# UNDERSTANDING CLIMATE CHANGE

Visual communication for scientific facts

Masterarbeit – Audiovisual Arts Computing

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*First, I would like to thank my supervisor, prof. Dipl.-Anim. Peter Kaboth.*

*He consistently allowed this paper to be my own work, but steered me in the right direction whenever I needed with his insightful feedback.*

*Thanks to my family, who offered her encouragement through these years.*

*Specially,  I would like to thank to my daughters who inspired me, believed in me and motivated me when I needed it the most.*

*This work is dedicated to them.*

*I hope our generation can do better, leaving you a worth living planet.*

*Love you "pirrus"!*

## Abstract

Climate change is happening now. Because of our dependence on fossil fuels, climate change will continue into the future with relatively unpredictable impacts on humans and the environment. There are several psychological barriers and other challenges that prevent people from committing themselves to the cause of mitigating climate change through behavioral change. The complexity of the issue, its abstract nature and the uncertainties associated with predictions and scientific research make it difficult for non-experts to grasp. Interdisciplinary collaborations can overcome the insular focus of climate change science. A shared methodology that combines best practices from other disciplines like psychology, marketing and visual communication, may help to better results when trying to communicate complex messages to the mainstream public. This research explores the above points and then develops a series of recommendations for climate change communication based on the gained knowledge.

The graduation project (a Website) is based on these recommendations https://climatechange.infografia-design.de/

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## Foreword

I started researching possible topics for my graduation paper at the beginning of this year (2021), the federal elections in November were still relatively far away and the catastrophic floods of summer 2021 in Germany were something that did not fit into the German collective imagination. Now, in September 2021, I am writing this introduction two weeks before the German federal elections, an election where climate change became one of the main campaign issues for the first time. It is a time when the various extreme weather events that have been occurring in Europe and across the world have set off global alarms and have permeated individual and community perceptions.

I remember hearing about climate change and the effects of man's actions on it as a teenager. At that time the apocalyptic scenarios were related to the hole in the Antarctic ozone layer and its consequences.

In 1974, the list of the main threats to the conservation of the ozone layer was published for the first time, and in 1985 it was discovered that there was a hole in the ozone layer over the Antarctic ice cap. A large number of scientific studies (Lickley, Solomon & Fletcher, 2020) had shown that certain substances (chlorofluorocarbons) used in industrial products such as refrigerants, aerosol propellants or solvents were directly damaging the ozone layer and causing its weakening. This set off worldwide alarms and raised concerns that continue to this day.

Faced with the imminence of the problem, action was taken; 197 countries signed the Montreal Protocol in 1987, a manifestation of the will of the governments that agreed on measures to reduce the production and commercialization of chemical substances that damage the ozone layer.

Why do I start my graduation paper by citing this example?

The ozone hole issue is considered one of the great successes of international agreements on environmental issues on a global scale. Decades ago, the scientific community warned about the harmful effects of CFC gases on the ozone layer, and the Montreal Protocol laid the groundwork for their reduction, which prevented the problem from worsening. Although the hole has been maintained as a result of the gases already emitted, the ozone layer problem is now considered to be under control.

This is what links the ozone example to the current discussion on climate change. Current calls to reduce emissions now to avoid damage in the future are fueled by positive examples such as the ozone layer: a challenge that, while humanity was able to address in time, makes it clear that recovery may take many, many years.

 On the other hand, the question remains open: what would have happened if the knowledge and understanding of the ozone layer problem had remained within scientific, environmental and political circles?

In the eighties, the ozone issue was widely covered by the media and captured the attention of the general public, the urgency of the problem was duly transmitted to the mainstream public. This contributed to generate pressure from citizens towards their governments, which in turn reacted by taking concrete actions.

If we have learned anything from the lessons of history, it is that political will (referring to democratic systems) and knowledge of a problem is not always enough to bring the needed change. Often, public pressure and derived political interests are a more effective means of pressure than the undisputed urgency of reforms.

For many decades there has been a general consensus within scientific circles that climate change is real, is happening now and will bring painful consequences for the inhabitants of planet Earth. However, it is only recently that the message is getting through to a larger part of the general public.

In this context and with the intention of channeling "pre-traumatic stress"[1] in a productive way, the motivation for my graduation work was born. In my role as a visual designer and communicator I take the question: how can communication design serve as a bridge to communicate the complex issue of climate change addressed by the scientific community in more understandable terms and thus reach the general public? as a starting point. In this way, I hope to contribute to communicate the message of responsibility and urgency to take measures aimed to curb climate change.

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1        Vague but inescapable fears of the coming climate catastrophe. Lise Van Susteren, MD speaks on Mental Health Issues and Climate Change: https://www.youtube.com/watch?v=vn9TlyhZBAw

## I Part

*"Despite extensive exploration into the use of language in climate change communication, our understanding of the use of visual images, and how they relate to public perceptions of climate change, is less developed. A limited set of images have come to represent climate change, but rapid changes in the digital landscape, in the way media and information are created, conveyed, and consumed has changed the way climate change is visualized."*

(Wang, Corner, Chapman, Markowitz, (2018))

## Introduction

*"It is worse, much worse, than you think..."*

So begins David Wallace-Wells' famous book *"The Uninhabitable Earth"* (2019).

Two years before the book appeared, in 2017, Wallace Wells published an article of the same name in the New York Times. There he portrayed a world of drought, plague and famine, in which acidified oceans drown coastal lands, latent diseases are released from ancient ice, conflicts arise and economies collapse. The article was on the one hand applauded by those who thought it was time to describe the stand of the things clearly and on the other hand criticized by those who considered it irresponsible alarmism. Among supporters and antagonists it was nevertheless one of the most widely read articles on climate change in U.S. history.

The interview with the author, made by Jonathan Watts (2019) for The Guardian newspaper, together with his book cover a thematic range that will be useful as an introduction to this work, as they help us to have an overview of the current state of knowledge on climate change and its discourse.

There has been a general consensus in the scientific community for many decades. Climate change is happening and human actions are responsible for it. The consequences of climate change are not only already visible, but are also documented by the statistics of the last decades.

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to provide comprehensive assessments of the state of scientific, technical and socioeconomic knowledge on climate change, its causes, potential impacts and response strategies. Since then, the IPCC has presented 6 special reports, the last one in August 2021. The summary of the main theses (IPCC, 2021):

1. We're on course to reach 1.5 degrees C of warming within the next two decades.

2. Limiting global warming to 1.5 degrees C by the end of the century is still within reach, but requires transformational change.

3. Our understanding of climate science - including the link to extreme weather- is stronger than ever.

4. The changes we are already seeing are unprecedented in recent history and will affect every region of the globe.

5. Every fraction of a degree of warming leads to more dangerous and costly impacts.

In his book Wallace Wells express; *"this is not a book about the science of warming; it is about what warming means to the way we live on this planet"* (2019 p.14). The author certainly gives a general account of the current state of scientific knowledge, but he does not spend much reading time ex-

plaining or trying to convince the reader of what is no longer in doubt. His work focuses on describing the consequences that await us due to global warming and above all, how they may become painful for humanity.

We could say that his intention is no different from Greta Thunberg[1]'s famous "I want you to panic". When talking about his motivation the writers says; *"I wanted people to be scared, and tell how scared I am and how fear motivates me to do something, in this case, it write about climate change."*

Wallace also calls for action, *"We should not sit back and feel complacent that the world beyond us will figure this out without political pressure. We cannot continue on the path we are on and believe our future will be secure and stable. We need to dramatically change our climate policy globally".*

In the same interview Wallace-Wells comments on the fact that was most shocking to him *"When I learned the astonishing fact that more than half of the carbon we have emitted into the atmosphere from burning fossil fuels was emitted in the past 25 years, that really shocked me. This means we have burned more fossil fuels since the UN established the Intergovernmental Panel on Climate Change (IPCC) than in all of the centuries before - so we have done more damage knowingly than we ever managed in ignorance."* (Watts, 2019).

This key point; to continue a behavior knowing the harmful consequences derived from it, is one of the most contradictory and yet most related

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1 "I want you to panic. I want you to feel the fear I feel every day. And then I want you to act. I want you to act as you would in a crisis. "Speech World Economic Forum, 25 January 2019

to human nature when talking about addressing climate change with concrete actions. The gap between what is known and what is done exists at the political, industrial and individual levels. Just think of our friend or family member who continues to smoke despite the fact that there is no doubt in the scientific community or in their individual convictions that smoking is harmful to their health and that the risk of suffering painful consequences from their behavior is real.

The discrepancy between convictions and behavior is a key issue in the area of climate change communication and a topic I will address in this paper.

Another topic covered in the interview, is the success of the article published in 2017, *"It had about 6 million page views. Within a couple of days, it was the most-read article we had ever published. It was a true phenomenon".*

According to the author, the range of scope obtained was a surprise for the editors, since it was assumed that articles on climate were not of general interest at that time (in the United States). According to the author, at the time of writing, common storytelling techniques were avoided and, although it sounds contradictory, extra drama was avoided to give extra drama to an already dramatic subject.

