MOS
duurzame scholen
straffe scholen

Climate Change

Causes, effects and solutions

DEPARTEMENT
OMGEVING

mosvlaanderen.be

REFERENCES

IPCC reports are the main sources used to write this mind map and the accompanying text. The different IPCC reports contain an abundance of climate information. You can download them for free on the official IPCC website: www.ipcc.ch/reports. (Currently) the most important ones are:

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www.oce.global/en/resources/ipcc-summaries-teachers

This is where you will find a summary of the IPCC report for teachers:
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Introduction

Before you lies a text that goes with the MOS climate mind map. This was developed by MOS to support schools with climate education.

What is MOS?

MOS is a collaboration between the Government of Flanders, Department of Environment and Spatial Planning, the 5 Flemish provinces and the Flemish Community Commission. MOS has been providing support to primary and secondary schools since 2001.

MOS empowers schools who tackle sustainability issues by connecting them to the living and learning environment of the pupils. Global themes like climate change and the decrease in biodiversity are connected to environmental and specific themes that live in and around the school. Teachers and pupils who work around subjects that are locally relevant, often feel more strongly involved and more motivated. That is why MOS offers tailor made coaching to the schools.

Along with the school team, the pupils, the neighbourhood and the local partners, MOS aims to turn the school into a sustainable living and learning environment.

A school that works with MOS can count on:

- Tailored made support
  The MOS coach works together with the teachers, the principal(s) and the community to see what works for the school. The support is adapted to the needs and questions of the school. One of the possibilities is to choose a thematical MOS trajectory like a climate trajectory, a greening trajectory ...
- Informatie en inspiratie
  MOS informs and inspires—through newsletters, the website, the MOS sub-site on KlasCement and social media—about the wide offer of environmental educational and sustainable initiatives in Flanders and Brussels.
- Professionalisation
  MOS organizes networking moments to give schools a chance to exchange experiences. MOS offers in-service training, when needed also tailor made.

Failed harvests
Fresh water shortages
Longer periods of drought and heatwaves
Mudslides
Floods
Heavy precipitation
Floods
Sea level rises
Buffering effect CO_2 absorption decreases
Thermal expansion of water
Stronger tropical storms
Ocean gets warmer
Weather and climate change
Loss of biotopes
Ocean currents can change
Sea ice melts
Land ice melts
Temperature rising
Extreme weather
Effects
acidification of oceans
Disrupted ecosystems
E.g. coral reefs and calcareous plankton dies
Nature
Loss of biodiversity
Regions under pressure
Humanity
Geopolitical tension and conflicts
Mass migration
Worse consequences for poor regions
Less products from ruminants
Influence your government
Talk about it with your community
Get informed
Sustainable electricity suppliers
Solar boiler
Warm water
Solar panels
Electricity
Solar power
Wind turbines
Electricity
Wind energy
hydroelectric power station
Water power
Renewable energy sources
What can we do?
Carbon captur
Limit and compensate air travel
Transport
Heat pump
The right heat source
Heating networks
Sustainable hydrogen gas
Smart energy use
Insulate
Low-energy household appliances
Energy efficient LED lighting
Consume less, buy smart, share and reuse
Circular economy
Stappen (On foot)
STOP principle
Personenwag (passenger ca
Trappen (By bike)
right engine
Openbaar Vervoer (public transport)

Climate change

What is it?

Climate <> weather

- Glaciers melt
- Fresh water shortages
- Sea level rises
- Floods
- Vulnerable regions e.g. river deltas, islands

Natural green-house effect

Enhanced greenhouse effect

- Climate inertia
- Extra greenhouse gas emissions
  - Methane (CH_4) 16%
  - Fluor gases 2%
  - Carbon dioxide (CO_2) 76%
  - Laughing gas (N_2O) 6%
- Tipping elements
  - Icecaps melt
    - less light reflection
  - Permafrost thaws
    - Extra methane

Causes

Burning fossil fuels (71%)

- Coal
- Petroleum
- Natural gas

Change in land use (9%)

- Deforestation
  - Agricultural land
    - Pasture
    - Monocultures (palm oil, fodder ...)
  - Mining
- Marsh draining
  - Stock breeding
  - Agriculture

Other causes (11%)

- Digestion process ruminants
- Limestone production and processing
- Waste sector

Dealing with the effects

- More nature and green
  - Cooling
  - Water infiltration
- Forestation
- Sustainable forestry
- Products with a label for sustainable forestry

Why a MOS climate mind map?

The climate mind map was developed to guide MOS schools that want to focus on climate education. In the two-year climate trajectories that MOS offers, the pupils and teachers are incited to think and act sustainably and climate-friendly.

During the first year of the climate trajectory, professionalisation plays a central role. The school goes deeper into the climate issues in different ways, with help from MOS.

