

## LEARNING UNIT PLAN

Title		SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE	
Learning number	unit	5	Duration 1h

General objective	To learn the basics of the sustainable development goals, the role of people, the planetary boundaries, the value of renewable energy, sustainable consumption and climate change endeavours.
Specific objectives	<ol style="list-style-type: none"> <li>1. To understand the basics of sustainable development</li> <li>2. To learn how we measure economic development and how it varies around the world</li> <li>3. To learn about sustainable food supply and the end of hunger</li> <li>4. To learn about sustainable cities</li> <li>5. To learn about curbing climate change</li> <li>6. To learn about saving biodiversity</li> </ol>
<p>Learning outcomes (at least 2 of each): Knowledge, Skills, Responsibility and Autonomy</p> <p>(see Bloom's Taxonomy Action Verbs- Annex)</p>	<p><b>1. Introduction to sustainable development</b></p> <p><b>Knowledge:</b></p> <ul style="list-style-type: none"> <li>○ to understand the sustainable development approach</li> <li>○ to distinguish between sustainable growth patterns and business-as-usual growth patterns</li> <li>○ to identify the consequences of business-as-usual patterns on the environment and society</li> </ul> <p><b>Skills:</b></p> <ul style="list-style-type: none"> <li>○ to define the Sustainable Development Goals</li> <li>○ to identify global poverty regions</li> </ul> <p><b>Responsibility and Autonomy:</b></p> <ul style="list-style-type: none"> <li>○ to articulate and summarize the sustainable development approach</li> </ul> <p><b>2. Economic Development – How We Measure It, How It Varies Around the World</b></p> <p><b>Knowledge:</b></p> <ul style="list-style-type: none"> <li>○ to understand standard ways of measuring income and economic growth and progress globally</li> </ul> <p><b>Skills:</b></p>

- to distinguish between patterns of urban versus rural economic growth

**Responsibility and Autonomy:**

- to critical analyse the GDP as a metric of economic success in a sustainable development framework
- to identify the driving factors behind urban migration

**3. Sustainable Food Supply and the End of Hunger**

**Knowledge:**

- to understand the complex concept of malnutrition in a global context
- to understand the relationship between climate change and food systems

**Skills:**

- to illustrate and use key indicators of malnutrition, including stunting, wasting, and obesity

**Responsibility and Autonomy:**

- to interpret the link between agriculture as driver of climate change and climate change as a threat to food systems

**4. Sustainable Cities**

**Knowledge:**

- to identify the factors driving urbanization and its consequences

**Skills:**

- to relate the consequences of the factors driving urbanization

**Responsibility and Autonomy:**

- to justify the relation between the key sectors central to making cities more sustainable

**5. Curbing Climate Change**

**Knowledge:**

- to identify the human factors driving climate change

**Skills:**

- to illustrate and relate the mechanisms behind anthropogenic climate change

**Responsibility and Autonomy:**

- to identify the key greenhouse gases and their sources and lifespans

## **6. Saving Biodiversity**

### **Knowledge:**

- to define "biodiversity" and "ecosystem services"

### **Skills:**

- to illustrate and relate how the terrestrial ecosystems works

### **Responsibility and Autonomy:**

- to identify the human factors driving the sixth extinction

## Learning unit summary (abstract – half a page)

Sustainable development is the most urgent challenge facing humanity. Its fundamental question is: How can the world economy continue to develop in a way that is socially inclusive and environmentally sustainable?

This course provides a broad overview of the interactions between the economy and our environment and humanity, from the constraints of finite resources, to the activities that drive climate change.

This course is also for anyone new to the concept of sustainable development who wants to understand its foundations and its relevance to their life and work. It is useful also for practitioners - as well as private-sector actors, such as those who work in corporate sustainability and responsibility - who want a concise overview of the latest developments in the field.

## List of resources, tools and methods<sup>1</sup>

### Chapter1: Introduction to Sustainable Development

- Sachs, Jeffrey D. The Age of Sustainable Development
- December 2012 Draft Framework for Sustainable Development, UN Sustainable Development Solutions Network
- the United Nations' 2030 Agenda for Sustainable Development, adopted September 25, 2015

<sup>1</sup> Example: videos; ppt; exercises; check list; case study; etc

- Presentation on Realizing the Future We Want for All, UN System Task Team on the Post-2015 Development Agenda
- Our Common Vision of The Future We Want outcome document of the Rio+20 Conference
- Executive Summary of a New Global Partnership: Eradicate Poverty and Transform Economies Through Sustainable Development, The Secretary General's High-Level Panel of Eminent Persons on the Post-2015 Development Agenda.
- A life of dignity for all: accelerating progress towards the Millennium Development Goals and advancing the United Nations development agenda beyond 2015, Report of the UN Secretary General

#### Chapter 2: Economic Development

- Maddison, Angus. The World Economy
- Sachs, Jeffrey D. The End of Poverty
- Gallup, John, Andrew Mellinger and Jeffrey D. Sachs, "Climate, Coastal Proximity, and Development, Oxford University Press, 2000

#### Chapter 3: Sustainable Food Supply and the End of Hunger

- Halving Hunger: It Can Be Done. UN Millennium Project Hunger Task Force
- Opportunities and Solutions for Sustainable Food Production. UN Sustainable Development Solutions Network Thematic Group on Sustainable Agriculture and Food Systems

#### Chapter 4: Sustainable Cities

- The Urban Opportunity: Enabling Transformative and Sustainable Development. UN Sustainable Development Solutions Network Thematic Group on Sustainable Cities
- Sustainable Urbanization. UN Task Team on the Post-2015 Development Agenda

#### Chapter 5: Curbing Climate Change

- Summary for Policymakers. Intergovernmental Panel on Climate Change
- Stern Review: The Economics of Climate Change
- Sachs, Jeffrey D. and Guido Schmidt-Traub. Financing for development and climate change post-2015

#### Chapter 6: Saving Biodiversity

- Summary for Decision Makers: Ecosystems and Human Well Being, Synthesis, Millennium Ecosystem Assessment
- Global Biodiversity Outlook 3, Convention on Biological Diversity.

- o The Economics of Desertification, Land Degradation and Drought: Methodologies and Analysis for Decision-Making. 2nd Scientific Conference on the UNCCD

## Chapter 1. Introduction to Sustainable Development

### 1.1 What Sustainable development is

Sustainable development is a crucial concept.

Our starting point has to be how crowded our world is today. We're 7.2 billion people. The numbers have soared. We're up ten times since the start of the industrial revolution. Billions more people are likely to be added to the world's population in the 21st century.

This is making for a very complicated world. A world divided between great wealth and still crippling poverty. A world facing unprecedented environmental challenges.



Sustainable development is really two ideas.

- One, is a way to understand this complicated world.

How do the economic, the social, the environmental, the political, the cultural factors fit together?

- And the second aspect of sustainable development is the idea of

sensible goals for this crowded, interconnected planet.

How do we make the world both prosperous, fair and also environmentally sustainable, so that our numbers, and our economy don't overrun the physical planet itself?

That's really the aim of the study of sustainable development. To understand the world and of course, to help improve the world.

And we need to get into that complexity. Any idea there's one answer, one simple, magic formula, one explanation, one force at work; we have to put that aside. We have to embrace complexity, because we are talking about a complicated, interconnected set of relations of a world economy that now spans all parts of the world. And connects all people, all businesses, technologies in flows of trade, finance, ideas, advertising, production systems, but also connects us with the physical Earth, in unprecedented ways.

Humanity actually changing the climate, changing what specie survive on the planet, changing the chemistry of the ocean, changing the safety of the air, changing the access and availability of fresh water.

It's an unprecedented situation. It's a fascinating situation. It will be the challenge of your generation. We are experiencing an incredible rise of global population.

Bangladesh is a country now, with around 160 million people. That's more than four times the 37 million people in Bangladesh in the middle of the last century in 1950.

Dhaka, itself, is one of the largest cities in the world right now but think of what's happened. In 1965 Dhaka had about a half a million people. Today Dhaka has more than 15 million people.

You can imagine how the infrastructure's been completely over run. How transport systems, water systems, sanitation systems and all the rest are facing unbelievable stress with this kind of population increase.

This is also part of the reality of our planet.

How do you achieve sustainable development in a, very low income, very, very crowded place like Bangladesh? Especially taking into account how vulnerable low-lying Bangladesh is to the climate change ahead.

So, sustainable development for us, first, is a way to understand these complicated challenges.

It's useful to think of there being **four dimensions** to that puzzle:

1. the economics,
2. the societal dimension, how our communities work, culture, civil society,
3. the natural environment and
4. our political or government systems.

How do economic, social, environmental and government systems interact?

The second way to think about sustainable development is not only as an analytical approach, one that takes a holistic view of society. But also, as what we would call a normative or ethical approach, identifying goals for society.

Sustainable development urges us **to have a holistic vision of what a good society should be.**

- ✚ Sometimes people say well good society is a rich society. But we know that can't quite be it just to focus on the economics.

If a country is rich on average, but all the wealth is held by very few people and most of the people are poor, think most of us would say that's not a good society in the sense, that we would aspire towards.

- ✚ So social inclusion is the second aspect of a good society. Meaning that economic well-being is widely shared among different ethnic religious or racial groups in a country. It's shared between men and women.

So, there's gender equality, it's shared among regions of a country, so that there's not just one pocket of prosperity in a sea of poverty.

- ✚ A third aspect of what we would think to be a good society is one that is a good steward of the natural environment.

We all know that if we break the physical systems of biodiversity, if we destroy the oceans, if we deforest the great rain forests, we're going to lose immeasurably. If we continue on a path that fundamentally changes the Earth's climate in a way that's unrecognizable for us in the way that humanity has developed. We're going to face grave dangers. So, from a normative perspective, environmental sustainability certainly seems right.

All over the world, people feel happier and better when they can trust their government. But unfortunately, many places in the world, people don't trust their governments to be honest, to be fair, even to keep them basically secure. So, from a normative perspective, we could say that a good society is not only a wealthy society. But is one that is prosperous and inclusive, environmentally sustainable and well governed.