The same communication strategy of the article was applied to his book, where he focuses on the consequences of a warming of approximately 2.4°C. His book is written in a factual and informative way, with easy-to-digest language and at the same time properly documented with footnotes and bibliographical references. This was in contrast to the over-detailed, neutral and sometimes difficult to understand language of the scientific communi-

ty. Wallace Wells had previously criticized scientific reticence, accusing this community of being extremely careful in conveying their troubling findings to the general public.

While both the article and the book were accused of hyperbolism, exaggeration and irresponsible scaremongering by their critics, the fact remains that the publications did their job: to reach a wide range of the mainstream public.

Referring to which strategy is the most effective in motivating change, the author admits that fear and alarm is only one of many options. There is also room for hope and optimism and the many shades between the extremes. While in his case it is fear that motivates him to act, the different motivations vary from individual to individual, as well as between social and cultural groups.

Wallace Wells does not describe himself as an eco-activist, but primarily as a journalist and writer. In his words *"It is important to mobilise people who at the moment are concerned, but basically complacent, and turn them into people who are much more activated and essentially voting about climate as a first-order political priority rather than a third- or fourth-order priority - judging politicians on the basis of their climate policy"*. He describes how the book is simply a product of the state of play and his work as a journalist, pragmatically stating *"We know these things are true to the extent that scientists can know them. I don't think the public should be shielded from them."*

Communicating the urgency of structural changes at the political, social and individual level is a goal currently shared by many initiatives at all levels; individual, communal, national and global. From 2019, when Wallace Wells' book was published, to the current date has not been that long, yet movements like Fridays for Future have spread beyond their original boundaries and peer groups. Fridays, Parents, Scientist, Creatives for Future and the list that continues to grow are examples of initiatives at the personal and civil level that exemplify very well how the

The Covid-19 pandemic is a lesson for humanity in how certain extraordinary emergency situations know no geopolitical boundaries. In the same way, extreme weather events no longer would occur only "on the other side of the world" but in our country, city or neighborhood.

Although there is a long way to go and time is not on our side, the increase in public interest is a positive development whose consequences are beginning to be felt at the political level and in the industrial sector.[2]

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2      Here I am mainly referring to the change in the political discourse on climate change. Concrete political action when it comes to taking measures still leaves much to be desired in terms of effectiveness and above all time for action. On the one hand, there is more awareness and willingness on the part of industry, private enterprise often does not face the bureaucratic obstacles of other institutions, but greenwashing is also at its peak. Political populism and greenwashing are important and related topics that will not be dealt with in this paper.

## Status quo
## Climate Change is everywhere and nowhere

*"Many people still question, or are not aware of, scientific findings regarding human-induced climate change. This lack of awareness and understanding exist today despite scientist having known for more than a century that the increased concentration of greenhouse gases in the air influences the global temperature"*. (Holmes & Richardson, 2020. Ch.2. p.22)

Climate change is occurring regionally and globally. The more the world warms, the greater the changes in the climate system become. These include more frequent and intense temperature extremes, marine heat waves, heavy precipitation, agricultural and ecological droughts in some regions, the proportion of intense tropical activity, cyclones and reductions in Arctic sea ice, snow cover and permafrost.

Climate change is also a social justice issue, The group of the 20 largest global economies are responsible for 78% of the world's greenhouse gas emissions. The richest 10 % (630 million people) are responsible for more than half (52 %) of $CO_2$ emissions between 1990 and 2015. (Gore, Alestig & Ratcliff, 2020).

*"Climate change is happening now and to all of us. No country or community is immune,"* said UN Secretary-General António Guterres. *"And, as is always the case, the poor and vulnerable are the first to suffer and the worst hit."* [3]

While for many people, especially in first world countries, climate change remains an abstract and distant reference to an upcoming problem, some of the most vulnerable populations and economies are being the first to feel its impacts. But sooner or later climate change will cease to be a problem far away in distance and time and will become a problem of our country, our community, and our home.

Communicating effectively on an issue that is complex, confusing, uncertain, and sometimes overwhelming is a challenge. For people to be motivated and empowered to adopt the changes needed to reduce environmental threats, they must be able to interpret and respond to information. The impact of communication on behavior varies dramatically depending on how information is handled and delivered.

In the following chapters we will examine common communication challenges, psychological barriers and mechanisms as well as tools and strategies for climate change communication.

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3        UN Secretary-General António Guterres delivered a landmark speech on the state of the planet at Columbia University in New York on 2 December 2020, setting the stage for dramatically scaled-up ambition on climate change over the coming year.

## Research question

How can designers and visual communicators contribute to transmit scientific knowledge and facts to a non-expert public in an understandable and relevant way, in order to generate awareness, motivate reflection and behavioral change.

What factors should be considered to generate visual materials suitable for communicating the knowledge and messages of the scientific community.

## Goals

- To understand the causes and consequences of climate change and share this knowledge in order to motivate change and raise public awareness.

- Analyze the factors that hinder communication on climate change.

- Analyze how different factors influence the perception of the message.

- To contribute in my role as a designer to transmit scientific knowledge related to climate change in an attractive and understandable way.

- Based on the two previous points, to make my contribution as a designer and communicator in order to disperse knowledge about climate change through a project.

**Note:**

For this work I will focus on the social and individual factors. The recommendations and strategies can eventually be applied at the institutional, governmental and corporate level.

## II Part
### Difficulties in communicating climate change

The effects of climate change are becoming increasingly severe and visible on our planet. The UN has called it *"the greatest challenge of our time"*[1], a challenge that requires urgent and drastic changes.

Science will save us and Co....

It is often argued that industry, being the main contributor to global emissions, is also the main responsible for taking action toward mitigation. Following a similar line of thinking, others see politics as responsible for regulations in line with climate change mitigation needs. A third argument is to rely on new technologies that will provide the necessary solutions.

True is, that human beings are experts in creating pretexts and a thousand and one excuses in order to keep us in our comfort zone. The aforementioned arguments have in common that they are used in order to evade individual responsibility and thus avoid behavioral changes that are perceived

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1        Various references including the website https://www.un.org/es/global-issues/climate-change

as undesirable or unpleasant for the individual. Excuses are always closer to deception than to argument.

A complex problem has no easy or unilateral solutions. Yes, political will, economic sector responsibility and technological innovations are needed; however, social, and individual actions and behaviors are a major factor, both as part of the problem and as part of its solution.

In this section we will look at different issues that hinder climate change communication or that constitute psychological barriers to individual action and behavior change.

## 2.1. The challenge

Although the subject has been studied and known within the scientific community for decades, great efforts have been made in recent years to disseminate the topic of climate change to the non-experts public.

Climate change poses a social and technological challenge, apart from political and private industry action, it is becoming increasingly evident how the social and individual scenario is an essential part of any strategy to curb global warming. Among the elements that make up the state of the social issue on climate change, we would highlight the following:

- A large part of the population is still unaware of the phenomenon of climate change, its causes and possible consequences, or has misconceptions about it; many people minimize its importance and even doubt its real existence.

- The model of life in rich countries, based on high energy consumption, enjoys high social acceptance.

- Even people who are well aware of the problem maintain energy consumption patterns that are at least similar to those of the rest of the population, so it seems difficult despite the progressive knowledge about the problem to generate, by itself, responsible behavior.

- Important economic sectors see their interests threatened by the proposed emission reduction proposals and openly oppose the implementation of substantial mitigation alternatives, hindering decisive responses to the problem.

**The individual factor and social behavior**

The environmental biologist Francisco Heras (Heras-Hernández, 2003) writes about the role of social and individual factors in aggravating or mitigating global warming. He cites two interesting examples of how social behavior can nullify the benefits of technological progress.

The first example is based on a study of Norwegian households:

*"The application of more stringent building standards has led to a doubling of thermal efficiency in Norwegian homes, however, the energy used to heat them has increased between 1960 and 1990 because the domestic floor area per person doubled in that time period (IPCC, 2001b). "*

the second example concerns the European automobile market:

*"For equal levels of power and capacity, cars manufactured in Europe are reducing their fuel consumption. However, consumption linked to transport continues to grow unstoppably due to the increase in the number of vehicles and the number of kilometers driven per year. In addition, sales of sports cars and off-road cars, which are precisely those that consume the most, have increased."*

These examples emphasize how individual lifestyles cannot be ignored when seeking solutions and developing strategies. Citizen awareness and response are indispensable to the global effort to reduce emissions; without broad citizen consensus and common will, many other initiatives lose their effectiveness.

Based on the above, we consider two important efforts for communicating climate change at the societal and individual levels.

First, it is necessary to continue to inform the public about current scientific knowledge. Understanding climate change involves understanding:

- its operation,
- its causes,
- its consequences for nature, society, the economy and thus our individual lives.

The first factor leads to the second; it is necessary to raise awareness of the role that individual behavior plays in this dynamic. Our model of life is comfortable and enjoys high social acceptance, our "normal life" is based on high energy consumption and in its sum is the cause of much of the harmful emissions. At the individual level, it is necessary to reconsider our habits in order to create environmentally responsible behaviors.