The MOS climate mind map is a tool that can be used for that purpose. In the accompanying text, we explain in a simple and clear way what climate issues entail.

Interested in a MOS climate trajectory?
More info: www.mosvlaanderen.be/themas/klimaat

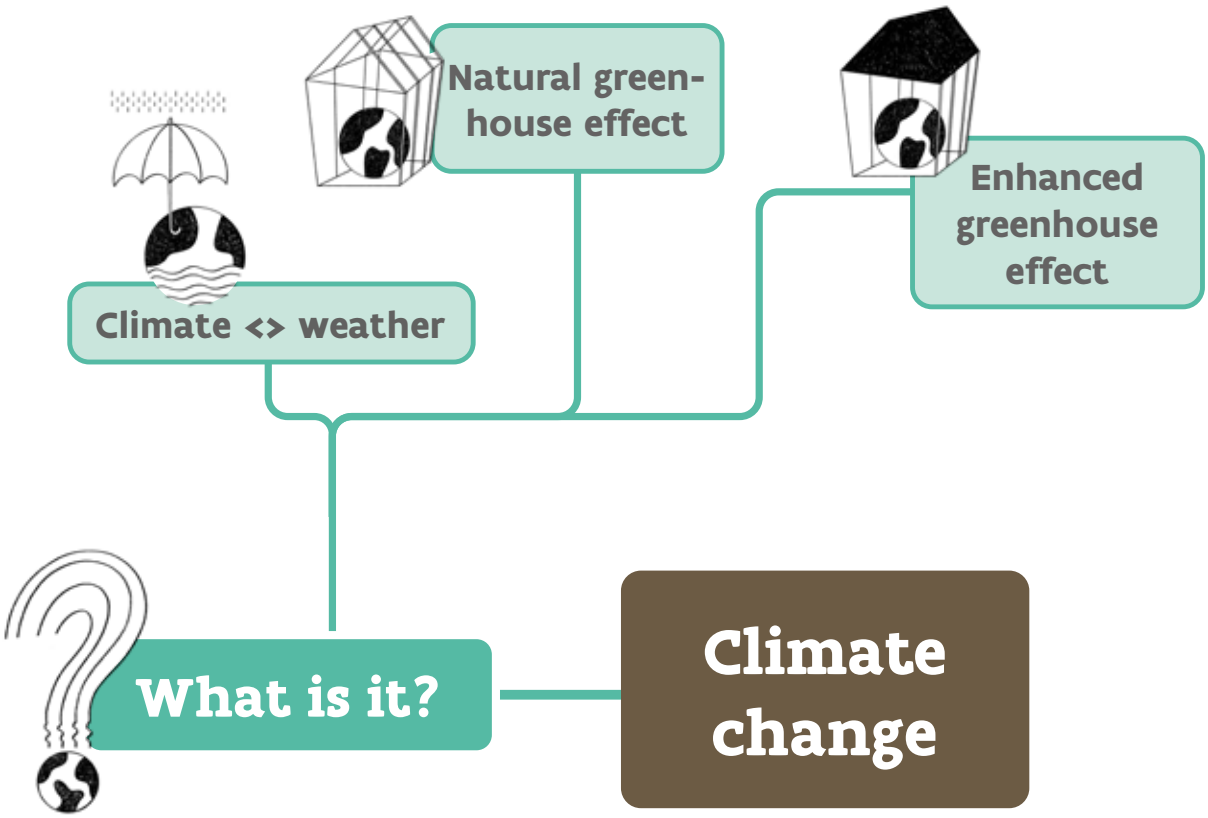
The MOS climate mind map explained

Climate change is the challenge of the 21st century. This worldwide problem causes a lot of confusion due to its complexity. There are a lot of misunderstandings about this subject among teachers and therefore also among pupils and students. MOS has developed the 'MOS climate mind map' to give answers. In making this mind map, MOS used information from scientific research and literature on the subject. Teachers can use the climate mind map and the accompanying text to keep an overview and to use it as teaching material.

A mind map mostly shows structure and connections with short keywords. To make everything as easy to understand as possible, we give additional information about the keywords.

Mind map explanation

A mind map mostly shows structure and connections with short keywords.
To make everything as easy to understand as possible, we give additional information about the keywords.


Natural green-
house effect
Enhanced
greenhouse
effect
Climate <> weather
What is it?
Climate
change

1. What is climate change?

Quickly: the difference between weather and climate!

The weather is de state of the atmosphere at a certain moment and a certain place (temperature, precipitation, clouds, air pressure, wind speed, atmospheric humidity ...). Climate is the general state of the atmosphere, the oceans, the sea ice ... for a longer period (30 years, preferably more).