And **our fundamental question will be how can we take sustainable development as a goal?**

Use our knowledge of the interconnections of the economy, of society, of the environment and of governments. To think through this crowded 21st century in a world of massive divisions of wealth and poverty and world of unprecedented environmental stress. But also, in a world of many technological miracles. How can we find our way through, through this century to produce property that is inclusive, that is sustainable? And that is according to decent governance with rule of law, transparency and accountability. There are some very powerful ways forward to meet sustainable development as a goal a shared goal for the planet.

## 1.2 Economic Growth and Progress

One very crucial aspect of sustainable development is economic well-being and prosperity. There have been great gains in material well-being. In average income per person, in other indicators of material life, such as health and life



expectancy, over the course of recent decades. We'll see, of course, that these are not gains enjoyed by everybody within a country, certainly not in all parts of the world. But on average there have been very notable gains in economic well-being achieved through decades of economic growth.

And this is a phenomenon that is of crucial importance for those countries that are still poor today. Perhaps their greatest goal is to achieve economic growth

so that they can narrow the gap in material conditions that they face today with respect to the richer countries.

If those countries living in extreme poverty today where, that they can hardly meet their basic needs, are aiming to live like more of the world that increasingly has assurance of basic needs, and many parts of the world that live with remarkably high standards of living.

Another aspect of this material change is that in a world of greater production greater ability to grow food greater productivity in manufacturing, in transport, in power and in other key parts of the economy.

The population has risen alongside that from the middle of the last century in 1950, the world's population at the time was about 2.5 billion people. It's roughly tripled since then, absolutely extraordinary to around 7.2 billion people today, and the numbers are continuing to rise. Roughly an increase of 75 to 80 million people added to the world's population each year. Meaning that it won't be long, probably around 2024, 2025, when another billion people will be on the planet when we'll reach the 8 billionth person.

### 1.3 Continuing Poverty

In many ways we live in a world of plenty. Economic growth has produced incredible wealth. Many parts of the world have escaped from economic hardship. Countries like China, which were once very poor, are now solid middle-income countries. But sustainable development calls for prosperity that is broad based. And, despite living in a world of plenty, there are still large numbers of people, more than a billion, more than one out of every seven persons on the planet, living in extreme poverty.

What is the face of extreme poverty?

If you look at this small farmer living in Northern Ethiopia.

There's no modern transport around you, don't see electricity grids in the distance. You see a pretty parched environment.

They are trying to ensure enough annual food production to feed themselves their families.

Maybe to get that surplus to bring to market for a little bit of cash income.







Another part of poverty?

Have a look at a street in a slum of Nairobi. Millions of people live in the slums of African cities like Nairobi, hundreds of millions of people live in urban slums around the world. This is another face of poverty.

While it remains true to this day that more than half of the world's population living in extreme

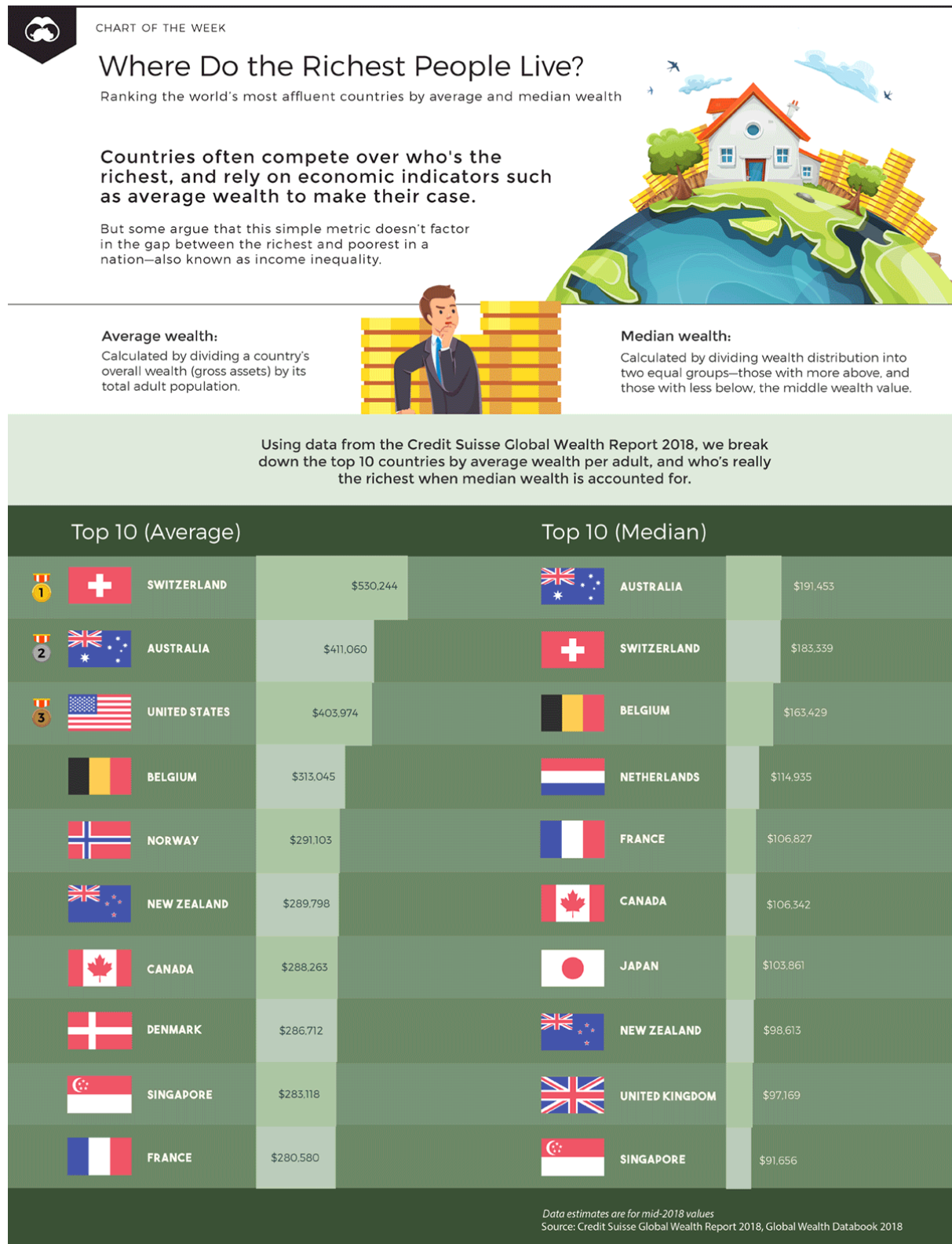
poverty lived in rural areas, of course, the urban poverty is known to us. Often the urban poverty is living right next to a great urban wealth, and what do we see in this street in Nairobi. You see an unpaved, muddy road. People living without modern power, probably without any modern sewerage or sanitation. In other words, even though these are people living in an urban area of several million people, they're also like that peasant in Northern Ethiopia, unable to secure basic needs. Access to emergency healthcare. Access to basic clean power in the form of electricity or natural gas for cooking. Lack of access to safe drinking water and sanitation, and barely eking out a monetary living that can meet even the most basic of minimum needs of clothing and safe shelter. When we speak about **poverty**, therefore, we're necessarily speaking about a **many dimensional concepts**. Poverty is usually viewed as lack of adequate income, but let's think about it as **a lack of income, a lack of access to basic health services**. A lack of access to basic amenities that most of the world takes for granted. Safe water, sanitation, electricity, access for children to, a decent education. People living in extreme poverty are people who cannot meet these basic needs. And while proportions of the world living in extreme poverty have been shrinking markedly in recent decades, the numbers are still staggering. Depending on one's estimate and one's exact categorization of extreme poverty, it's fair to say, that between one and two billion people in the world are struggling to meet basic needs. And probably fair to say, that around one billion people struggle for daily survival.

Will they have enough to eat? Will polluted water cause a disease that threatens their lives? Will a mosquito bite carrying malaria carry away their child because they can't get access to the \$0.80 dose of medicine needed to cure the disease? That's the struggle of daily survival for people living in extreme poverty. Where is this poverty?

Well, one place to look is the average incomes in different parts of the world. Take the national production of the economy, divided by the population so

that one gets the amount of income generated per person, per year, in different countries of the world.

You can see a huge variation in income levels around the world.



We have a very serious challenge, a moral challenge and a practical challenge with people living in extreme poverty, that face risks of survival.

Often countries where poverty rates are very high, succumb to violence, to terrorism, to epidemic diseases, to mass migrations, to environmental disasters, that not only are tragedies for them, but can trigger unrest and instability among their neighbours and in other parts of the world as well.

People living in extreme poverty face a burden of disease and shorter lives as a consequence. That make their lives distinctly more difficult, often more painful and tragic than lives of people in other parts of the world.

## 1.4 Environmental Threats

**One of the most important messages of sustainable development is that we've become a threat to ourselves.**

Economic production has become so large, our productivity in many ways so high, and the numbers of us on the planet so vast, that the effect of all this economic activity on the physical Earth itself has become overwhelming. For the first time in human history, for the first time in the planet's history, one species, that would be us human beings, are threatening the fundamental parts of the Earth's own dynamics: the climate system, the water cycle, the nitrogen cycle, the ocean chemistry.

Think about the basic arithmetic. There are 7.2 billion of us on the planet now. On average, each individual is producing around \$12,000 of output per year, rough number, averaged over the whole year.

But with 7.2 billion people, an average of \$12,000 per person, it means that the world economy as a whole, has an output of between 80 and 90 trillion dollars per year. Many times, larger than ever in the past and continuing to expand rapidly. And the result of all of that, in the water we are using, the energy that we are burning, the land that is being devoted to feeding the planet, the chemicals that are being produced, and the pollution that results from that poisoning the air and the waterways, it's leading to an unprecedented environmental crisis. One of things that's notable about this crisis, is that it's felt by rich and poor alike.

We are causing massive disruption of the climate system, global warming, and more extreme events like droughts and floods. It is a stark illustration of how humanity is changing the basic Earth processes.

A group of scientists got together a few years ago and noted that it's not only the carbon dioxide in the air, but many other things that we're doing.