## 2.2 Barriers to Climate Action

"For more than three decades a host of messages from well-meaning scientists, advocates, and others have tried to not only bring the facts about climate change home but also break through the wall that separates what we know from what we do and how we live. " (Stoknes, 2018)

Assuming that individual X already has a level of information that allows him to understand the complexity of the issue, as well as the awareness of his individual responsibility and the desire to make changes in his energy consumption habits, we are going to address the issue of psychological barriers; the factors that hold the individual back from taking action.

There is an unconscious tendency to separate ourselves from the climate problem by qualifying it as someone else's problem. The message, despite being more widespread than a few years ago, is not generating the expected effect and this applies not only to the disinterested audience but also to the more aware population.

**Psychological barriers**

In his often cited book *"What We Think About When We Try Not To Think About Global Warming: Toward a New Psychology of Climate Action"*, Per Espen Stokne (2015) describes his 5D approach (distance, doom, dissonance, denial, iDentity) about psychological barriers to climate action. The author states that psychological defense techniques can be summarized in 5 cases:

- **Distance:** the feeling that climate change is a distant problem is common. Although many regions of the world are already experiencing the consequences of climate change at first hand, for a large part of the world the catastrophes sound like a distant problem. In the case of Germany, for example, we see how the debate that reigned in the media after the floods of 2021 has been quickly silenced. The immediacy of climate change will remain for the thousands of people who lost their homes, for the rest it will again be a distant problem.

- **Disaster** (doom): the representation of climate change as an event over which we are losing control or that can only be solved through loss, high costs and sacrifice generates a feeling of frustration and impotence that paralyzes action, under the moto of "all is lost". When framed as a disaster, the message fails and causes ecological anxiety.

- **Dissonance:** a disconnect between the issues (mainly the fossil fuel economy) and the things people choose in their lives. What we know is not reflected in what we do. Social acceptance of the way we live makes it difficult to change, which can create a sense of being out of place, being the only one swimming against the tide.

- **Denial:** psychological self-defense to avoid feeling overwhelmed by fear or guilt. Ignoring or denying the problem consciously or unconsciously is a common attitude that protects us from fear or guilt. On the other hand it gives an excuse to avoid individual responsibility.

- **iDentity:** disconnects created by social identities, such as conservative values., which are threatened by the changes that must take place due to climate change. It consists of the technique of filtering information by assuming the part of it that suits us and denying what does not happen in our worldview. For example, conservative groups deny any subject that comes from a liberal group because of intrinsic distrust.

These 5 strategies often work hand in hand and make behavior change difficult. They are all interrelated even though they are distinct from each other. Anti-climate movements have been able to capitalize on these psychological strategies by leveraging them with disinformation. But paradoxically, climate activists have also leveraged them through a poor or confused communication strategy.

**"The backfire effect" - Counterproductive communication strategies**

*"The real problem is not lack of knowledge or information but how the presence of knowledge or information can incite paralyzing emotions such as fear, helplessness, and guilt, which them make processing and acting on that knowledge or information difficult or even impossible"* (Norgaard,2011 , as cited in Seymour, 2018, p.45).

The connection that exists between environmental scientific knowledge, our affections as human beings, our peer groups, the social context where we live, as well as our habits act as filters at the time of assimilating the given message.

Images such as a polar bear on a melting ice field are iconic. But in terms of getting people to act on climate change, they can be ineffective because they provide an alien and distant face to the problem.

Pictures of deforestation or forest fires in the Amazon or Australia also do not give a sense of closeness or eminent danger. The description of these tragedies saddens us, however, we do not see a direct connection to our current reality.

Plastic pollution or deforestation can be clearly visualized, however, the gases that cause global warming, such as carbon dioxide and methane, are invisible to our eyes, the impacts they have on the climate are slow and not always visually striking.

Other counterproductive strategies have been campaigns that generate unnecessary polarization. It has been argued that strictly science-based messages may even increase public polarization on controversial scientific issues such as climate change (Hart and Nisbet, 2011).

In a study carried out in the United States by Sol Hart and Erik Nisbet, it was noted that the polarization of the public regarding climate change has increased in recent years instead of decreasing. Looking for possible variables to explain this phenomenon, they concluded that; "Exposing 240 adults to simulated news stories about possible climate change health impacts on different groups, we found the influence of identification with potential victims was contingent on participants' political partisanship". These results are not necessarily extrapolable to Germany or other parts of the world, but they are an example of how social and personal identification factors influence the assimilation of a message and should be considered when developing persuasion techniques.

Strong values and ideological orientations act as a perceptual screen that influences audiences to filter information by accepting only the part that reinforces their predispositions or privileges. This phenomenon is known as motivated reasoning.

Identification or non-identification with the affected group is another factor that influences in a similar way to motivated reasoning. The degree of identification with the groups depicted in a given message or story can influence whether people are willing to help those in need and what responses to the problem they may support.

The interactions of these two mechanisms: motivated reasoning and social identification; exemplified the potential for boomerang effects in scientific communication. We speak of a boomerang effect when a message is strategically constructed with one intention but produces an outcome that is the opposite of that intention.

Mainstream eco-activism has been dominated for many years by a moral strictness and seriousness, as well as an overestimation of the power of science as the ultimate instance of knowledge. In this way the message has been distancing itself from a large part of the public, ordinary citizens familiar with the contradictions and ironies of everyday life. In short, the values and meanings we hold or relate to the environment are determined not only individually but also within the social context we live in, our framework of beliefs as a member of a given society.

## 2.3 Communicating scientific knowledge

*"People need to understand the basic science of climate change in order to consider the effectiveness of nationally and globally determined policy-making processes. An appreciation of the complexities of the science can help improve communication of related issues where scientific and political elements are interwoven"... "Helping the public realize the reality and likely impacts of climate science is likely to help garner effective responses and related policy choices leading to reduction in greenhouse gases and adaptation to the impacts of climate change" (Holmes and Richardson, 2020. Ch..2. P.22).*

The scientific community, like other groups, has its own idiosyncrasies and customs. The science of the greenhouse effect is well studied, understood, and documented. However, the earth's climate system is complex and making predictions of different aspects of climate change is difficult. This applies particularly to those aspects that are of most interest to people, such as the current state of weather and climate extremes on regional and local scales. The consequence is that communication of the scientific basis is more difficult in these areas leading to the false conclusion that there is not scientific consensus neither trustworthy knowledge.

Part of scientific study involves making predictions that go hand in hand with uncertainty. While this is normal within the scientific field where obtaining new results based on new information is common, in the non-experts group it can create a sense of inconsistency in the message or uncertainty. This in turn has been exploited by climate change deniers to be used as proof that scientists are wrong.

The nature of scientific research itself can pose a challenge for communication. Science is expected to produce information that is useful to society, if not immediately, then eventually through a cumulative and self-correcting process. Scientific findings often represent a work in progress and cumulative results that are applicable only to particular contexts or populations, or are unresolved questions for which the public wants clear answers. Consequently, the uncertainty associated with scientific work and the challenges it faces poses difficulties in communicating with the mainstream public.

As scientists have become increasingly certain about the human causes of climate change and the urgent need to address it, one might expect that public opinion on climate change would follow a similar pattern in beliefs about human causation, perceptions of the threat of climate change, and support for government climate change mitigation policies. The reality is that this has not always been the case.

This means that climate scientists will need to learn how to communicate effectively (Jucan and Jucan 2014), perhaps in alliance with psychologists and artists.

### 2.3.1 Science denial and misinformation

Another obstacle hindering action against climate change is denial of the science, as well as related misinformation techniques. These factors have caused negative impacts such as polarization of the public and have counteracted outreach efforts over the years. While we will not delve into this

topic in this paper, it is important to have an overview of the main actors and their motivations in disinformation campaigns.

## 2.3.2. Actors and amplifiers

There is a wide network of actors that are sources or amplifiers of climate change disinformation. Corporations, conservative foundations and think tanks motivated primarily by economic and in some cases ideological interests have actively worked to thwart environmental efforts. Disinformation and manipulation of public opinion has been a central strategy for these groups. In their article for the Resarch Handbook on Communicating Climate Change, Riley E. Dunlap and Robert J. Brulle expose the anti-environmentalists' efforts. Dunlap and Robert J Brulle outline the main motivations and the various actors involved in disinformation (Holmes and Richardson, 2020. Ch. 6):

**Strong economic motives:**

### The corporate world

Private companies and large corporations depend on economic growth and profit-making to survive. Sectors such as the fossil fuel industry and others dependent on them, as well as large chemical corporations have been among the main generators of greenhouse gas emissions. Large companies have not only systematically ignored the warnings of scientists, but have funded studies to the contrary, and have cooperated with groups to promote uncertainty and discredit scientific opinions.

**Front groups and coalitions**

While corporations try to protect their image by hiding their anti-environmental actions from the media and the public, they have also pursued other strategies by partnering with organized groups that take on the job of defending their interests by lobbying and spreading disinformation.

**Public relations companies**

Organized campaigns designed by professional public relations firms and funded in part by the sectors and groups mentioned above have been responsible for spreading misinformation. Advertising companies associated with the fossil fuel industry develop campaigns that promote a positive image of this industrial sector, which commonly opposes climate change mitigation measures. The purpose of these campaigns is to persuade public opinion and pressure the political sector to make decisions favorable to the corporations represented. Their techniques include emulating civil movements in the form of lobby groups, intimidating scientific and civil participation in political forums by threatening lawsuits or "hiring" fake experts to refute scientific information.