1.1 WHAT IS THE 'NATURAL' GREENHOUSE EFFECT?

The earth is surrounded by an atmosphere where greenhouse gases are naturally present. We can look at this atmosphere as a blanket. The way the sun heats an object, the sun heats the earth. If we hold our hand above an object that's in the sun, we feel the heat emitted by the object (for example a car that's standing in the sunlight). The earth radiates its heat back into space the same way.

It's this heat radiation (invisible infrared radiation) that is absorbed by the greenhouse gases (the blanket) and sent back to earth. The sun heats up the earth and the earth sends its heat back into space. In other words: because of the natural greenhouse gases in the atmosphere, part of that heat stays here on earth and not all heat disappears into space. That is why the average temperature on earth is 15°C. Without the natural greenhouse effect, that temperature would be -18°C.

So, this natural greenhouse effect is very important for life on earth. A long as the incoming and emitted heat are in balance, the average temperature on earth stays constant. The greenhouse gases largely determine the energy balance of the earth. The greenhouse gases (the blanket) slow down the speed at which the earth surface loses heat.

1.2 WHAT IS THE 'ENHANCED' GREENHOUSE EFFECT?

Since the industrial revolution (1750), when coal, petroleum and natural gas were discovered, humanity has been bringing more greenhouse gases into the atmosphere. The greenhouse gases accumulate, which causes the insulating blanket to stop even more heat radiation and the earth to keep getting warmer. The blanket basically becomes a double duvet.

Around 2019, the average temperature on earth had risen by 1.1°C compared to about 100-150 years ago. That may not seem like much, but for the climate system, such a warming is unbelievably fast. This makes that all life on earth has to adapt to the global climate change, but this adaptation is difficult for both humans and nature because of how quickly it's warming (more info in 3. What are the effects of climate change).

What we see now is a result from emissions from dozens of years ago. Just like it takes a while for the living room to warm up when you put the thermostat on a higher temperature, it takes a while for the earth to react to the higher concentration of greenhouse gases. Between the emission and the consequences of it, there is a delay of dozens to thousands of years. That is called **climate inertia**.

According to the NOAA measurements, the concentration in April of 2020 (416 ppm) is the highest since the start of the measurements in 1958. For similar concentrations, we have to go over 3 million years back in time, according to research from ice samples. The 'modern' human being has only been walking around on this earth for 200 000 to 300 000 years and therefore has never lived through such concentrations. This concentration is 150% more than before the industrial revolution.

In 2019, about **55 gigatons of CO_2 equivalents (see "What do you need to know about these greenhouse gases") of additional greenhouse gases** were brought into the atmosphere, globally. That is 55% more than in ca. 1990 and 40% more in comparison to the beginning of the 2000's. Greenhouse gas emissions still increase every year. This CO_2 will keep having its insulating effect for thousands of years.

It's time to stop this global warming NOW. If we don't intervene fast, we will live in an entirely different world 100 years from now. A world where humans, animals and plants can barely survive.

1.3 WHAT IS A TIPPING ELEMENT AND WHAT ARE THE EFFECTS OF THAT?

Tipping elements are like dominos that, when they fall, cause irreversible processes. Some tipping elements lead to quick, local changes. Others increase global warming, which causes a process that reinforces itself, which becomes constantly harder for us to control.

The rise in temperature, therefore, has to stay as low as possible, preferably under 1.5°C, if we want to keep the effects of global warming under control.

Some well-known examples of tipping elements:

- **The thawing of the permafrost.** The permafrost is the frozen soil, for example in Siberia and North America. Because of the thawing, large quantities of stored methane and CO_2 are freed and released into the atmosphere. Because of that, the warming speeds up and the permafrost keeps thawing. This is already happening right now.
- Another dangerous tipping element is the **melting of sea ice on the north pole and the ice cap in Greenland**. When there is less ice, solar radiation will be reflected much less and is absorbed by the sea water and the earth's surface. Because of that, the temperature rises and the ice keeps melting away.

It is hard to predict when these tipping elements will occur. We have to do everything we can to prevent them.

