, air), ultimately spelling doom for humanity. To address this paradoxical situation, with almost 25% of arable land in a degraded state, FAO estimates that:

- to feed a population of 9 billion people by 2050, an additional 1 billion tons of agricultural produce and 200 million tons of animal products are needed;
- improving soil fertility and agricultural productivity require investments of about 750 billion euros by 2050 for irrigation, and 120 billion euros for land reclamation and soil conservation.

Furthermore, it is imperative to combat wastage. According to FAO, up to one third of all food in the world is spoiled or squandered before it is consumed by people. This represents 1.3 billion tons per year for a value of around 1,000 billion dollars[14].

Source : https://news.mongabay.com/wp-content/uploads/sites/20/2015/11/1117-cookingfire1200.jpg

→ Think in systemic ways and identify regionalized solutions tailored to the local context and implemented as closely as possible to the field (subsidiarity)

STRATEGIES

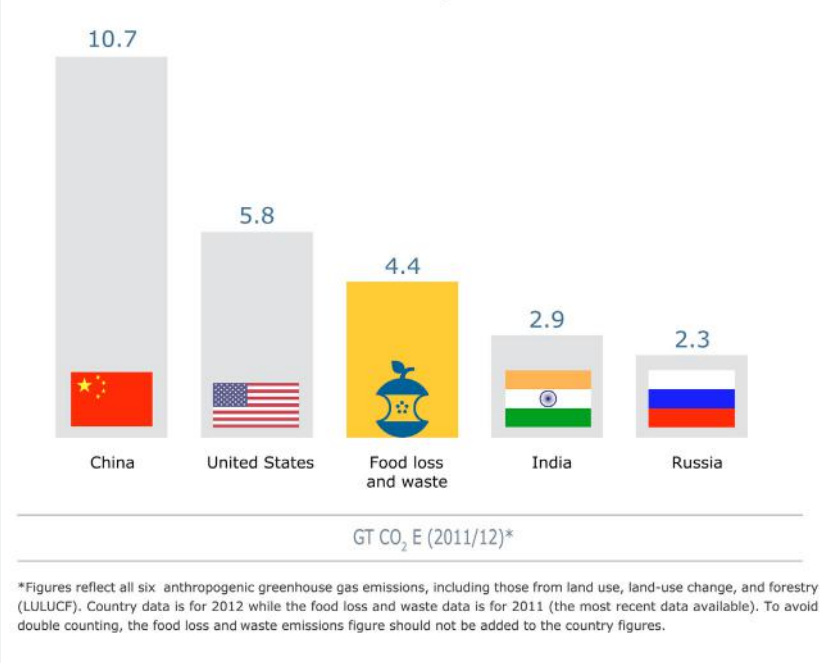
Food production (agriculture, fisheries, livestock), which involves no transformation of production areas, alters the biosphere only if it takes place on fragile areas, such as the soil of tropical forests. It contributes to accelerated deforestation because cleared areas can be productive only for a short period of time (shifting cultivation), hence the need to:

- use remote sensing or local coring to identify the most suitable land for agriculture, re-register land, to lease identified land to farmers' cooperatives, subject to respecting an ecological charter as far as production, irrigation and storage are concerned;
- secure the process through blockchain[15] and monitor charter compliance through spatial imagery and random physical checks.

In any case, it is necessary to:

- reorganize the supply and distribution channels to encourage proximity (urban structure)
- ensure pooling of waste collection and developing waste treatment to obtain by-products (compost ...)
- provide training on new approaches: ecological agriculture, choice of species, drip irrigation ... based on an assessment of current processes.