**Strong ideological motivation**

In their description of the case for conservatism, Riley E. Dunlap and Robert J Brulle refer to the Republican Party in the United States. Since the 1960s there has been a strong reaction from conservative groups familiar with privilege and power who feel threatened by liberal reforms. The political discourse in which change is presented as a threat to tradi-

tional lifestyles and values is generally motivated more by economic interests and fear of loss of privilege than by the moral values promoted.

Several individuals and families of conservative ideology manage large amounts of capital with which they finance disinformation initiatives. Among the techniques used are the creation of philanthropic foundations that in turn finance a wide range of conservative organizations, lobby groups, magazines, radio, and television programs through donations that in turn create tax advantages. These foundations have established numerous think tanks that provide a theoretical or ideological basis for anti-progressive and environmental movements. Conservative think tanks are amplifiers of climate change denial theories, flooding society with disinformation through books, TV and radio programs. They use the small number of scientists critical of the environmental movement to give a more serious basis to their thesis and increase uncertainty. Counter-scientists have contributed to legitimizing disinformation to the public, creating an image that climate science is full of contradictions.

Given the organized disinformation efforts, it is especially important that the "anti-climate change" movement continues to grow and remain strong. Scientists concerned politicians and civic activists (especially youth) are essential to keep the environmental movement on the national political agenda. It is also important to generate public attention to the issue as a political issue that influences voting intentions.

### 2.3.3 Repercussions of climate science denial

Disinformation about climate change promoted by contrarian scientists and other denialist sources causes several negative impacts on the public. High levels of per capita emissions are associated with skepticism about the science of climate change. At the individual level, misinformation contributes to misconceptions, reduces support for mitigating policies, and causes public polarization.

Referring to the U.S. case, Freundenburg and Musselli (2010) comment *"Perhaps in part because these critics' charges have received extensive attention in the U.S. media, independent surveys indicate that the U.S. public increasingly believes the scientists themselves to be far more deeply divided than the peer-reviewed literature on climate disruption would indicate."*

Attacks on the integrity of climate change science erode public confidence in the scientific community that has been forced to take an extremely cautious approach to reporting results. The IPCC observed as early as 2010 that predictions of climate change effects were 20 times more likely to underestimate impacts than to overestimate them (Freudenburg, Muselli, 2010).

The various impacts of misinformation, particularly its ability to neutralize accurate information, highlight the need to develop interventions to neutralize these negative influences. However, understanding the rhetorical arguments of climate science denialism is necessary to develop effective responses.

Misinformation on climate change presents a wide range of assertions that in turn contain a set of rhetorical techniques and logistical fallacies. One of the main impacts is to cancel accurate information, in addition to which these techniques cause a series of other negative impacts that have the effect of diminishing public support for mitigation policies, thus delaying efficient climate action.

In his essay "Deconstructing climate change denial" (Holmes and Richardson, 2020. Ch. 7) John Cook describes the main arguments and common techniques of disinformation and message manipulation. After citing different studies on the topic "climate change denial" Cook presents the five general categories existing in the climate disinformation discourse: it is not real, it is not us, it is not bad, the solutions will not work, and the experts are not reliable. These five categories reflect the five key climate beliefs identified in psychological research: it is real, it is us, the experts agree on the first two points, it is bad, and there is hope.

**Main techniques:**

**Fake experts** are spokespersons who give the impression that they are experts on a subject when they have no relevant expertise. A common feature of science denialism is that the vast majority are "private researchers" without the credentials necessary to publish climate research. Fake experts are often used to cast doubt on the expert consensus.

**Logical fallacies** are found in arguments in which the premises do not logically lead to the conclusion. For example, the premises are not relevant to the conclusion, the scope does not consider all the evidence, or the argument contains false premises. Attempts to discredit a person, ambiguity, false analogies, misrepresentation, and oversimplification are just a couple of the different techniques used by climate deniers.

**Impossible expectations** are a demand for unrealistic or unattainable standards of scientific proof. This rhetorical tactic can be persuasive because of the public's misperception that science provides absolute proof.

**The selection of the best** consists of selectively focusing on data that lead to different conclusions from those obtained by using all available data. This technique can be a form of manipulation, involving statements that are strictly true but lead to misleading conclusions.

**Conspiracy theories** involve the suggestion of secret plans to implement nefarious schemes and are a common theme in climate disinformation.

*"Most educational material or communication campaigns in response to climate misinformation have focused on explaining scientific content such as rising global temperatures or the overwhelming level of scientific consensus. However, Cook and colleagues (2018) demonstrate that a basic understanding of argumentation is sufficient to refute a large number of climate denialist claims, consistent with the Aristotelian approach of inoculating against false arguments with rational argumentation"* (Holmes and Richardson, 2020. Ch.7. p74).

In his conclusions Cook argues that according to different studies; both providing scientific facts and explaining the rhetorical techniques typical of denialism are effective in neutralizing disinformation. Furthermore, it is interesting to note how the rhetorical techniques described above are not exclusive to climate discourse but are used in many other scientific contexts and topics, as we have recently seen in relation to the Covid19 pandemic, countering efforts to control it such as restrictions and vaccination.

## 2.3.4 Responding to climate science denial

Understanding the sources of climate change denial and the rhetorical techniques often used provides an important background for considering how best to address science denial. Drawing on best practices from psychology, sociology, communication and political science, Emily Vraga and Sander van der Linden identify in their essay "Responding to climate science denial" five possible strategies for responding denialism (Holmes, Richardson, 2020. Ch. 8. p.79)

- **communicating** scientific consensus

- **persuading** individuals to show resistance against climate denialism

- **creating** media literacy messages or training to encourage people to recognize climate misinformation

- **responding** to climate misinformation and correcting it when it arises

- **use** techno-cognitive solutions to reduce the range of disinformation techniques.
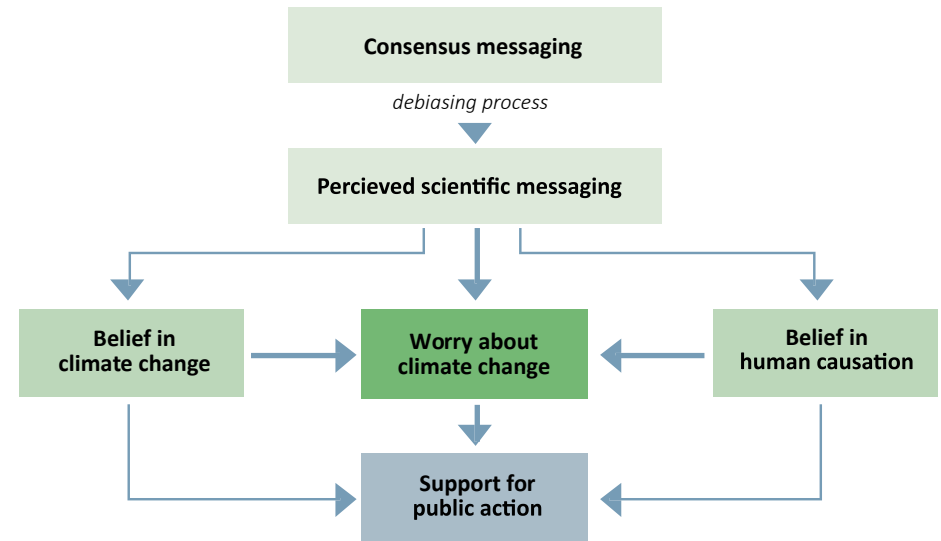


Fig 1. Gateway Belief Model.Based on van der Linden et al. (2019)

The Gateway Belief Model as shown in the graphic above, is premised on the principle that perceived (scientific) consensus is a central belief within a larger network of cognitive and affective judgments about climate issues. The model features a two-stage mediational process where the first stage is the main effect on perceived scientific consensus and the second stage includes downstream direct and indirect effects on private attitudes and policy-support.

Communicating the scientific consensus on climate change is an important method to change climate belief and move people to take individual and political actions.

## Endnotes

In the second part of this paper, we have focused on the different factors that make it difficult to communicate and understand the problem of climate change, as well as to take action to mitigate it.

On the one hand, there are our own psychological barriers, as well as the influence of our social environment, and on the other, there are active efforts on the part of groups that see their interests threatened. They try to manipulate public opinion to prevent measures that they see as detrimental to their ends.

In the following section we will study the different possibilities that are within our reach to improve the communication and dissemination of the climate change challenge.

## III Part
## On climate change communication

*"Should a climate scientist be expected to be both a rigorous scientist and an expert communicator to a wide variety of audiences?" (Holmes, Richardson, 2020)*

The role of scientists as an authoritative and trusted voice will continue to be necessary as we move forward in responding to the challenge of climate change. The complexities around the combination of certainty and consensus, along with the need for clarity and transparency around the uncertainties associated with scientific research, will continue to pose communication challenges.

Scientists have little or no training in communicating with non-experts. For effective communication they need practical support from other disciplines such as social sciences (psychology and sociology) or experts in the field of communication.