1.4. WHICH GREENHOUSE GAS CONCENTRATIONS ARE CAUSED BY PEOPLE?

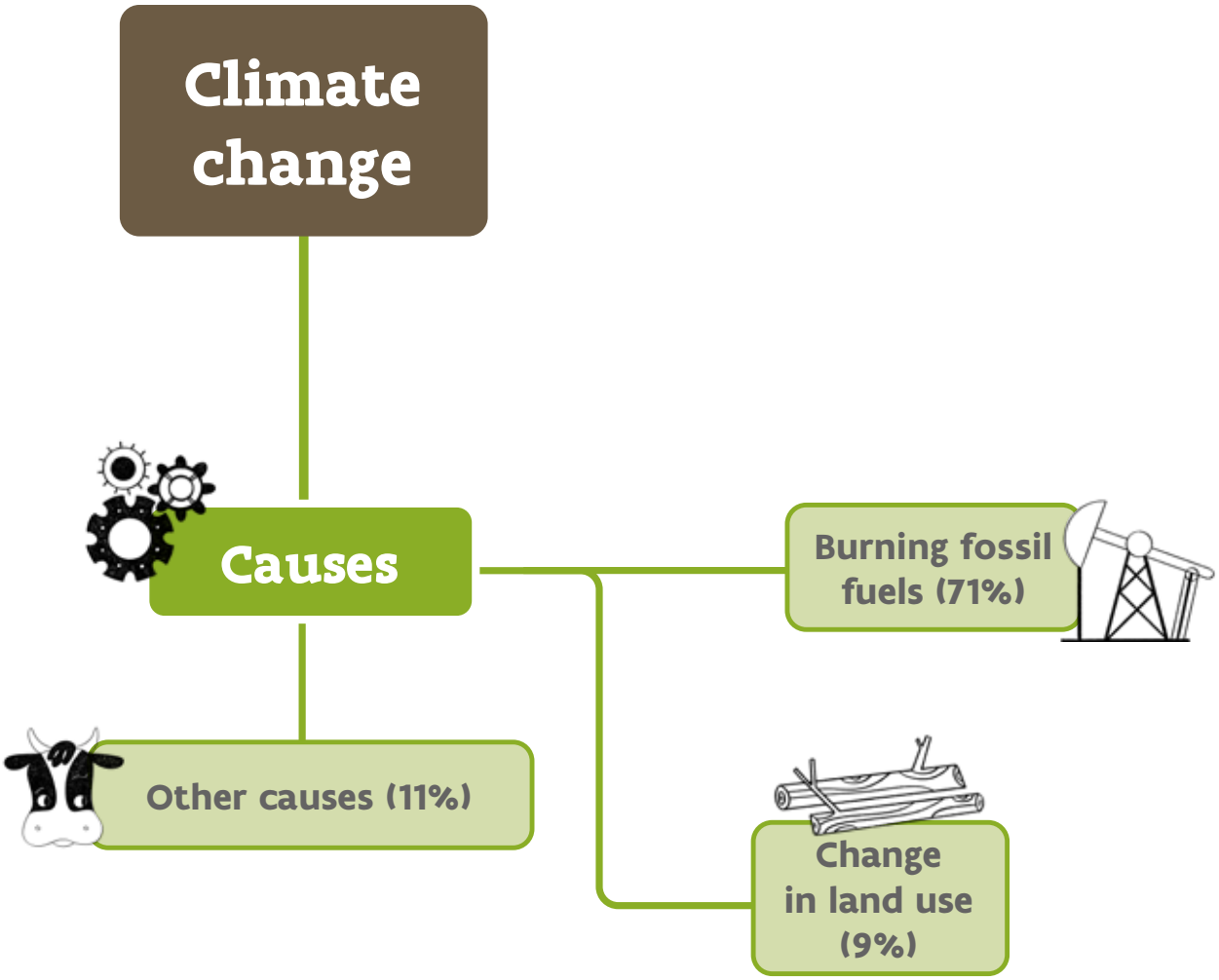
- Carbon dioxide or CO_2 is the greenhouse gas with by far the biggest impact. It is caused by the combustion of fossil fuels.
- Methane CH_4 comes from natural gas (often as a by-product from the extraction of petroleum), but you can also find it in the digestive gases of ruminants (especially burping).
- Besides those, there are a couple of gases with a more limited total effect on the climate, nitrous oxide gas and fluorine gases. Nitrous oxide gas comes from fertilized soil. Fluorine gases come from, among others, badly disposing of airconditioners and fridges.

1.5. WHAT DO YOU NEED TO KNOW ABOUT THESE GREENHOUSE GASES?

Not all greenhouse gases have the same effects. Certain greenhouse gases are much more powerful, others have a longer lifespan or are rich in number. Put these three factors (power, lifespan and quantity) together and CO_2 appears to be responsible for about 76% of the human greenhouse effect. Methane is responsible for about 16% and fluorine gases 6 and 2% respectively.

To compare the power of greenhouse gases, CO_2 equivalents are used (CO_2 eq). CO_2 itself is 1 CO_2 eq. Methane (CH_4) is 25 CO_2 eq. (www.klimaat.be)

Besides the long lifespan of CO_2 (thousands of years), it's mostly the large quantity of it (99.5% of all emitted greenhouse gases) that causes the strong effect of CO_2.


Climate change
Causes
Burning fossil fuels (71%)
Other causes (11%)
Change in land use (9%)

2. What are the causes of climate change?

2.1 FOSSIL FUELS

About 71% of the enhanced greenhouse effect is caused by the combustion of fossil fuels.