- The way we're using water the way that we're putting nitrogen based fertilizers into the soil to help crop productivity. But putting it on in such large amounts that the nitrogen cycle, itself, is effected.
- The way that carbon dioxide in the atmosphere affects the ocean chemistry, making the ocean more acidic.

- The way we're chopping down trees to make room for new pasture land and farmland.

In other words, all the varied effects of a big crowded planet and a lot of economic activity, threatening the planet systems. And so this group of scientists said we are trespassing, boundaries that are safe for humanity. So these scientists said we need to identify the safe operating limits for the planet, we need to understand what those planetary boundaries are:

- climate change,
- ocean acidification,
- ozone depletion,
- the nitrogen cycle,
- the phosphorous cycle,
- global fresh water use,
- changes in land use,
- loss of biodiversity,
- driving other species to extinction,

that is, aerosol loading, the particles we're putting into the atmosphere through industrial processes, and chemical pollution, poisoning air and waterways. These are planetary boundaries that we trespass at profound risk for ourselves and for our children.

### 1.5 Business as Usual vs. Sustainable Development

One part of sustainable development is to understand the inter-linkages of the economy, of society, of the environment, and of our politics and government processes, and the other part of sustainable development to do something about it.

We will examine two different scenarios for the future of the world. One, which we will call *business as usual*. If we continue more or less on the course that we're on right now.

- ✚ What kind of world we could expect in ten, 20, 30, 40 years?

It's not all bad. Because, after all, many wonderful things are happening on the planet. Poverty has been declining. Technologies have been advancing. But, there are a lot of risks with business as usual. Especially as we trespass planetary boundaries, especially as we see growth that is not inclusive, and leaving large numbers of people behind. So we want to contrast the business as usual, or BAU path, with a truly sustainable development path for the planet.

- ✚ What would a **business as usual** path look like?

It's not all terrible. For many people, especially comfortable people of, at the top of the income heap, they say business as usual, looks pretty good. The world economy is expanding, life expectancy rising, infant and child mortality falling. One could say, not bad. If we get business as usual, no disaster. Sure,

business as usual offers more economic growth, but is it fair and inclusive? How many people will be left behind?

What will happen in societies, where the favelas, the slums, are right up against, the modern, and wealthy part of the world. What happens in those parts of the world really left far behind. The peasant farmers in dry lands facing more and more droughts.

Places that find themselves vulnerable to ever more flooding, but are too poor to do something about it. We know that all too often, the result isn't merely protest, the result can even be violence, and especially what happens if we just go on our merry way, thinking that we can produce more, have more cars, burn more coal, oil, and gas.

Put more carbon dioxide into the atmosphere. Cut down more trees.

Acidify the oceans. And not respect the planetary boundaries.

There we think, we are surely going to get our comeuppance in ways that we really are not very clear about right now, certainly not in our broad, public discussions. Because the environmental dangers are vast. They are so large, they are coming so fast, they're so threatening that they could upend the very process of economic development itself.

So we see more and more how risky business as usual can be.

 **A sustainable development pathway**, the core features of that would be societies that ensure that all parts of the society.

Girls as well as boys, women as well as men, and minorities all of different regions, all children have access to a healthy start in life, to good nutrition and healthcare, and especially to the education that they will need to be productive.

And skilled members of their society both in the labor force and also as citizens. A good start means inclusion and it means avoiding these mass inequalities of wealth and poverty that afflict the planet.

Sustainable development will mean a new kind of urbanization. Smarter cities, new transport systems, smarter power grids, fed by renewable energy rather than by traditional fossil fuels.

New kinds of vehicles, public transportation, or bicycles, and walking that can also keep us healthy. New ways to build buildings that are much more energy efficient. And much more pleasant and consistent with the, with nature. At the essence of sustainable development, is problem solving.

**We need to move from the business as usual trajectory to the sustainable development trajectory.**

And in order to accomplish that, every part of the world will have to be involved in brain storming in determining new and creative ways to ensure inclusive and sustainable growth.

## **1.6 Agenda 2030**

It took several decades of the world coming to grips with the reality that we have a collision course of our economic growth, our social cohesion, and our environmental sustainability. None of this was very clearly evident many decades ago. Of course, the world knew about the gaps of rich and poor and have debated the ways to achieve economic progress at least since the Wealth of Nations written by Adam Smith in 1776, but in our current period of the last half century, we have been grappling with the new realities of a world that is divided unprecedentedly between the richest and the poorest, societies that seem to be coming apart at the seams also with the rising inequalities and social exclusion, and with the environmental crisis becoming more and more serious and encompassing global warming, destruction of biodiversity, massive pollution.

The Brundtland Commission, in 1987, brought the concept of sustainable development to the world, by introducing its most famous definition, that sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

In September, September 25th, 2015 the Agenda 2030 and the 17 Sustainable Development Goals were adopted and a few weeks later on December 12th, 2015 in Paris, the Paris Climate Agreement, to come to grips with the dramatic crisis of human-induced global warming, was adopted as well.

The 17 Sustainable Development Goals covered the three key pillars of sustainable development: prosperity, social inclusion, and environmental sustainability. Agenda 2030 is the text which includes the 17 Sustainable Development Goals and lays out their rationale, their purposes, and in more detail the shared direction forward.



# SUSTAINABLE DEVELOPMENT GOALS



## Chapter 2: Economic Development – How We Measure It, How It Varies Around the World

### 2.1 Incomes Around the World

Sustainable development we've seen has three major aspects:

- economic development,
- broad-based inclusion and
- environmental sustainability,

all supported by good governance.

- But what do we mean by economic development?

Of course, there are many different aspects of a true and proper understanding of economic development, but we tend to use a short hand, and that is called **the gross domestic product of a country**.



The gross domestic product has three words and three concepts in it. It means the total production taking place within the geographic boundaries of a country in a given year, so the gross of the gross domestic product means you're measuring everything that is taking place within the country.

Domestic signifies the fact that we're talking about a geographic area, and we're concerned with how much economic activity or production takes place within the boundaries.

In general, we are interested in getting a sense of the standard of living of a country, and to do that we take the total production in the country over a given time period, usually the year, and divide it by the population so that we're interested in the *gross domestic product per person, or per capita*.

- Why is that?

Well, of course, larger countries produce more because there are more people.

There are more workers, but if we simply were to compare countries in terms of the total production, we'd find that highly populous countries would have higher production but we wouldn't learn very much about whether the living standards of those larger countries is really higher than the living standards of a small country, which may produce a little bit but quite a bit for each person in the economy.

So when we think about economic development, we tend to think about the gross domestic product per person.

We want to know other indicators of well-being, but as a shorthand, when we want to get a sense of a country's overall level of economic development, we start by looking at the gross domestic product per person because it's going to be a pretty good indicator of where things stand.

The World Bank keeps very systematic tabulations on gross domestic product per person, and it classifies countries in a way that is also extremely helpful for us.

The World Bank gives three categories of countries:

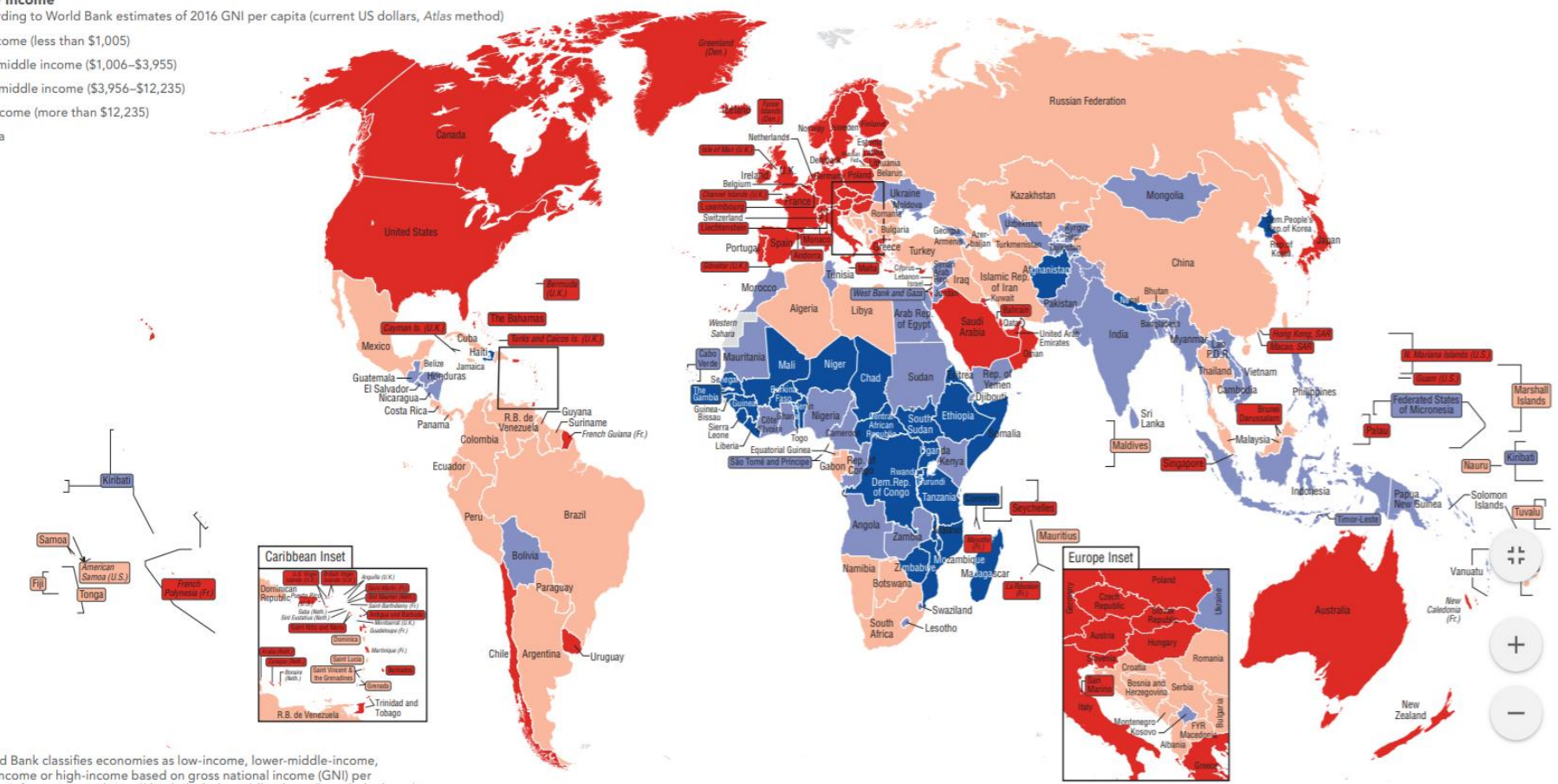
- ✓ high income countries,
- ✓ middle income countries and
- ✓ low income countries,