In their article on communication and trust (2013) Goodwind and Dahlstrom explain the challenges of communication: "complex and extensive scientific knowledge must be delivered in an understandable and usable form to culturally and ideologically diverse global audiences in an environment already saturated with controversies and conflicts of interest". The trust placed in scientists by the media and the public is of great importance; the reception of the message is influenced more by the trust inspired by its sender than by the message itself. Thus, the motivations that scientists have for communicating will influence the public's perception of them. For this reason, to optimize the dissemination of knowledge, the scientific community must cultivate and maintain the public's trust. It is imperative for the public to have access to this knowledge, and equally important for the media to share it with non-expert audiences.

Denial techniques and disinformation campaigns have contributed to a significant part of the public doubting or mistrusting scientists, who in turn have sought strategies to improve communication, generally through interaction with professional communicators, who use mechanisms to distill their messages more effectively using simpler language, metaphors, narratives, reframing, etc.

In this first part of the paper, we have focused on barriers and challenges that hinder the transmission and understanding of scientific knowledge to the mainstream public. In the next section we will deal with best practices. What approaches can communicators use to get attention, and what tools do we have to increase understanding.

## 3.1 The role of social norms

Social awareness and re-evaluation of existing social norms is of high importance as a reinforcement of individual behavior change. Individuals are more likely to adopt climate change mitigation behaviors if they are endorsed by other important people in their lives. When individuals identify with groups that have norms that support climate action, they are more likely to adopt climate mitigation behavior. Conversely, if individuals identify with groups with norms of climate skepticism, they are less likely to be motivated to adopt mitigating behaviors.

The distinction between detrimental and descriptive norms highlights the potential for conflict between what people believe and what people do. This conflict is shown in relation to climate change: most people think it is necessary to address climate change, but only a minority are committed to serious action.

Psychology has not been absent from the study of the human dimensions involved in climate change, and in particular, in the psychological processes that allow us to better understand the risks we face. When norms conflict with interests, people are often demotivated rather than inspired to change.

The current economic model, based on growth and consumption to achieve a level of well-being, constitutes a major obstacle to the development of general political agendas that generate effective change. Our first-world model of high energy consumption enjoys wide social acceptance. However, the consequences of climate change will fall disproportionately on developing countries and the most disadvantaged populations in all countries, further increasing inequalities in health and access to adequate food, clean water and other resources.

Francesco Rocca, president of the International Federation of Red Cross and Red Crescent Societies (IFRC) states that *"In a world whose temperature rises by 1.5°C, more extreme weather events will affect the entire population, with particularly cruel consequences for those communities struggling to survive today amid conflict, insecurity and poverty"*.

A first basic element to achieve social commitment is to ensure and provide good information on climate change, its causes and consequences, as well as to offer alternatives that allow society to commit to action.

## 3.2 Communicating with different audiences

Climate change communication is important given that many of the environmental damages currently occurring are beyond direct human perception. Currently, many environmental initiatives are aimed at raising public awareness to mobilize citizens to collaborate with mitigation and adaptation efforts. To increase the success of these efforts it is necessary to know the different audiences, the motivations of different groups and subgroups are decisive to motivate change.

Detenber and Rosenthal (Holmes, Richardsonn, 2020. Ch. 22), define several important elements to consider:

> The first element for communication is to **define the scope** and **purpose of the message**. This can be defined as providing information, influencing behavior, or changing cultural norms and values.

> The second element is to **define the content** of the language. "Messages that frame climate change as personally relevant to an audience result in greater climate change engagement" (Scannell and Gifford 2013, as cited in Holmes, Richardsonn 2020 (Ch.22, Detenber and Rosenthal). p.214). The narrative methods used must also be taken into consideration as they influence audience perception both positively and negatively.

> The third element is **the emissary**. The decision of what to include in the message is as relevant as the credibility that the audience attributes to the source, both factors influence the perception of the message. According to a study cited by Detenber and Rosenthal audiences consider scientists and non-governmental organizations as the most trusted sources of information (Malka et al. 2009, as cited in Holmes, Richardsonn 2020 (Ch.22, Detenber and Rosenthal). p.215).

The fourth element is **the channel** chosen for communication. The use of the Internet and its different possibilities has radically changed the dynamics of information and access to it. The public has the possibility to choose between traditional and non-traditional sources of information, as well as to inform themselves according to their interests and beliefs.

The fifth element is the **evaluation of results.** Modern evaluation methods, such as statistical data (analytics) are especially used in social media marketing campaigns. By means of them it is possible to obtain statistics on the range of reach and the degree of engagement. On the other hand, the ease of conducting surveys makes it possible to obtain information about the public's opinion on the campaign in question.

The final element to discuss is **the audience itself**. Often the range and purpose of the project is related to changing beliefs, attitudes or behaviors of a given audience. In order to mobilize the audience to make the changes it is necessary to take into account their current beliefs, attitudes and behaviors, as well as their needs and goals.

### 3.2.1 Audience segmentation

Now, that the factors to be considered when planning the communication strategy have been explained, we will talk about the concept of audience segmentation from a marketing point of view.

Why? As the media and the accessibility of information sources have changed, the marketing industry has developed tools to market goods and services to different consumer groups. The utility of these tools is not limited to selling products or services.

*"Social Marketing"*, the term coined by Kotler and Zaltman (1971), *"is the design, implementation and control of programs calculated to influence the acceptability of social ideas"... "the core idea of marketing lies in the Exchange process. Marketing does not occur unless there are two or more parties, each with something to exchange and both able to carry out communication and distribution".*

While we typically relate the idea to the exchange of products or services for money, the concept of "social marketing" refers to the application of common marketing tools to promote socially beneficial behaviors.

Non-profit organizations and other institutions have for many decades applied different tools as a means of information or persuasion to achieve objectives within social behavior.

The audience segmentation method is used to develop social marketing campaigns, where heterogeneous groups are segmented into subgroups that show similarities, needs and preferences. The use of segmentation makes it possible to understand, for example, how different sectors of the population think about scientific facts and climate change.

Metag and Scharfer (1918) mention as a starting point for segmentation the identification of a population that is diverse in characteristics that are relevant to the analysis. As a second point it is necessary to collect data from this

population by means of different techniques such as surveys, observation, research. Finally, relevant sectors of the population that are homogeneous in the characteristics defined will be identified. For example, demographics, attitudes, beliefs, etc.

Detenber and Rosenthal (Holmes, Richardsonn, 2020 (Ch.22)) list the following key concepts for audience segmentation with respect to climate change:

**Knowledge.** For effective communication it is necessary to know what knowledge the target population has. Especially if the goal is to educate.

**Values.** Regardless of knowledge, the predisposition to do something is often influenced by personal values.

**Emotion.** Each individual has an emotional response to problems. For example, worry and anxiety are emotions that generate more responses.

**Behavior.** The above factors, knowledge, values and emotions are often poor predictors of behavior. Motivating audiences to think about climate change is easier than motivating them to change their behavior.

**Demographics.** Knowing the age, gender, education, and average income of the social group is helpful in knowing where to find these people and where to deliver the message.

**Time.** The identified segments are not immune to change. Unexpected events, cultural or political movements, scientific discoveries, etc., are factors of change within the groups previously analyzed.

The use of segmentation analysis has been increasing in recent years within the scientific and environmental field. One analysis that has been particularly prominent is the perception of and attitudes towards climate change. In their article Metag and Scharfer (2018) cite a series of studies conducted by Yale University and its "Program on Climate Change Communication". These studies identify 6 different audiences with different attitudes towards climate change in the United States; the **"Alarmed"**, who are most engaged about global warming; the **"Concerned"**, who believe that global warming exists but are less involved; the **"Cautious"**, who are not as certain and do not think climate change is a threat to them personally; the **"Disengaged"**, who have not thought about the issue much; the **"Doubtful"**, who doubt either that climate change exists and/or that it is caused by human activity; and the **"Dismissive"**, who firmly believe that global warming is not happening. "

Metag and colleagues (2018) conducted a similar segmentation analysis in Germany. This yielded five groups that, though using different measures, presented similarities with the American study; **the alarmed** (24%), **concerned activist** (18%), **cautious** (28%), **disengaged** (20%) and **doubtful** (10%). They note: *"Interestingly, the concerned activist expressed less concern about climate than the alarmed group, but they were more likely to practice energy conservation. They were also the youngest group, on average. Missing from the German model was a dismissive group that denies that climate change is occurring, as had been found in Australia and the US."* Nevertheless, this cited dismissive group has been surging in the last years mostly motivated by populistic politic movements.

Although sector analysis has proven to be a useful tool for communicating environmental issues, it has limitations in its scope. Important to highlight is; there is an important sector of the population, whose size varies from country to country: the "disengaged", a group that is difficult to reach due to their lack of knowledge or interest in the subject.

Another ongoing problem mentioned at the beginning of this paper is the gap between knowledge and action; sincere concern is still no guarantee that consistent individual action will be taken.

## 3.3. Behavior change interventions

*"People can change even strongly habitualized behavior if they are motivated to do so; and behavioral change is best conceptualized as a goal-oriented self-regulation process driven by negative feedback loops."* (Holmes, Richardsonn 2020 (Ch.23, Bamberg and Schulte).