What are fossil fuels?

Fossil fuels originate from remains from plants and animals from dozens of millions up to hundreds of millions of years ago. They are easy to extract and are heaped with energy. Coal, petroleum and natural gas are used to generate energy for transport and generating electricity. Out of these fossil fuels, (brown) coal is the most polluting fuel. Coal produces twice as much CO_2 per energy unit as natural gas.

2.2 CHANGE IN LAND USE

Changes in land use are responsible for about 9% of the total emission of greenhouse gases. Massive deforestation gives space to human activities and marshes are being drained for arable and livestock farming. Marshes have a lot of CO_2 stored in the ground. During the reclaiming of these areas, that CO_2 is released.

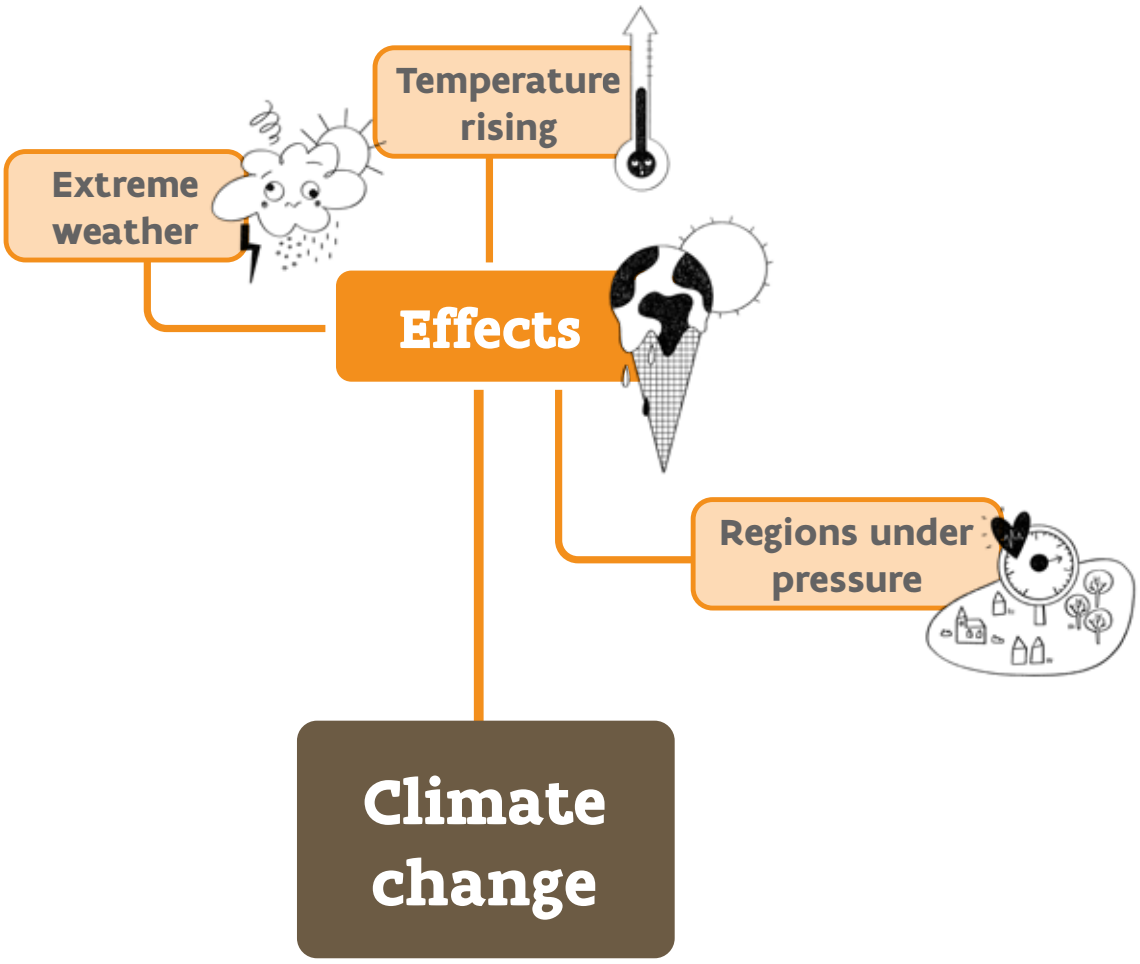
Trees take in CO_2 and give oxygen in its place. Sadly, lots of forests are cut down and burned down, usually to make space for agricultural land. These are often meant for monocultures and palm oil plantations and soy fields for animal fodder. While large scale deforestation in Europe already started in the Bronze Age, deforestation is now mostly focused on tropical regions. First and foremost are Brazil and Indonesia. Tropical forests are in 3 out of 4 cases burned down to make space for new agricultural land, often for the production of palm oil and soy (fodder).