**The world by income**

Classified according to World Bank estimates of 2016 GNI per capita (current US dollars, Atlas method)

- Low income (less than \$1,005)
- Lower middle income (\$1,006–\$3,955)
- Upper middle income (\$3,956–\$12,235)
- High income (more than \$12,235)
- No data



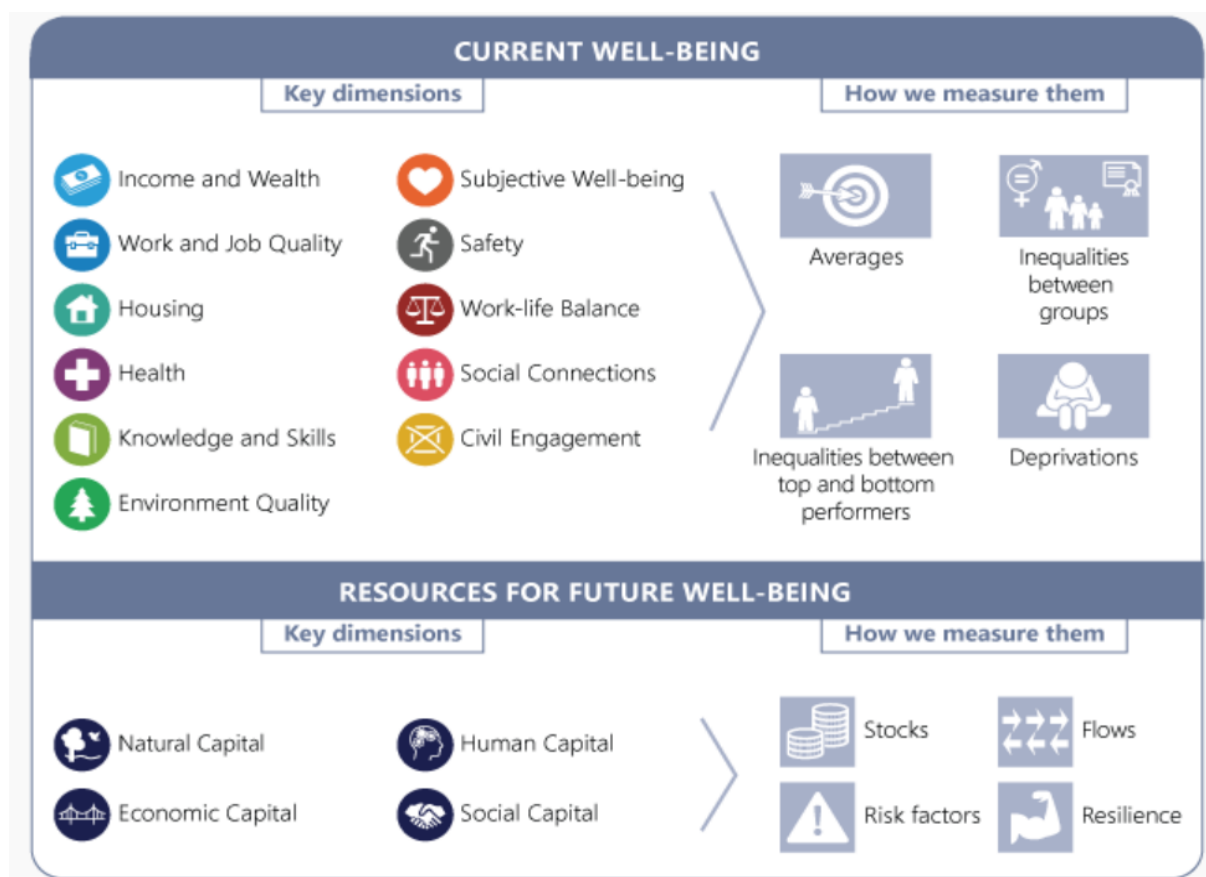
Note: The World Bank classifies economies as low-income, lower-middle-income, upper-middle-income or high-income based on gross national income (GNI) per

## 2.2 Measuring Well-being

Let's discuss how we measure well-being, how we can track whether our economies and more broadly our societies are on track to raise the material conditions of life and to raise well-being even more generally than that.

The mother of all measures is the national income accounts and specifically the national income per person.

The Organisation for Economic Co-operation and Development (<https://www.oecd.org/>) differentiates between measures of material conditions of life, which are essentially **measures of income and wealth, jobs and earnings, and housing, and other quality of life indicators which include leisure time, health, education, social connectedness, whether society has the social capital to come to the aid of each other, civic engagement, voter turnout, environmental quality, personal safety, and subjective well-being.**



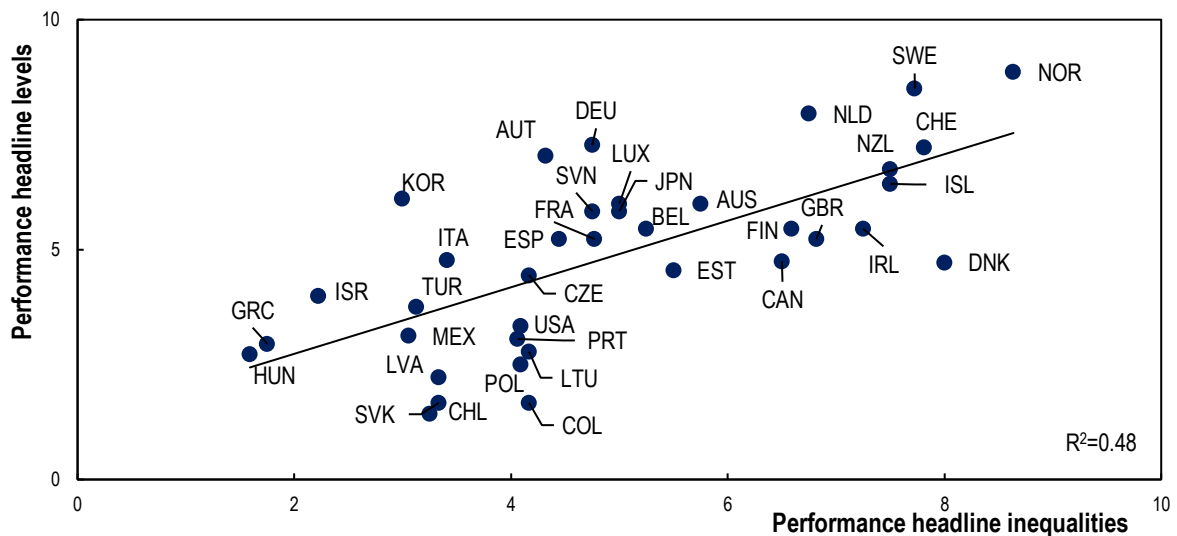
In other words, the OECD has done a good job of canvassing a wide range of indicators to assess a broad-based measure of one's sense of the quality of life and to look at the factors that contribute to that subjective sense of well-being. Well it turns out we can usefully compare across countries and when we do,

we see a lot of the top performers across a number of these indicators but we also see some very interesting patterns as well.

In 2018, the countries expressing the highest subjective well-being were Finland, Norway, Denmark, and Iceland--four Nordic countries-- and Sweden, the fifth of the Nordic countries, shows up ninth in the world on that list.

**Countries with greater average well-being also tend to be more equal**

Comparative performance on current well-being averages and inequalities, 2018 or latest available year (with missing data excluded)



OECD countries' performance in terms of average well-being levels are based on 12 headline indicators: household disposable income, household median wealth, housing affordability, employment rate, life expectancy, student skills in science, access to green spaces, life satisfaction, homicide rate, time off, social interactions and voter turnout.

<https://www.oecd-ilibrary.org/sites/9870c393-en/1/3/1/index.html?itemId=/content/publication/9870c393-en&csp=fab41822851fa020ad60bb57bb82180a&itemIGO=oe.cd&itemContenttype=book#figure-d1e1495>

If we look at the Human Development Index, which averages over income, health, and years of schooling, Norway shows up at the top of that list.

**Chapter 3: Sustainable Food Supply and the End of Hunger**

### 3.1. End of Hunger

We need to consider one of the most complicated and unsolved problems of sustainable development.

- How are we going to feed ourselves?

It's an age-old problem, it's been with humanity for a long time before, but for quite a few decades. This is problem that many people thought was already solved with the great breakthroughs in food productivity. In increasing farmland, increasing yields, it seems that food production would inevitably stay ahead of the growing world population.

Now we have some serious doubts. Not only are we coming to realize how badly fed the world population is in certain ways, but how many real threats there are ahead.

That is our challenge. We can't say we haven't been warned. The warnings have been with us for more than two centuries. They started, with Thomas Robert Malthus, who in 1798 in his *Principles of Population* posed the basic question of how food production can stay ahead of a growing population.

When Malthus wrote, there were around 900 million people on the planet. Now with 7.2 billion people, an eight-fold increase, the challenge is with us again. In fact perhaps in an even more complicated way than Malthus imagined. Because now, we come to understand that not only is the world not feeding itself but in a healthy and fair manner. But there are many, many obstacles that lie ahead.

- Let's start with the question of, what does it mean to feed ourselves in a healthy way?

And we can ask that by looking at the question of malnutrition. Malnutrition is a pervasive problem on the planet.

We think convincingly that perhaps 40% of the world's population is malnourished.

In one way or another.

But to understand that, we have to understand what we mean by malnutrition. Now, one thing that jumps to mind, of course, is hunger and undernourishment.