As well as in other areas, the popularity of social marketing as a tool for motivating behavioral change has been increasing in recent decades in environmental and climate change related issues. Governmental and non-governmental entities are using these techniques to motivate citizens to make voluntary changes in their daily behavior.

In his article "Changing environmentally harmful behaviors: A stage model of self-regulated" Sebastian Bamberg (2013) builds on research on systematic stage models as a form of behavioral self-regulation. His model describes the process of behavior change as a sequence of 4 stages:

1. Pre-decision stage,
2. Pre-action stage,
3. Action Stage and
4. after-action stage.

Bamberg emphasizes the fact that transition is not always linear: "the transition process through the four stages is characterized by setbacks: people get stuck in specific change stages or even fall back into earlier stages. This is caused by the fact that each stages has its specific challenge that people have to master for progressing." (Holmes, Richardsonn 2020 (Ch.23, Bamberg and Schulte)).
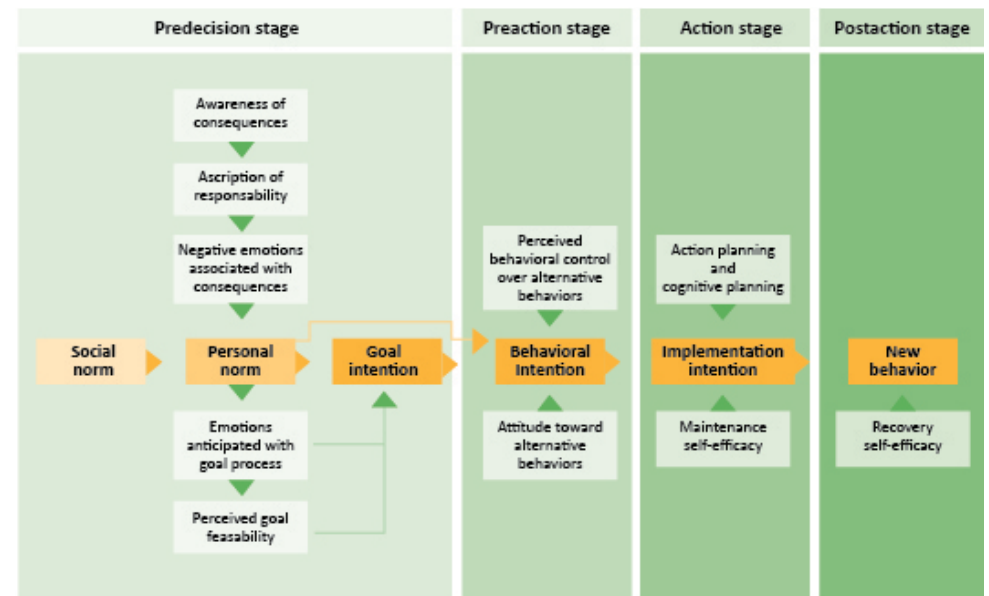


*Graphic: The stage model of self-regulated behavioral change, adapted from Bamberg (2013b)*

Using a CBSS model is useful when planning interventions designed to promote behavior change and considering the specific needs and barriers at each stage of the process. Bamberg and Schulte cite several cases based on different studies.

For example, interventions targeting individuals in the **pre-decisional** phase are more likely to be successful if they focus on providing information that can increase both awareness of the problem and perceived personal responsibility. In addition, interventions that activate social and personal norms are likely to be important at this stage. Second, individuals who have set a goal-intention need information about the availability and pros and cons of different behavioral alternatives. Third, individuals who intend to switch to an alternative behavior benefit most from interventions that support the implementation and initiation of this intention, e.g., detailed behavioral planning. Finally, individuals who have implemented a new behavior benefit from interventions that reduce relapse to earlier stages.

To create the necessary transformation there must be a joint effort. A change in behavior is necessary at both the individual and collective level. Citizenship, industry, and politics must work together to achieve the desired goals.

At the individual level, the behaviors that have the greatest environmental and climate impact are reduced to three areas: **housing, transportation, and food.** While there are certain structural (and cultural) constraints; citizens have personal influence over these areas and can create an impact. Christian Klöckner (Holmes, Richardsonn 2020 (Ch.12, Klöckner) lists several decisions that help to reduce the negative impact of the individual way of life:

1.Size of the house or apartment, its location with respect to the center of work and study as well as its energy standards (insulation, heating system, etc.).

2. Energy standards of major household appliances.

3. Transportation methods and customs. Informed decisions when using and purchasing vehicles.

4. Composition of the diet, reduction of food waste and consumption of meat and dairy products.

5. Reduction of consumption in general, increase the time of use of products, recycle, repair, avoid waste.

6. Political participation and voting rights. Generate public pressure.

## Endnotes

Behavioral change studies have proven that Social Marketing and Audience segmentation are tools that could be useful elements in developing communication campaigns aimed to motivate daily life changes. Their use helps motivating self-reflection and behavior change, especially in areas or examples that are easy to implement at a personal level.

To optimize the effectiveness of these tools, it is advisable to adapt the messages to the stakeholder's belief and value system and to consider their state of intention to act.

In the following section we will discuss recommendations and techniques that should be considered when generating campaigns, as well as the benefits of interdisciplinary work, in the specific case, of the arts and visual language.

IV Part
Recommendations for communication

*"The purpose of communicating climate change science is to encourage participation in discourse and influence behavioral change to help avoid dangerous changes to the climate system" (Holmes, Richardson, 2020. p.33).*

The second section of this paper mentions the importance of scientists finding effective ways to communicate with the public and suggests the importance of using knowledge from different disciplines for this purpose.

Understanding the challenges and difficulties of communication provides a background for developing messages and disseminating them based on best practices from psychology, sociology, marketing, and visual arts.

In this chapter we will discuss recommendations and possible strategies to optimize communication. Especially we will discuss the role that arts and visual language could play.

## 4.1 Principles for solving communication complexities

Simon Torok and colleagues (Holmes, Richardsonn 2020 (Ch.4, Torok, Pearce and Hassol)) describe the purpose of climate change communication; "to encourage participation in discourse and influence behavioral change to avoid dangerous changes to the climate system".

Aware that the mere communication of scientific facts does not have the expected effect, they ask the question "what approaches can communicators use to get attention, and what tools do we have to increase understanding? In their article they set out a series of suggestions and list the tools that communicators can use to get attention, increase understanding, and motivate a change of attitude towards positive action to mitigate climate change.

**Message must be consistent.**

It is important to keep the message consistent. It must be conveyed from the perspective that climate change is happening now and is not a problem of the future. It is also necessary to emphasize that there is no need to delve into debate at this point. Climate change is real and is produced by human causes.

**Credible information.**

It is important to emphasize the vast number of studies that over the years have reaffirmed the consensus within the scientific community regarding climate change. Entities such as the IPCC are responsible for collecting, reviewing, and cataloguing this information and regularly report on the current state of scientific knowledge. Publications from these entities such as this one should carry more weight than, for example, self-published articles on Facebook.

**Communicating what is known.**

Certainly, scientific research is fed by uncertainties, open questions, and the generation of hypotheses. However, the starting point of the discussion should not be based on uncertainties but on proven facts. For example, "the earth is warming, heat waves are becoming stronger and more frequent. Statistics show that this is an increasing trend." Then it is important to cite publicly available studies that allow the public to know the source of the information and to inform themselves if they are interested.

**Connecting with physical mechanisms**

Explaining cause and consequence relationships facilitates understanding. For example: "A warmer atmosphere holds more moisture, which leads to heavier precipitation". Understanding the interrelationships of climate components, how they affect each other, is an important starting point for understanding climate change.

**Using metaphors**

The use of metaphors in which a physical phenomenon is compared with other types of phenomena that are familiar to us can help to facilitate the understanding of more complex phenomena.

**Avoid tragic images**

Both fear and feelings of powerlessness are proven to be negative emotions that encourage inaction. Language that discusses climate change and the threat it poses to our future in an honest and realistic way is important, however, it is important to focus on solutions and our ability to contribute to change.

**Bringing global to local**

Regional efforts that increase the public's perception of the consequences at the local level are helpful in communicating an issue that is distinguished by the psychological distance it sometimes generates. Talking about possible changes in our local environment and nature helps to reinforce the immediacy and importance of the problem.

**Telling a story.**

Humans are conditioned to understand, remember, and respond to stories, something the scientific community has been slowly learning. The facts do not necessarily speak for themselves, but reach a wider audience combined with personal stories or visions of climate change impacts and solutions.

## 4.2. Interdisciplinary efforts
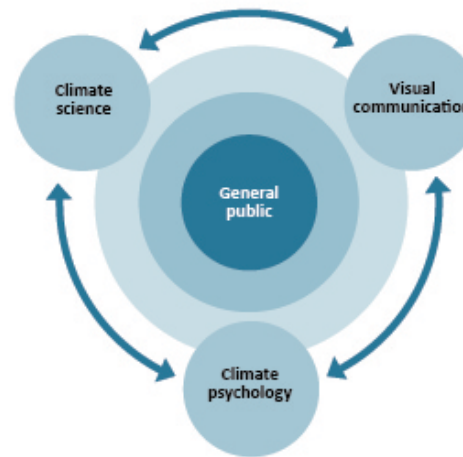


Interdisciplinary collaborations can overcome the insular focus of individual disciplines. A shared methodology that combines best practices from the involved disciplines may help to better results when trying to communicate complex messages. In this work, we focus on communication methods from science, psychology and visual arts. *Graphic @andreabrenes*

The exchange of information and active communication is normal between experts in a given area, however, this communication is often limited into the peer group, as the experts have no contact with other scientific or social disciplines and do not know how to communicate with them. The result is that the different disciplines of knowledge do not always work hand in hand and do not even question the importance of doing so.