2.3 OTHER

Stock breeding: Ruminants (cows, sheep, goats and buffalos) produce special gases during digestion (mostly methane), by burping and (less so) farting. We don't find this methane in the digestion of poultry or pigs, which makes the meat from these animals a lot more climate-friendly. Stock breeding is responsible for about 11 to 14.5% of the enhanced greenhouse effect. Deforestation, animal fodder and transport included.

Limestone production and processing causes 3.5% of the current global warming. During the production of cement, limestone and clay are mixed under high temperatures. During the heating of limestone, CO_2 is released.

Waste sector: Waste is an important environmental issue. The waste sector, however, only slightly contributes to global warming. In Belgium, it's responsible for 1.3% of the total national emissions. The issue is mostly present in badly ventilated dumping grounds, where methane is released.


Temperature rising
Extreme weather
Effects
Regions under pressure
Climate change

3. What are the effects of climate change?

Between the moment of emission and the effects of it, is a delay of dozens to thousands of years. The change in climate we see now, is mostly the effect of emissions from the second half of the last century. This is because of a couple of slowing, buffering mechanisms. The oceans play a very important role here, because they can absorb a lot of heat and CO_2.

3.1 PRESENTLY, TEMPERATURE HAS ALREADY INCREASED BY 1.1°C

The temperature rise of 1.1°C is a global average. By the poles, it warms up twice as fast as this average. In the northern hemisphere, it warms faster than in the southern hemisphere, because there is more mainland which heats quicker than water. In Western Europe, temperatures have risen about 1.5-2°C compared to the pre-industrial era.

A rise of just a couple of degrees may not seem much, but it can have gigantic effects on what the world looks like. During the ice age, for example, temperatures were about 5°C lower than they are now and the world looked completely different. Sea level was 120m lower than it is now. We are currently moving quickly towards a warming of 3 or 4°C, unless drastic measures are taken.

Global warming causes our oceans to get warmer. This causes a thermal expansion of the sea water that results in a sea level rise. The salt concentration of the ocean is being influenced by the incoming meltwater. This could change ocean currents. These have an influence over the weather conditions and the climate on land. The Gulf Stream for example, a warm current that exchanges energy between The Tropics and the Arctic, largely determines our Western European weather and climate. If this current slows down or disappears, our weather and climate will change drastically. The warmer the ocean temperature gets, the less CO_2 can be absorbed by the ocean and the smaller its buffering effect.

The consequences of the rise in temperature are the melting of floating sea ice, land ice (glaciers, ice caps) and the permafrost. The melting ice caps contribute to the sea level rise. It's not the melting sea ice that has an effect on the rise, but the melting of land ice. In the long term, melting glaciers can locally cause fresh water shortages.

3.2 EXTREME WEATHER CIRCUMSTANCES WILL ARISE

In general, we can say that climate can change a lot locally. This means that Southern Europe for example, can evolve to have an extremely dry climate. Western Europe can probably be confronted with long periods of drought during summer and heavy rains in winter.

Climate change causes less stable and more extreme weather. Chances of heatwaves and long periods of drought increase. There will be short periods of extreme precipitation, causing floods or mudslides. The odds of strong tropical storms developing (hurricanes, cyclones, typhoons) increase as well. Because of these extreme weather circumstances, more harvests will fail, drinking water in certain areas will be more scarce and we will have more floods.

3.3 VULNERABLE REGIONS UNDER PRESSURE

According to geological standards, the current global warming is going extremely fast: at least ten times faster than the fastest natural rise in temperature ever recorded. In the past, we've seen that fast changes in temperature always went with a wave of extinction among plants and animals. Such a wave is going on right now. Plants and animals aren't just confronted with climate change, but also with a drastic loss of biotopes. Sensitive species and species in need of certain living conditions will go extinct much easier because of the extreme weather. Species try to adapt to climate change, but this doesn't always work because it is happening so fast and because they also have to deal with other kinds of human disruption. Disrupted ecosystems arise, like in the example below. Example: The rise of CO_2 in the atmosphere causes oceans to absorb part of that CO_2. The increase of CO_2 in the water however, brings about the acidification of the ocean, which in turn causes marine life (e.g. corals, shellfish) and fishing activities to be affected.

Large groups of people might/will migrate looking for a better place, because the lowest regions (like river deltas and islands) will be taken over by the ocean and the drought will continue to take its toll.

Because of this, vulnerable regions, especially the poorest, will become sensitive to scarcity and conflicts. Geopolitical tensions will rise and turmoil looms. There will be more and more climate refugees, an estimate of ten times what we have today within 30 years. The most vulnerable regions are first and foremost the Middle East, Africa and South-east Asia.