- Undernourishment in it's most direct sense is, simply not taking in the calories that are needed for daily activity and daily survival. Hungry people feeling the pangs of hunger and not having enough energy for more than mere survival and in some desperate cases, not even that, remains a problem afflicting hundreds of millions of people in the world.
- There's another kind of under nourishment. That is a bit less visible. And that is a category sometimes called hidden hunger. The calories may be there. But the micro-nutrients nutrients such as vitamins and particular





incredibly varied in what's grown, where, how, climate, soils, topography biodiversity, all have an enormous effect in shaping farm systems.

And because of that, there is certainly no single answer to how farms can become more productive for example. Or how local populations can become healthier in what they eat.

Different places grow different foods. They eat different foods. They face different climatic and agronomic challenges.

And, part of our proper, problem-solving our diagnostics and our solutions for the issues of a sustainable food supply, depend on us understanding, in detail, how these farm systems differ around the world.

So we have a problem. Here we are in the 21st century. And still around 40% of the world's population is malnourished. And around 30% of the world's population is undernourished, either in open flagrant hunger, nearly billion people, or another billion in addition to those also suffering from hidden hunger of micronutrient deficiencies.

Farm systems everywhere are already under stress. Unable to provide the healthy diets and nutrition in economical way, to meet the needs of the world's population. But, there are some big challenges ahead that are going to make all of these problems even tougher than they are now.

The most direct of these challenges is the fact that the world's population continues to grow and continues to grow relatively rapidly, even if not in percentage terms, in absolute terms.

Every year another 75 to 80 million people add it to the world population. By 2025 we'll reach eight billion people. By the early 2040s, nine billion people. And on the current medium forecast of The United Nations we've seen, almost 11 billion people by 2100.

At the same time that we'll be grappling with the challenge of feeding more and more people.

The current food supply, which is already putting so much stress on the world's environment is also going to be stressed by another couple of features.

One is that for those parts of the world getting richer. The tendency and we, we hope it's a large part of the world I, I should quickly emphasize.

The tendency will be to add more meat to the diet, even too much meat. Too much meat for human health and well-being. But as meat is added to the diet that is a kind of amplifier of the demand for grain production, because for animals like cows and pigs which give us our beef and pork.

For every kilogram of beef that we consume, there have been around 10, and in some farm systems, up to 15 kilograms of feed grain consumed by the cow to produce the 1 kilogram of beef.

So there's a huge amplifier as diets shift to meat in terms of the underlying demand for feed grains on the planet, and therefore for the total demand on the agricultural system.

There's a second major reason however, in addition to that stress and that is **environmental change** is going to make it harder and harder to grow food in many places in the world. So much so that we can't really know in detail but we have major cause for worry.

Climate change threatens the soil moistures. Threatens the productivity of crops as result.

Climate change of course, means more than warming. We know, it means changes in precipitation patterns. Many parts of the world will become drier. And many dry parts of the world will find it extraordinarily difficult, perhaps impossible, to grow a crop.

If the general principle that the dry places will tend to get drier and the wet places tend to get wetter is valid as a very rough summary of the effects of human induced climate change.

We can see the trouble ahead because places that are in the margin of crop growing right now, may find themselves pushed right over the edge. Where the growing seasons are too short, the rainfall too small, the precipitation too erratic.

To be able to support farming in places where there are large numbers of people, right now.

We know the climate change also means rising sea levels.

It means the places that are farmed right now in lowland areas near the coast will be threatened.



And not only will sea level rise essentially force, major loss of cropland in such areas.

In addition to climate change, ocean acidity, many other environmental changes already are degrading farmland and threatening agricultural

productivity. Farmers use large amounts of pesticides and herbicides to grow the crops, but the poisoning of the soils and the environment is taking its toll, on biodiversity. We're seeing a drop of significant biodiversity of many kinds of

species, including pollinators, for example, like honey bees. And other pollinators that are vital for crop productivity for growing fruits and other kind of flowering crops. And this has led to alarming and so far, to an important extent, unexplained declines of biodiversity.

The environmental threats ahead of depleted fresh water supplies, weather from the glaciers that reduce river flow, or the depletion of groundwater is another extraordinarily serious menace.

That threatens farming in many parts of the world. Under the pressures of intensive agriculture, often when farms have encroached on forest lands or in topography not really suitable for farms, the result is also rapid land degradation. Soil loss. Depletion of soil nutrients.

## Chapter 4: Sustainable Cities

### 4.1 The Patterns of Urbanization Around the World

In 1950, 38% of the world's urban population was in Europe. The UN forecasts that as of 2050, Europe will only be 9% of the world's population in urban areas, because Europe's total share of population is falling and because the rest of the world is urbanizing.

Imagine how different the world will be in culture in the sense of where things are happening, where the dynamism is taking place. The era in which European and U.S. cities were the dominant cities of the world is coming to an end.

### World Population by Region





















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#	Region	Population (2020)	Yearly Change	Net Change	Density (P/Km <sup>2</sup> )	Land Area (Km <sup>2</sup> )	Migrants (net)	Fert. Rate	Med. Age	Urban Pop %	World Share
1	Asia	4,641,054,775	0.86 %	39,683,577	150	31,033,131	-1,729,112	2.2	32	0 %	59.5 %
2	Africa	1,340,598,147	2.49 %	32,533,952	45	29,648,481	-463,024	4.4	20	0 %	17.2 %
3	Europe	747,636,026	0.06 %	453,275	34	22,134,900	1,361,011	1.6	43	0 %	9.6 %
4	Latin America and the Caribbean	653,962,331	0.9 %	5,841,374	32	20,139,378	-521,499	2	31	0 %	8.4 %
5	Northern America	368,869,647	0.62 %	2,268,683	20	18,651,660	1,196,400	1.8	39	0 %	4.7 %
6	Oceania	42,677,813	1.31 %	549,778	5	8,486,460	156,226	2.4	33	0 %	0.5 %











This is also borne out by the dynamics of the world's largest cities.



## TOP 20 LARGEST COUNTRIES BY POPULATION (LIVE)

1	 <a href="#">China</a>	1,441,273,319	11	 <a href="#">Japan</a>	126,342,016
2	 <a href="#">India</a>	1,384,805,010	12	 <a href="#">Ethiopia</a>	115,993,628
3	 <a href="#">U.S.A.</a>	331,685,463	13	 <a href="#">Philippines</a>	110,099,767
4	 <a href="#">Indonesia</a>	274,548,117	14	 <a href="#">Egypt</a>	103,026,440
5	 <a href="#">Pakistan</a>	222,431,455	15	 <a href="#">Vietnam</a>	97,648,089
6	 <a href="#">Brazil</a>	213,091,919	16	 <a href="#">D.R. Congo</a>	90,554,745
7	 <a href="#">Nigeria</a>	207,987,699	17	 <a href="#">Turkey</a>	84,660,613
8	 <a href="#">Bangladesh</a>	165,270,042	18	 <a href="#">Germany</a>	83,877,820
9	 <a href="#">Russia</a>	145,956,301	19	 <a href="#">Iran</a>	84,374,993
10	 <a href="#">Mexico</a>	129,412,529	20	 <a href="#">Thailand</a>	69,861,291

<https://www.worldometers.info/world-population/>

Rank	City	Population in Year 2018
#1	 Tokyo	38,194,000
#2	 Delhi	27,890,000
#3	 Shanghai	25,779,000
#4	 Beijing	22,674,000
#5	 Mumbai	22,120,000
#6	 Sao Paulo	21,698,000
#7	 Mexico City	21,520,000
#8	 Cairo	19,850,000
#9	 Dhaka	19,633,000
#10	 New York City	18,713,000

<https://www.visualcapitalist.com/worlds-most-populous-cities-500-years-history/>

If we look at the places in the world that have populations of 10 million or more. These are so called, urban agglomerations, they don't necessarily mean areas

within a legal city limit of 10 million, they mean a concentrated area that may include many political jurisdictions within one concentrated agglomeration. What we're seeing is, first of all, a sharply rising number of these giants, these mega-cities. But also we're seeing that those mega-cities are arising in what are today's developing countries.

Cities that face special opportunities in trade and in being cosmopolitan areas connected to the world, but cities that face special challenges of being threatened by more extreme storms, and by rising sea levels, as a result of the long-term trends of human induced climate change.

#### 4.2 What Makes a City Sustainable?

If most of us are going to live in cities, then we better ask the question, what is it that makes a city sustainable?

And the answer that we want to give is two-fold.

✚ One is that it is **a green city**

Green in the literal sense that there are parks and places of people and open areas combined. But also green in the sense that its economic impact on the environment, the ecological footprint of the city, is also limited.



✚ The other dimension of a sustainable city is that it is **resilient**

Why resilient? Because we, in the era of planetary boundaries, in a period where, whether we like it or not, we are going to be experiencing more jolts of human-induced climate change know that the cities are going to be buffeted.



If the cities are on the coasts, and sea levels are rising, what that means in terms of vulnerability to storm surges, more intense cyclones, and other storms, other dislocations, is very great.

And so cities need to prepare for those shocks. Not as disasters that seemingly come out of the blue, but rather as known, even if unpredictable specific events that need to be prepared for

with care.

What is it that makes a city sustainable?

▫ The energy system

Is the city a major contributor to greenhouse gas emissions? Especially through its energy use, but also through landfills that may emit methane, or through problematic industrial processes that are emitting nitrous oxide.

Or, is the city efficient both energy efficient, and based on a low carbon, clean energy system.

- Transport

Cities can be places of incredible congestion, smog, huge waiting times, traffic jams, and of course, large amounts of CO2 emissions coming from all those internal combustion engines burning all of that petroleum and diesel. Or cities can be places of highly efficient transport through very clever integration of walking areas, bicycling areas, as well various kinds of public transportation, taking the pressure and the demand off of the automobile.

And so the nature of the city's transport is a crucial determinant of its sustainability.

- A city's infrastructure, its water, its sanitation, its waste management, its ability to recycle industrial waste, and to control industrial pollution, are clearly fundamental determinants of a city's sustainability.

How effectively the city plans and prepares for the future is obviously decisive. Not one of these issues, energy systems, transport systems, waste management, recycling, open green areas, resiliency to shock, is something that takes care of itself or something that is solved by a market economy. Certainly not a market economy, just left to run on its own.