If food loss and waste were its own country, it would be the third-largest greenhouse gas emitter



Source : CAIT. 2015 ; FAO.2015. Food wastage footprint & climate change. Rome : FAO ; Nature. Waste production must peak this century, Daniel Hoornweg, Perinaz Bhada-Tata & Chris Kennedy, 2013

STRATEGIES

Industrialized agricultural production concerns agriculture, livestock and fisheries. Its contribution to biosphere alteration is particularly diverse:

- **The «land-grabbing» phenomenon** can involve abrupt, large-scale transitions in local ecosystems[16]. Food crops represent 25% of all acquired land in the world. But in Africa, only 13% of acquired land is for food production[17];
- Overexploitation of fishery resources, including excessive use of water resources, soil and groundwater contamination by man-made products, contamination of bees and insects by pesticides, contributions to $C0_2$ and methane emissions, hydrocarbon consumption, waste generation, particularly plasticulture, contribute to environmental degradation resulting from agricultural activities. We should add to this list the substances contaminating humans directly, such as drug residues (antibiotics).

To address this situation, the following strategies can be considered:

- implementing – through labels, exemptions and subsidies – a policy to promote the development of **ecologically intensive agriculture**[18] in very small-scale farms, riding the locavore trend, would eventually compel larger firms to follow suit;
- enforce **drastic measures to protect endangered species** in the oceans and on land;
- impose, at global level, a number of hectares per country to be devoted to **food production**, regardless of land ownership, in light of demographic forecasts;
- promote broad-based development and train farmers on new modes of agriculture for the future, including **Climate-Smart Agriculture**[19].

STRATEGIES

The **distribution network**, including storage of food supplies before processing should be revised: in developing countries 40% of losses occur at post-harvest and processing[20].

Several actions should be undertaken, especially in developing countries:

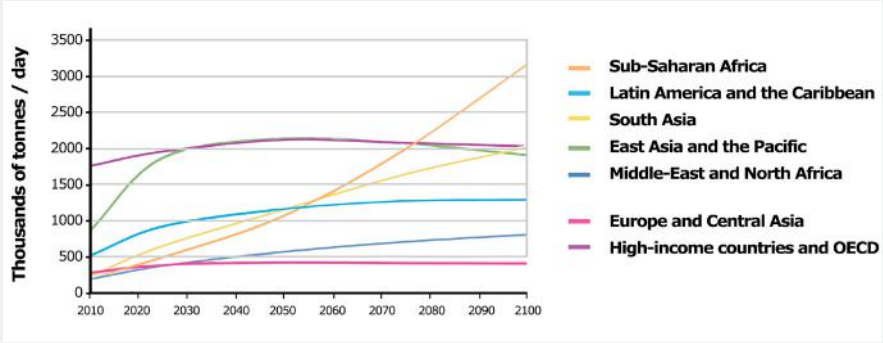
- Speed up research in **conservation technology**, such as pulsed electric fields[21]. where the cold chain cannot be maintained;
- Develop **rodent-proof silo construction techniques** and natural humidity management systems (ventilation) to combat crop decay.
- Organize **storage cooperatives** to promote crop circulation and the monitoring of silos, and improve the latter through the use of solar collectors, applications for mobile phones...
- **Bring food production areas close to consumption zones** and encourage consumers themselves to do the harvesting.

The cooking and processing of agricultural products are a source of both CO_2 emissions, including cooking with wood and charcoal, waste generation (waste water, organic matter), energy consumption and overconsumption of various products such as salt, sugar, fat ... The following should therefore be encouraged:

- ensure the widespread use of solar ovens;
- organize networks for the collection and treatment of organic waste to make compost and cattle feed, and ensure wastewater treatment;
- Review additive standards so as to curb their use and reduce their adverse impacts on both ecosystems and human health.

Municipal solid waste generation by region 2010-2100

Scenario : Business as usual



Source : Nature. Waste production must peak this century, Daniel Hoornweg, Perinaz Bhada-Tata & Chris Kennedy, 2013 _ IRES reprocessing

STRATEGIES

There are three problems with current food **consumption** patterns :

- the exorbitant volume of waste and food waste;
- nutritional imbalance for the majority of the population (obesity and malnutrition) and unequal access to the right nutrients;
- the unsustainable growth of meat consumption in the world, given the high ecological cost of each kilogram of meat produced.