The Paris Climate Agree-ment

On December 12, 2015 the first climate agreement where nearly all the countries in the world agreed to take action against global warming, was made in Paris. The goals they agreed upon were to keep the average rise in temperature below 2°C and to work to limit the warming to 1.5°C. The agreement uses a bottom-up approach, where every country determines their own national contribution and executes it. But already, it's become clear that the pace at which countries do their share, will lead us to a warming of 3.2°C in 2100. That is why the participating countries promised to evaluate each other's climate policy every 5 years and adapt if necessary. In the agreement, arrangements were made about a climate fund, financed by the wealthier countries with the highest historical emissions. With the money from the fund, developing countries should be able to protect themselves against the effects of global warming and be to continue their development in a climate-friendly manner.

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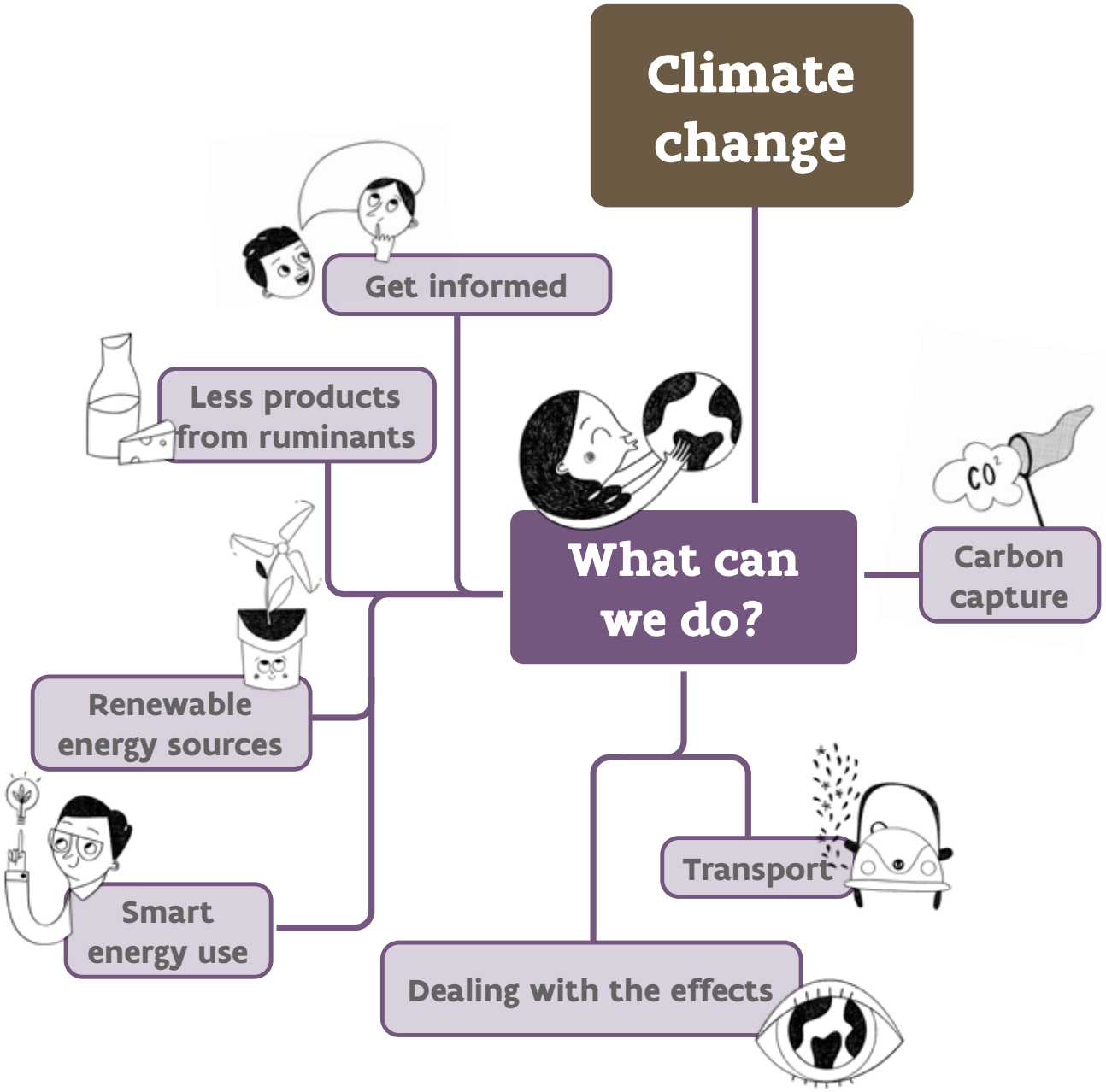
Climate change
Get informed
Less products from ruminants
What can we do?
Carbon capture
Renewable energy sources
Smart energy use
Transport
Dealing with the effects

4. What can we do?

What can we do at school, as youngsters, as citizens ...?
We made a summary of the most important things.