A scientific and technological problem such as climate change is of common interest and concern to the general public, yet it is difficult to assess and communicate from the point of view of just a single discipline. Scientific experts must identify what the problems are and how they develop; engineers must develop technologies suitable for general solutions; on the other hand, psychologists and other behavioral scientists must understand human behavior and strategies for changing it while communication experts have to develop strategies for communicating all this information effectively.

We have talked about how interdisciplinary efforts contribute to closing the knowledge gap between the scientific community and the non-experts public. We have seen how studies from different disciplines like psychology and marketing are used as tools to develop communication campaigns. Another area of expertise that has joined these efforts is visual communication.

### 4.2.2 The role of art and the power of images

*"Whereas science-based communication leads to a more intellectual approach, art can also tend to the emotional side of the issue of climate change, which is important for stimulating discussion on this global topic and changing behaviour."* (Roosen, Klöckner & Swim (2017))

The influence of images on climate change to bring about behavioral changes has been the subject of several studies. Different articles explore the role art has or can have within climate change communication (Rossen, Klöckner and Swim (2017); Simms 2015). In the closing of his article for the Guardian Simms (2015) argues that "...art may be a hammer with which to shape reality, for others it's a window opening on a world seen in a compellingly new way. But it can also be a feather that tickles you through a difficult idea to a new understanding and frame of mind." While Rossen, Klöckner and Swim (2017) pose as their research question, "Can art motivate and inspire the audience to act in more pro-environmental ways, and if so, how? "; Wallace-Wells (2019) devotes a chapter of his book "Storytelling" (p.191) to analyze examples of different fictional narratives on the topic climate change.

The different authors have in common the conviction that narrative fiction, visual art, or art in general have the capacity to communicate in a different way with different audiences, sometimes favoring their receptivity. Rossen, Klöckner and Swim cite as possible factors that "an important and beneficial aspect of art is that when people view it, they naturally become more mindful than at other times. They pay more attention to art and search for hidden meanings and associations." Climate change is seen by many as an abstract problem that is difficult to visualize in ways that relate to their daily lives. Art often makes use of alternative forms of visualization, moving away from the obvious, seeking different channels of communication, generating associations, emotional reactions and moving to reflection. Another advantage of art is to minimize polarization by focusing more on individual and collective values rather than scientific arguments, and it is even common for artistic works to renounce the use of verbal elements altogether.

Rossen, Klöckner and Swim affirm that the tone of a large part of environmental communication is based on negative aspects, focusing on the consequences of our behaviors, and inciting negative emotions such as guilt,

shame, fear or anxiety. Changes generated under these motivations lack the self-reinforcing effect of changes motivated by positive feelings.

According to the authors, art inspires, and people need inspiration. Inspiration motivates, encourages, and moves people to find and adopt unconventional solutions. This seems to be beneficial in the context of measures and interventions to address environmental crises. Like Wallace-Wells the authors consider storytelling techniques through words or images as useful tools to increase the feeling of personal relevance in the receiver. Conveying narratives in which the recipient identifies with the story can both change convictions and motivate change.

It has been argued that strictly scientific messages can even increase public polarization on controversial scientific issues, such as climate change. Visual art that uses more emotive and personally relevant language can help bridge the gap between scientific information and personal responsibility.

Visual environmental communication has the potential to foster the general population's understanding of climate change by acting as a bridge between the abstract concepts surrounding climate change and our everyday experiences.

## 4.3 Images of climate change

In a study designed by Betsy Lehman, Jessica Thompson, Shaw Davis, and Joshua Carlson (2019), the researchers collected "relevance", "emotionality", and "valence" data from 320 images to investigate the relationship between relevance and emotional characteristics of these images and the perception to climate change problematic. The authors of the study argue that "individuals' opinions on climate change are often based on emotion rather than on scientific evidence". The aim of the study is to create parameters to build a publicly accessible database that can be used by policy makers, scientists, and other stakeholders.

For each image, participants were asked how relevant or irrelevant they consider it (relevance), how relaxing or exciting it was (arousal), and how negative or positive it was (valence).

The results showed that the images rated as the most relevant (relevance) were also those that presented the highest index in the emotional factor (arousal). In turn, the images that showed higher relevance values tended to be rated as negative (valence).

From the same study, data was obtained showing how people for whom climate change and environmental issues were important, reacted more sensitively to the images shown.

An important part of the study is that the test group chosen was a group of non-experts, "we chose to explore what visual imagery is meaningful to our non-expert participants."
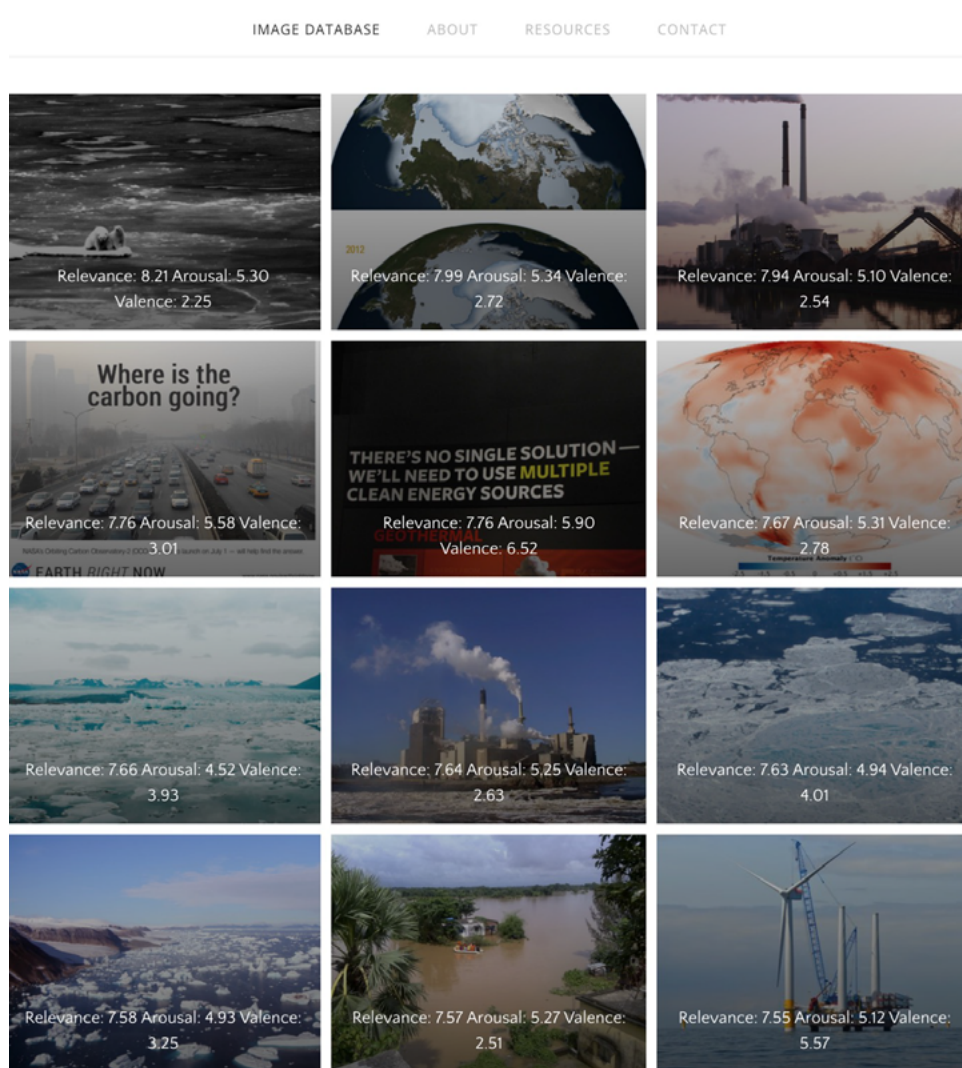
Source: https://affectiveclimateimages.weebly.com/
Database with the 320 images from Lehman et al. (2019) work is posted online.

Like this study, the website climatevisuals.org[1], a project of the organization Climate outreach, also presents an image database for public use; "a unique and trusted source of evidence and images for over 350 climate change and environmental groups, journalists, educators and businesses".

The mentioned study and the example of Climate Visuals show, among other things, how the climate change discourse already has certain imagery. These images cause different associations by the non-expert public and are images capable of generating different reactions in observers. In the two cases mentioned above, the selection of images was based on studies on the visual impact on the non-expert public; they are images designed to provoke an emotional reaction.