Urban resilience and urban efficiency and low ecological footprint, low impact on the natural environment are aspects of city life that must be planned.

- ✓ What does it mean for a city to be unsustainable?

First, it means that the city is highly vulnerable to shocks. Shocks again may seem like they're coming out of the blue, but they can be predicted if not in exact timing, at least with the probabilities of their visitations. Cyclones, droughts, earthquakes in many places, floods, and storm surges, landslides, in a few cities' volcanoes are threats to lives, to livelihoods, to the economy.

And mitigating those threats, anticipating the risks, making cities resilient, able to withstand shocks such as these, is absolutely a fundamental part of sustainability and a fundamental signal of unsustainability when those preparations are not made.

Just about every city in the world has a huge job to do in anticipating water needs, and ensuring that water and sewerage, or waste treatment are properly managed.



**Cities are unsustainable when they are unproductive** because people are sitting in traffic jams for hours every day, breathing polluted air, losing productivity. Poor health. Social inequalities that make it impossible for large parts of the population to participate in a productive way in the economy of the city.

And **cities are unsustainable when populations are suffering from massive and growing disabilities of health**. When an obesity epidemic coming from unsafe food combined with sedentary behaviour of city life, with an absence of places for walking, bicycling, exercise, for a healthy lifestyle, mean that people are ill. They are often disabled. Absent from work, and, of course, suffering a serious setback in their sense of well-being.

Highly dense cities, if properly prepared for, tend to be both highly productive and lower emitting of greenhouse gases, than lower density settlements.

This may seem surprising. High density seems a lot of people are jammed together, but in high density it's also possible to have more efficient transportation, to have more opportunities to walk, to reach places close by.

And so places of high population density tend to be places with lower ecological impacts, notably lower carbon emissions per person of the population.

#### 4.3 Planning for Sustainable Development

Sustainable cities are green and resilient. They're green in that they have a low ecological impact, low greenhouse gas admissions per capita a pleasant environment for people to live and to work, safe, clean air, parks ways for people to remain active and healthy.

They're also resilient in that they know that increased shocks are on the way.

That in the age of the Anthropocene, storm surges, heat waves, massive floods, droughts, food insecurity, unfortunately will be real and growing threats in the future that must be anticipated.

Smart cities plan in smart ways with transport infrastructure, power systems, water and sewerage, in smart grids, in smart zoning that enables them to be green and resilient.

A good example in sustainable development city planning is the plan of the city of New York, PlaNYC.

PlaNYC was a strategic plan released by New York City Mayor Michael Bloomberg in 2007 to prepare the city for one million more residents, strengthen the economy, combat climate change, and enhance the quality of life for all New Yorkers. The plan brought together over 25 City agencies to work toward the vision of a greener, greater New York and significant progress was made towards the long-term goals over the following years.

PlaNYC specifically targeted ten areas of interest: Housing and Neighborhoods; Parks and Public Spaces; Brownfields; Waterways; Water Supply; Transportation; Energy; Air Quality; Solid Waste; and Climate Change. It has ten goals that are important to note.

1. Housing and neighborhoods

Anticipating changes of population New York anticipates a continuing rise of population. Perhaps another million people within the next couple of decades. And making sure that housing is affordable and sustainable is part of any forward looking plan.

2. Parks and Public Spaces- vital for quality of life and for public health.

3. Brownfields- Cleaning up polluted areas, so-called brown fields.

4. Waterways- Waste fills dumping sites that are dangerous for local communities, for the water supply and that deprive New York of valuable land that could best be used for other purposes.

Improving the quality of water ways for transport, for recreation, for safety, for coastal ecosystems.

5. Water Supply - ensuring the safety and adequacy of New York City's water supply is obviously an absolutely central objective for sustainability.

6. Transportation- a robust, resilient, efficient, low-cost ecologically sound public transportation system used for the community and for the enormous business sector of the New York City region.

7. Energy- energy efficiency, energy reliability, avoiding the kinds of massive blackouts and shutdowns. Being much more energy efficient as part of the overall Greenhouse gas mitigation strategy.

8. Air Quality- improved air quality, to keep particulate pollution low, to keep air quality as high as possible.

9. Solid Waste- solid waste management, to get away from the traditional landfill model with all its high costs and loss opportunities, and to look for new strategies, for instance, waste to energy, and much more recycling.

10. Climate Change- New York already has a per capita CO<sub>2</sub> emission that is less than a third of the USA's national average. But at six tons per capita that's still going to be far higher than what the worlds standards will need to be.

As part of Plan YC, New York has adopted a goal of reducing New York's carbon dioxide emissions by 30% by the year 2030. New York is rightly thinking ahead even if the U.S. Federal Government is not yet thinking ahead.

## Chapter 5: Curbing Climate Change

## 5.1 The Basic Science of Climate Change

Climate change is the biggest of all the environmental threats that we face, and the magnitude of this threat is only gradually dawning on humanity.

Our economy runs on energy. And energy in the form of fossil fuels is both the driver of the world economy, and the essence of the climate change problem. Because when we burn fossil fuels, we emit carbon dioxide into the atmosphere. And that is the major reason why humanity is changing the climate.

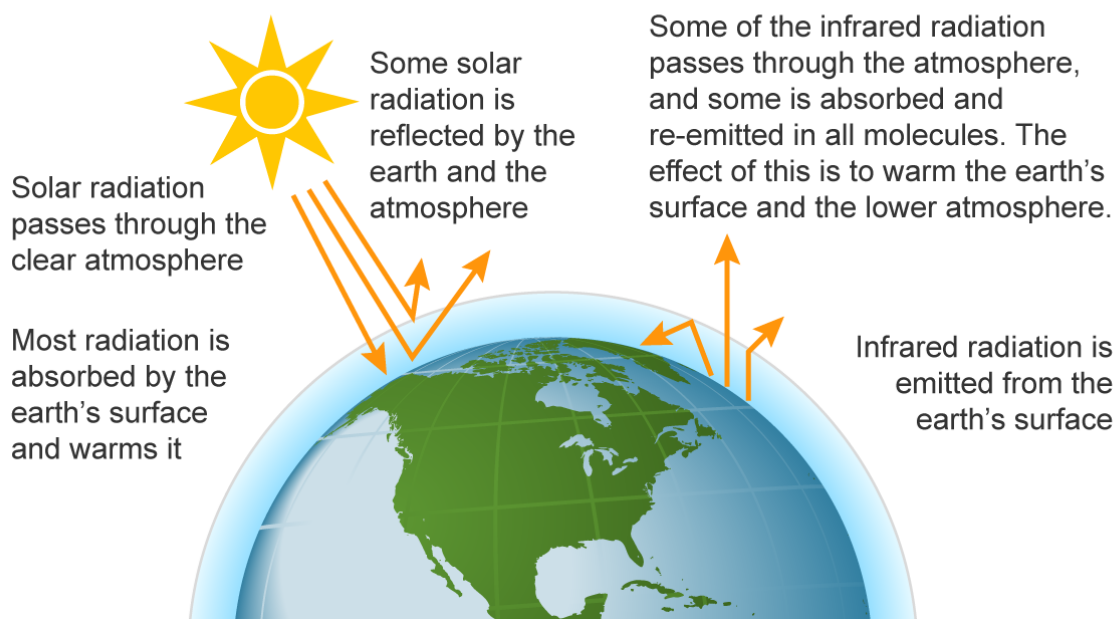
Then we have the slow moving. We're just not good enough to see it day by day, year by year, what's really happening to the planet.

The scientists are telling us, watch out, you're getting to the cliff, you're hitting the thresholds, you're crossing the boundaries of safety, but life goes on.

And because this is a problem that stretches out over decades the politicians, the businesses and all of us don't necessarily feel it and know it and realize the dangers of it.

Useful to understand the climate change is this schematic diagram of the greenhouse gas effect.

### The greenhouse effect



What it shows is that sunshine coming from the sun reaches the planet as ultraviolet radiation. A little bit of it is reflected by the clouds. Most of it reaches the earth. A little bit of that is reflected by the ice and other land surfaces on the planet but most of it is absorbed by the earth. The Earth warms and as a result of it's warming, the Earth radiates infrared radiation back into space.

The Earth warms enough so that the outgoing infrared radiation equals the incoming ultraviolet radiation. That's a thermal balance, or thermal equilibrium. Now you put a level of greenhouse gases into the atmosphere. Carbon dioxide, methane, nitrous oxide and others. Those molecules have a particular property that they absorb some of the infrared radiation and trap it and warm the planet more than the planet would be warmed if those greenhouse gases didn't exist.

Indeed, if we had no greenhouse gases the temperature of Earth would be something like the temperature of the moon. A lot colder and unable to support life as we know it.

It's because of this envelope of greenhouse gases that Earth is indeed warmer. But now if humanity increases the amount of the greenhouse gases in the atmosphere, then we create problems. Because life on the planet, and humanity, and our civilization, have evolved in a certain kind of climate, but now we're changing the climate by adding more molecules of greenhouse gases in the atmosphere, warming the climate and pushing the thermal equilibrium to higher temperatures that threaten us in a variety of ways.

The total warming effect sometimes called the total radiative forcing of the greenhouse gases, is the sum of the effects of each of these greenhouse gases. The total radiative forcing caused by human activity that is caused by the emissions of CO<sub>2</sub>, methane, nitrous oxide and these industrial chemicals leads to the overall warming effect and of that, carbon dioxide accounts for about 77% or about three quarters of the total effect.

Methane is the second most important of the human induced greenhouse gases. And nitrous oxide is the third and the sum of the radiative forcings of those three types of greenhouse gases account for about 99% of the total greenhouse effect.

The carbon dioxide part of that total is about 35 billion tons of carbon dioxide. Most of that is coming from burning coal, oil and gas a much smaller part of that, around 10% is coming from cutting down trees.

Cutting down the rainforest and there by releasing carbon dioxide from the trees back into the atmosphere.