4.1 GET INFORMED AND GIVE THE RIGHT EXAMPLE

Get informed and investigate how you can live more climate-friendly. Talk about it with your neighborhood and stimulate others to consume as little CO_2 as possible. Influence your city and the government to take action and reduce CO_2 consumption as much as possible.

4.2 CHOOSE RENEWABLE ENERGY SOURCES

The worldwide potential of renewable energy is huge. With modern technology, we can generate 4 to 6 times more energy than what the world currently needs, at a reasonable price. We have to evolve towards a society that runs on electricity, generated by solar and wind energy.

Solar energy from solar panels, wind energy from wind turbines and hydroelectric power stations can just as well provide us with the necessary energy. So install solar panels and a solar boiler on your roof, if possible.

Choose a sustainable electricity provider. Check the Greenpeace rating, which objectively ranks the providers.

Choose sustainable heating like:

- **heat pumps** are a sustainable heating solution with a low CO_2 emission. The appliances get 75% of their energy from renewable sources like the ground, air or water.
- **heating networks** are underground circulation pipes, connected to a heat source, like a heating installation or a big factory with a lot of residual heat. Houses, companies, appartements, schools, hospitals and even entire cities can be connected like this for heating and warm water.
- **sustainable hydrogen** gas is a way to use the residual green electricity to generate hydrogen gas. This can be mixed into our natural gas network. This technique cannot be applied by regular citizens yet. The generation of sustainable hydrogen gas is only happening on a small scale right now, but there is still a lot of potential and it offers perspectives.

4.3 BE SMART ABOUT USING ENERGY

Avoid unnecessary use of energy. Investigate where you can contribute to consume less energy yourself. E.g.:

- Use efficient lighting. LED lights can save a lot of energy.
- Buy household appliances with the most economical energy label.
- Insulate your house as well as possible.
- Choose responsible consumption and share things with neighbors/friends/family. Repair and buy secondhand (see also www.detransformisten.be). Don't buy rubbish or unnecessary items, go for quality. Exploiting raw materials, production, transport and processing mostly happens with energy generated from fossil fuels...
- Buy local food and locally made items.
- Make your purchases (and possible investments ...) at companies prepared to make the transition to a circular economy that runs on renewable energy.
- In a circular economy, the CO2 impact of a product or service across its entire lifecycle will definitely be smaller than in a linear system. In Belgium, they take the final dismantlement at the end of the lifecycle into account during the design stage of a product. To this end, materials are used in such a way that they can be easily separated and reused and there are already customers for the residual products.

4.4 THINK ABOUT YOUR TRANSPORT AND CHOOSE A LOW-CARBON EMISSION OPTION!

Travel according to the **STOP** principle: first '**S**tappen' (on foot), then '**T**rappen' (by bike), after that comes using '**O**penbaar vervoer' (public transport) and lastly, if there really isn't another option, you use a '**P**ersonenwagen' (passenger car). If you buy a new car, choose one that drives solely on electricity. Share your car with the neighbourhood. Limit airplane travel, take the train whenever you can inside of Europe. If you have to take a plane, compensate for your flight by investing in a certified CO_2 compensation project.

4.5 CAPTURE CO_2

Remove CO_2 out of the air by planting as many trees as possible and provide sustainable forestry. Trees and plants can capture a lot of CO_2 on a large scale and lower the CO_2 concentration. So plant as many trees as possible and contribute to sustainable forestry. Buy paper and wooden furniture with a sustainable forestry label (FSC, PEFC). There is a lot of experimenting around the capture of CO_2, **but there is no miracle solution.**

4.6 AVOID RUMINANT PRODUCTS

Eat as little beef, lamb and animal dairy products as possible. They all come from ruminants that have an enormous climate impact. Become a vegetarian or choose more often for a vegetarian alternative and when eating meat, choose chicken and (to a lesser degree) pork. These have a significantly lower climate footprint than beef.

4.7 DEALING WITH THE EFFECTS

Climate adaptation is the process of society adapting to the actual and expected climate change and the effects of it. More nature is definitely important to slow down certain effects of global warming: green and water elements have a cooling function and green areas are the sponge that can moderate the negative impact of floods in other places. Make your own garden therefore green with lots of variation and little paving and stimulate your city to develop green parks.

If we all live more climate conscious, we contribute to limiting the emission of greenhouse gases and a slower global warming. In addition, we will be working towards healthier air and cleaner water. Planting more greens provides a more comfortable living environment, for man and animals. Together, we can do this!

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