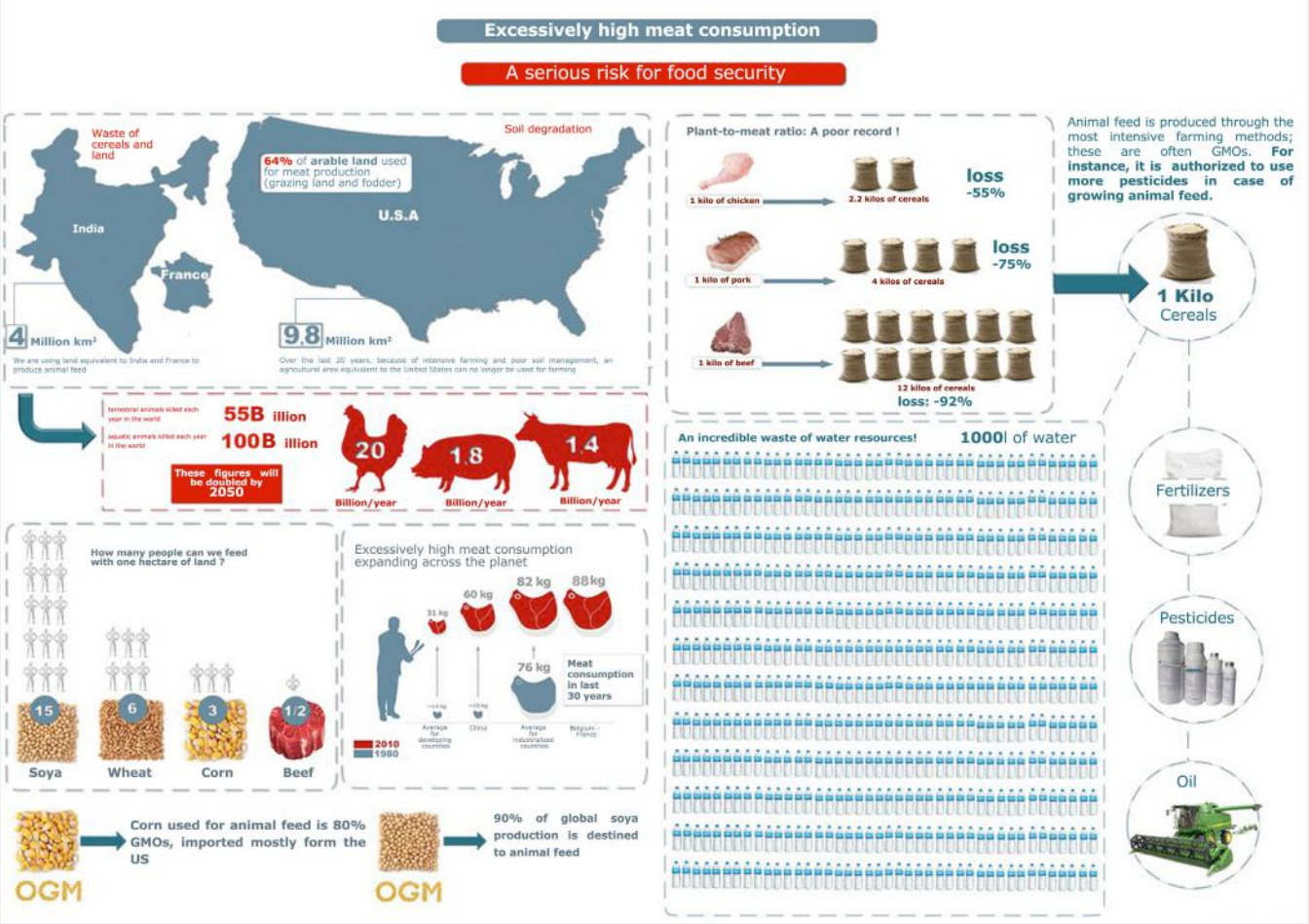
A global strategy should seek to:

- develop the **circular economy** to recycle waste while levying charges on their production (packaging for instance) at industrial and individual levels;
- promote **short circuits and local production** to reduce costs and ensure better nutritional quality;
- develop and promote a food mode that fosters **brain development** rather than muscle development (less meat, less fat, less sweets) and use biochemical knowledge (digestion, nutrition) in agronomy;
- **penalize** the suppliers and **consumers** of endangered species
- develop **urban agriculture** since 80% of the world population will live in the city by 2050: aeroponics farms, green roofs, community gardens, urban farms in brownfields ...

STRATEGIES

In 2030, demand for animal products could be, as is the case now, at the origin of over 80% of food-related greenhouse gas emissions[22].

Demand for vegetable food products would account for 15% of food-related emissions in 2030.



Source : F.Derzelle 's graphism, Végétik _ IRES reprocessing

FOCUS ON AGRICULTURE FOR THE FUTURE

Climate-Smart Agriculture

It reflects an approach to achieving agricultural development priorities in a context of climate change. The aim is to increase productivity sustainably while strengthening resilience regarding key aspects in the livelihoods of rural households. The implementation of a smart agriculture policy is determined by the context and specific capabilities of each country.

The Global Alliance for Climate-Smart Agriculture was set up in 2014 during the United Nations Climate Summit to assist stakeholders in the implementation of smart agriculture strategies. It has some sixty members, including 22 countries, like Switzerland, France, the United Kingdom, the United States, Canada ..., in addition to international organizations, research centers and private companies.

The digital agriculture

Profound concerns regarding current issues are inducing countries to adopt innovative solutions that take into account the future of the planet. The digital agriculture is one of those solutions. Indeed, robots, sensors, drones ... are now being used in the agricultural sector. As part of its vision of agriculture for the future, Australia, for instance, has been using the digital technology in agriculture; it unveiled its first agricultural robot in 2014, called «ladybird». This robot monitors the growth of fruits and vegetables as well as the presence of pests. It is fully autonomous and runs on solar energy. Equipped with a robotic arm, this robotic ladybug can also remove weeds and is also expected to help with harvesting.

Digital Agriculture

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GENERAL CONCLUSION

The degradation of the Earth's biosphere due to climate change, overexploitation of natural resources and pollution is such today that we must ask the **question regarding conditions for the survival of mankind**.

Two major disruption factors have appeared: the release of methane into the atmosphere and mass extinction risks in the ocean.

Despite growing awareness and the adoption of major global objectives, the implementation of regional and national **measures** is still **too slow** and **ineffective**.

Three reasons best explain this situation:

- the **great complexity of natural systems** which are not yet fully understood;
- the growing gap between humans and nature due to an **increasingly urbanized and technological world**;
- **population growth** and access, by a large segment of the world population, to a lifestyle which is incompatible with the frugality required.

It is therefore time to act and to implement **concerted actions** at the global level (between countries and regions) and at local level (between different levels of governance), laying emphasis on **subsidiarity** to address problems at the most appropriate scale.

Since it is impossible to address all problems at once, **prioritization** is necessary, building on a **systemic vision** of all factors of change (urgent and correlated) and taking into account the **vulnerability** of the populations concerned – be they human, animal or plant. This vision must be clearly and quickly developed.

International awareness of the **urgency of the climate change situation** is a major step towards adopting a mitigation and adaptation policy commensurate with the stakes involved. But focusing on energy and the climate at the expense of all other factors which contribute to the degradation of the biosphere is a risk we must vigorously seek to eliminate.

Restoring the balance of the biosphere will not happen without developing a new mindset, including a radical break with the predatory attitude of humans vis-a-vis the environment. In fact, the entire **relationship with nature** needs to be revisited.

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