## 5.2 Consequences

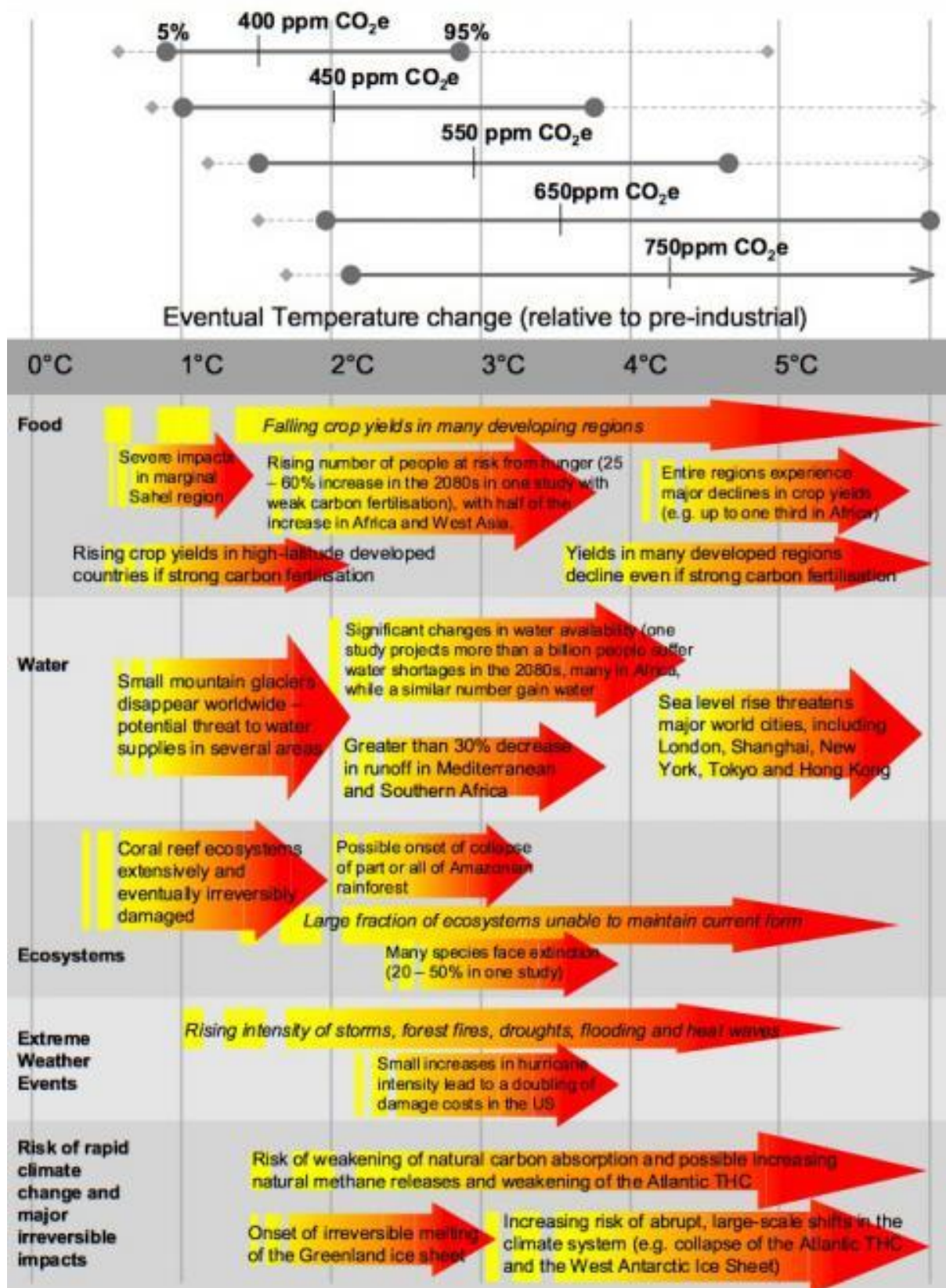
- Why should we care about human-induced climate change?

The fact of the matter is, we should be scared, truly scared. Not so frightened that we're paralyzed, but rather scared into action because the consequences on a business-as-usual trajectory for this planet could absolutely be dire.

We are on a path of putting so much carbon dioxide, methane, nitrous oxide into the atmosphere that the temperature increase on average on the planet could be several degrees centigrade by the end of this century.

One very useful way to view this was presented in an important report on climate change produced by Lord Stern in the United Kingdom a few years ago.





Now, you see across the horizontal axis, zero degrees centigrade, one degree, two degrees, three degrees, four degrees, five degrees centigrade.

This is showing all of the possibilities for the increase of temperatures during the twenty-first century depending on how much greenhouse gas we end up emitting and how the Earth's systems respond to that.

Down the side axis, we have the kinds of consequences that we should expect for different temperatures.

- There will be consequences for the food supply.
- There will be consequences for water.
- There will be consequences for the functioning of ecosystems and the survival of other species.
- There will be consequences for extreme weather events such as droughts, floods, mega heat waves, mega storms, big cyclones, typhoons, hurricanes.
- There will be consequences and risks of very rapid, dramatic changes to key Earth systems that could cause the climate, not only to change as markedly as shown here, but even more markedly through sudden alterations of the Earth's climate system.

### 5.3 Adaptation

It is possible to reduce human emissions of greenhouse gases substantially. The technologies are within reach.

- ✓ We need energy efficiency.
- ✓ We need low carbon electricity.
- ✓ And we need electrification of parts of the economy, like automobiles, like home heating, and some industrial processes, to use that clean energy from clean electricity rather than the dirty energy coming from burning fossil fuels.

How do we get there? What do we do?

Energy is so deeply embedded in our economy, in how we do everything, in industry and transport, in our living, the organization of our cities. We can't make that transition to low carbon energy overnight.

Even if we wanted to, the only way to dramatically reduce greenhouse gas emissions in the short term would be pretty catastrophic. We'd have to close down large parts of our economy.

What we're really looking for, therefore, is a transition over the course of 30 to 40 years. Not a sudden, abrupt end of emissions. But we need to move quickly, because what science tells us is that we have to cut by half or more our total emissions by the mid-century, even as the world economy is expanding dramatically.

So, we've gotten the hints of what to do.

What kinds of policies can be used to get there?

- ✓ Energy efficiency

One standard kind of policy, which has been quite successful around the world, is to put appliance standards into effect through regulation. And places that put basic standards on automobile, mileage, per gallon, for example, or the energy use in refrigerators and air conditioners, or a shift from a heavy energy using traditional light bulb, the incandescent light bulb, to LEDs and to compact fluorescent light bulbs, can be managed by appliance standards. And quite a lot of energy saving can be accomplished at very, very low cost, or even at net economic savings.

- ✓ Building codes can make a big difference

And building codes are part of the normal policy, framework of any normally run city. And we know that the quality which buildings are built, the insulation materials, the ventilation properties, the placement of the cities, the use of roofs, the internal energy systems whether it's furnaces and boilers or, or whether it's electric power sources make a huge difference in the energy efficiency of buildings.

Introducing smarter grids and new metering and smart ways that the utility company meters household and then applies pricing systems to encourage households to economize on electricity use, and helps customers to be aware of options on energy efficiency can make a very, very big difference.

- ✓ Corrective pricing

Market prices be corrected in a variety of ways.

- One way is simple, you put a tax on the use of coal, reflecting the CO<sub>2</sub> emissions and the health burdens that using that coal will cost. Only companies that capture the CO<sub>2</sub> and safely store it wouldn't have to pay the tax on the coal.

And companies that use a non-carbon source of energy, like solar power or wind power, would avoid that tax as well. So, the market signal would say, you cannot get away with it any longer, using a socially costly form of energy.

Because of that tax, there will be a natural incentive of companies and households and builders everywhere to economize or substitute a way from coal, oil, and gas, and move towards the alternative energy sources that are now less expensive because they don't bear that tax.

- There's another system that can be used, which is that you're required to have a permit to emit carbon dioxide, and only a few and shrinking number of permits are given out each year.

Those permits can trade, a company that has no alternative might buy permits from others. But it's expensive to buy that permit.

- Another way to correct market prices is what's called feed in tariffs.

The government says to a utility company or a power generator, we'll buy electricity from you, but we'll pay an extra high price if the electricity that you're bringing into the system is clean.

- So rather than taxing the dirty stuff, you give an added incentive for power generation coming from wind power or from solar power.

The main problem with wind power is that the wind sometimes doesn't blow. This is an intermittent power supply. The main problem with solar power is too, night-time and clouds, and so the reliability and predictability of solar power, and the fact that it's only available certain hours of the day.

Mean that solar and wind power and many other kinds of renewable energy need to be stored somehow, stored in batteries, stored in other solutions that are being developed right now.

## Chapter 6: Saving Biodiversity

### 6.1 What is Biodiversity?

An **ecosystem** is a collection, of plants and animals and microbial life, interacting with the abiotic or non-living part of the local system, with the energy and nutrient fluxes.

The key is that this is a set of living organisms together with the non-living environment. Interacting in a system and of course, what ecologists do in studying ecosystems, is study the fluxes and dynamics of the system.

How does nutrient flow take place within a food web and within the processes of metabolism, of oxidation, respiration, and, photosynthesis, and other basic processes of the metabolism of the living organisms, within the system.

When we have an ecosystem, we're also interested in another core concept. And that is the biological diversity or **biodiversity** of that ecosystem.

**Biodiversity** is the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.

We care about the variability of life within a species, each of us is different from from other people. We have different genetic codes. We carry different effects of our environment.

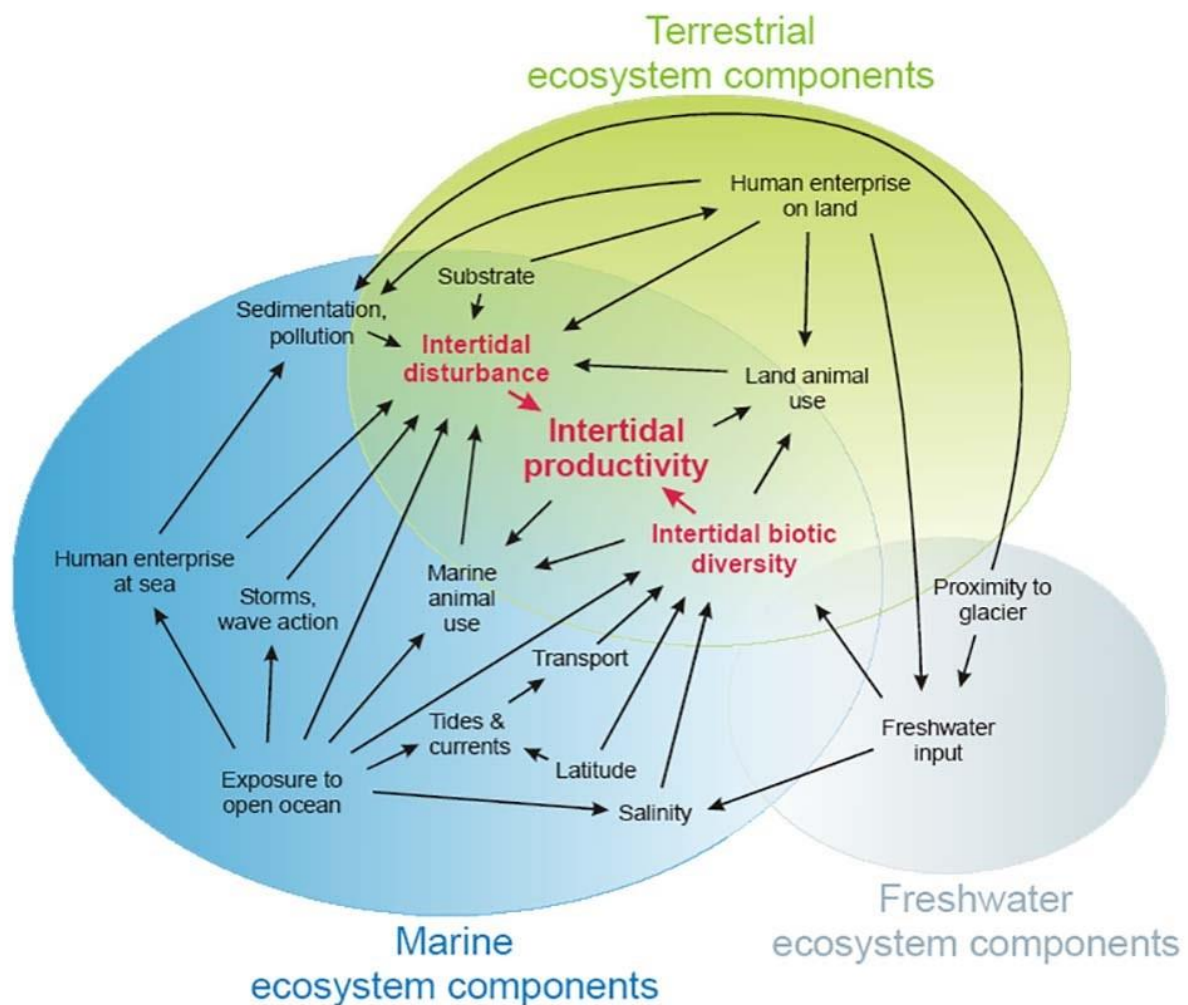
We know that the relationship of environment and genetics, is extremely complicated. We found out that it's even more complicated than we thought, through the emerging field of epi-genetics, which tells us that the environment affects how our genes code or don't code, in ways that actually can transmit across generations.

Even not in the DNA itself, but in the way that DNA is expressed in cells from a parental generation to offspring.

So, we care about the variation, within a species. We care about the interaction across species. All of the various relationships of predator and prey,

and mutualism, and parasitism, and the ways that species interact, and live together and are part of, larger food chains and nutrient fluxes.

The interaction of ecosystems, of dry land ecosystems, or desert ecosystems, interacting with the humid ecosystems, with alpine or marine ecosystems, is also absolutely crucial for understanding, how any of those individual ecosystem's functions, but also understanding the global functioning of the, the earth as a whole.



What happens in the oceans or what happens in the polar regions or what happens in the rain forests, affects global dynamics of heat dissipation, of the water cycle, and through multiple processes, affects ecosystems all over the world.

So there are distant relationships between changes in the pole-ward regions, for example.

So, biological diversity or biodiversity, requires us to understand the variation of life, at all different levels of organization, and to understand how that variability affects the performance of ecosystems, in ways that matter.

## 6.2 Biodiversity Under Threat

Ecosystems provide vital services for human wellbeing, provisioning and regulation among them.

Biodiversity, the variation of life within species, across species, and across ecosystems determines to an important extent, how well ecosystems perform. And therefore, how well they provide vital services for humanity.

There was a long-standing hunch that a greater degree of biodiversity.

More genetic variation within species a richer web of species in a food chain or in a given ecosystem, would raise the performance of ecosystems.

And over the last 20 years, ecologists have been making valiant efforts to understand the linkage of biodiversity to ecosystem functioning.

Their conclusion is a very strong one. And that is that biodiversity, biological diversity, raises the performance of ecosystems in valuable ways.

And when biodiversity is under threat, at any level of organization, less genetic variation within a species, less variation of the range of species, less favourable interaction across ecosystems.

When biodiversity is a threat, ecosystem functions are degraded.

Some of the main threats to biodiversity are:

1. Human Activities and Loss of Habitat,
2. Deforestation,
3. Desertification,
4. Marine Environment,
5. Increasing Wildlife Trade and
6. Climate Change.

### **1. Human Activities and Loss of Habitat:**

Human activities are causing a loss of biological diversity among animals and plants globally estimated at 50 to 100 times the average rate of species loss in the absence of human activities. Two most popular species in rich biomes are tropical forests and coral reefs.

Tropical forests are under threat largely from conversion to other land-uses, while coral reefs are experiencing increasing levels of over exploitation and pollution. If current rate of loss of tropical forests continues for the next 30 years (about 1 percent per year), the projected number of species that the remaining forests could support would be reduced by 5 to 10 percent relative to the forest in the absence of human disturbance.

Biodiversity loss can result from a number of activities, including:

- (a) Habitat conversion and destruction;
- (b) Over-exploitation of species;
- (c) Disconnected patches of original vegetation; and
- (d) Air and water pollution.

Over the coming decades, human-induced climate change increasingly become another major factor in reducing biological/biodiversity. These pressures on biodiversity are, to a large extent, driven by economic development and related demands including the increasing demand for biological resources.

Activities that reduce biodiversity, jeopardize economic development and human health through losses of useful materials, genetic stocks, and the services of intact ecosystems. Material losses include food, wood, and medicines, as well as resources important for recreation and tourism. Losing genetic diversity, like losing species diversity, makes it even more likely that further environmental disturbance will result in serious reductions in goods and services that ecosystems can provide.

Decreased biodiversity also interferes with essential ecological services such as pollination, maintenance of soil fertility, flood controls, water purification, assimilation of wastes and the cycling of carbon and other nutrients.

## **2. Deforestation:**

Forest ecosystems contain as much as 80 percent of the world's terrestrial biodiversity and provide wood fiber and biomass energy as well as critical components of the global cycles of water, energy and nutrient. Forest ecosystems are being cleared and degraded in many parts of the world.

Current projections suggest that demand for wood will roughly double over the next 50 years, which will make increasing use of sustainable forest practices more difficult. In addition to threats to biodiversity and potential shortages in the supply of forest products, the degradation of forests represents an enormous potential source of greenhouse gas emissions.

Forest ecosystems contain about three times the amount of carbon currently present in the atmosphere and about one-third of this carbon is stored above ground in trees and other vegetation and two-third is stored in the soil.

When forests are cleared or burned, much of this carbon is released into the atmosphere. According to current estimates, tropical deforestation and burning account for about one quarter of carbon emissions into the atmosphere from human activities.

## **3. Desertification:**

Desertification and deforestation are the main causes of biodiversity loss. Both processes are decisively influenced by the extension of agriculture. The direct cost of deforestation is reflected in the loss of valuable plants and animal species. Desertification process is the result of poor land management which can be aggravated by climatic variations. Converting wild lands to agriculture often involves ploughing the soils which leads in temperate regions to an

average decline in soil organic matter between 25 and 40 per cent over twenty-five years.

Decreasing soil organic matter is always a clear indication of soil degradation, and often is accompanied by reductions in water infiltration, fertility, and ability to retain fertilizers. Ploughing also exposes soils to wind and water erosion, resulting in large-scale pollution of freshwater resources.

#### **4. Marine Environment:**

Oceans play a vital role in the global environment. Covering 70 per cent of the earth's surface, they influence global climate, food production and economic activities. Despite these roles, coastal and marine environment are being rapidly degraded in many parts of the globe.

In coastal areas, where human activities are concentrated, pollution, over-exploitation of resources, development of critical habitats such as wetlands, and mangroves, and water-flow from poor land-use practices have led to drastic reductions in near shore fisheries production and aquatic biodiversity.

#### **5. Increasing Wildlife Trade:**

According to Nick Barnes, "Trade is another cause of biodiversity depletion that gives rise to conflict between North and South." Global trade in wildlife is estimated to be over US \$ 20 billion annually. Global trade includes at least 40,000 primates, ivory from at least 90,000 African elephants, 1 million orchids, 4 million live birds, 10 million reptile skins, 15 million furs and over 350 million tropical fish.

#### **6. Climate Change:**

As climate warms, species will migrate towards higher latitudes and altitudes in both hemispheres. The increase in the amount of CO<sub>2</sub> in the air affects the physiological functioning of plant and species composition. Moreover, aquatic ecosystems, particularly coral reefs, mangrove swamps, and coastal wetlands, are vulnerable to changes in climate.

In principle, coral reefs, the most biologically diverse marine systems, are potentially vulnerable to changes in both sea level and ocean temperature. While most coral systems should be able to grow at a sufficient pace to survive a 15 to 95 centimetres sea-level rise over the next century, a sustained increase of several degrees centigrade would threaten the long-term viability of many of these systems.

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<sup>2</sup> Example: exercises for learning assessment (multiple choice questions; quizzes; true or false questions; etc.)



This will be developed in the IO3- Youth Workers Pedagogical Handbook