As access to the Internet has expanded becoming widely used in most sectors of the population, the use of images to communicate the most diverse topics has also been evolving. Years ago, the process of creating and publishing images that could reach a wide audience was limited by economic and distribution factors, today each person can publish their own images or share them with others with a couple of clicks, for free or with a minimum of costs. Also, the current capacity of computers or smart phones allow to upload all kinds of images in a fast way. A few years ago the waiting time to upload information was a criterion to consider when using images in digital media, the fall of this barrier has generated a flourishing of visual language to communicate all kinds of topics. Now, In the age of social media, we are exposed to images all day long. Instagram, Facebook and company are part of the daily routine of millions of people around the world.

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1        Website: https://climatevisuals.org/climate-visuals/, https://climateoutreach.org/

Internet has become the window to an infinity of information with the power to reach tens of thousands of people through images. This partial independence from written language makes design an effective tool with an exponential reach to heterogenous audiences.

The different types of visualizations have a wide potential to be used extensively to communicate and stimulate the public's willingness to engage with causes. Kevin Robins (as cited by Nicholson-Cole, 2004) outlines the advantages he sees in the use of visual language "*... include the capacity to: convey strong messages, making them easy to remember; condense complex information and communicate new content; provide the basis for personal thoughts and conversations, contributing to people's memory and issue-awareness; communicate ideas in an instant using many different media and contexts*."

In a study led by Sophie Nicholson-Cole (2004), the visual conceptions and feelings about climate change of the study group were explored. The researchers then focused on eliciting visualizations of climate change and analyzing feelings of participation about it. Nicholson summarizes the results of the study as follows "*... people's perceptions and attitudes toward climate change are related to their visual imagery about the issue; strongly influenced by input from various visual media as well as personal experience.* "

It also lists a number of important characteristics that visualizations must have in order to capture attention, be remembered and motivate behavioral change. Visualizations must be;

1. Easy to relate to and personally applicable both spatially and temporally, possibly involving a high level of realism.

2. As scientifically certain as possible, representing the soundest projections from a source trusted by the target audience.

3. Instructive with a clear message in order to send the message that climate change is an important issue, and that individuals can make a difference (by doing certain things). These must come across as being easy to do, positive and feasible given other life commitments.

4. Attention grabbing so that people notice the image and think about it. It seems that pictures with people or animals in them have this characteristic. Such pictures have an affective dimension, eliciting an emotional reaction which is perhaps more likely to initiate a thought process or feelings that the issue is salient and worth doing something about.

5. Tailored for the target audience according to their perceptions of climate change and attitudes toward it; aiming the right tool at the right.

While different images and visualizations alone are not able to mobilize people to commit to the cause, different joint efforts have proven to be effective. The use of different sources and avenues of information, as well as a variety of media to reach the public, have increased general awareness of the problem.

V Part
About the project
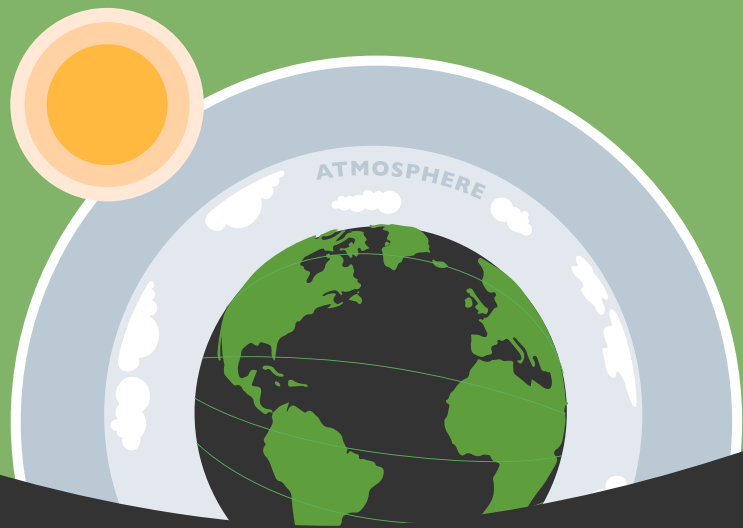
# UNDERSTANDING CLIMATE CHANGE

**The Website:** https://climatechange.infografia-design.de/

Different information on climate change is distributed throughout the web; the amount of information, the different topics and their complexity can make the process of becoming familiar with the issue difficult, as sometimes the initial approach plan or guide is missing. Where to start? How are the different aspects related? Why does some information seem to contradict each other?

The main goal of my project is to achieve an easily accessible global site where the main interrelationships between the components of climate are exposed, in that way the visitor can get a general idea of how the different climate mechanisms are interrelated in a single site visit.

Climate change and its consequences for life on the planet is a broad topic, with many ramifications and information disseminated from many different sources. As discussed in the first part of this paper, both scientific knowledge and consensus on the subject have been accepted and widespread for many decades within the scientific community. In the civil sector, where the average citizen lives his day-to-day life, the subject is in many cases only superficially known and in others consciously ignored. A large part of the population has not yet approached the subject in a deeper or more critical way that would allow them to understand the functioning of the climate, the interrelationships between its components and the dynamics generated by greenhouse gas emissions caused by humans as a destabilizing factor.

As mentioned in this paper, understanding these dynamics is the first step in understanding the extent to which our social customs and individual actions can contribute to mitigating or worsening the problem. However, the complexity of climate processes and the difficulty that characterizes scientific language represent barriers to easy understanding. Misinformation is also distributed through the web making the topic confusing for one part of the mainstream public.

The website project intends to deal with the generality of the subject in a simple, understandable, and attractive way; with the intention of helping people to inform their selves on the climate change topic. What are the main causes and the cascade of consequences that generates the warming of air and water for people and life on the planet in general.

With this information I intend to move the individual to reflect on his habits and motivate him to explore with which changes he can begin to assume part of his individual responsibility.

## Definition

**Scope** and **purpose of the message** is to provide the public with basic information about the functioning of the climate system, the causes of overheating and the consequences of this.

**The content;** different information on climate change and its consequences is presented in the form of graphics, texts and images, some of which are animated.

**The emissary.** The information for the Website was obtained from recognized sources such as the World Wide Fund for Nature (WWF), Intergovernmental Panel on Climate Change, United Nations and other scientific or governmental institutions.

**The channel:** world wide web

**The audience:** the **"Alarmed"**, who are most engaged about global warming; the **"Concerned"**, who believe that global warming exists but are less involved; the **"Cautious"**, who are not as certain and do not think climate change is a threat to them personally;

## The message

- To explain the interrelationships between the actors in the climate system and how anthropogenic emissions are affecting them by reenforcing the natural greenhouse effect.

- To give an overview of how changes in climate will sooner or later affect our communities and our daily lives.

- Give a guide of small changes that we can implement in our daily lives to reduce our carbon footprint.

## Communication Strategy

**Target group**: The alarmed, the concerned activist and cautious. People who at the moment are concerned, but basically complacent.

People who are in the **pre-decision** or **pre-action** stage (according to the Bamberg model, p. 33).

For the selection of the information and the way of presenting it, I have based myself on the recommendations for communication set out in chapter 4.

**Message must be consistent:**

Climate change is real and is produced by human causes. This statement is repeated in different sections of the page, as well as emphasizing the scientific consensus on the subject.

Credible information: The page contains links to the different sources, which in most cases are scientific institutions, or well-known non-governmental foundations that, as mentioned in this work, are trusted by a large part of the public.

**Communicating what is known.**

The data presented are based on measurable data and statistics from different sources. It is intended to avoid speculations, for example, what happens if it warms up 1.5C or 2.0C, although there is a lot of information on the net about it, for the purpose of this work it was decided not to delve in different predictions.

**Connecting with physical mechanisms**

The home section of the page sets out to clarify the interactions between the components of the climate system and how it works. The following pages focus on individual components (hydrosphere, biosphere, stratosphere, etc.).

**Avoid tragic images**

On the visual side, the page has a tonality that ranges from neutral to optimistic. At the bottom of each page is a section listing possible actions to be taken and solutions.

**Other considerations for the communication**

- Simplifying the information using little text and by renouncing complicated language

- Present the results in an attractive way using graphs and illustrations and short texts to keep the audience's attention.

- Use of animated elements to catch the visitor attention

- Optimize the UX of the website to facilitate navigation between the different themes.

- Focus on generalities so as not to overload the visitor with too much information.

- Although climate is a global system use regional examples or emphasize how our actions in Germany influence other regions of the world.

- Appeal to individual responsibility not only in daily behavior but also in making informed policy decisions.

- Present information in a neutral and factual manner, avoiding drama or generalized judgments to avoid generating feelings of helplessness or guilt.

## Design and realization

The design is oriented towards infographic techniques, where the aim is to reduce the amount of text by relying on visual language. The use of illustration makes it on the one hand neutral for audiences from different regions and on the other hand more attractive and apt to capture attention.

The **homepage** provides the basic information needed to get started on the topic:

- What is the greenhouse effect and how does it work
- Why the earth is warming
- How the components of the climate system are interrelated.
- What climate changes are currently being observed

The structure of the web page is oriented on the different components of the climate system, each of these was assigned a color to make it easier to differentiate the topics:

- The atmosphere- greenhouse gases and emissions
- The stratosphere- land and vegetation
- The hydrosphere- the oceans
- The biosphere- life on earth



Screenshot: Homepage
Webdesign, Graphics and Illustrations
@Andrea Brenes
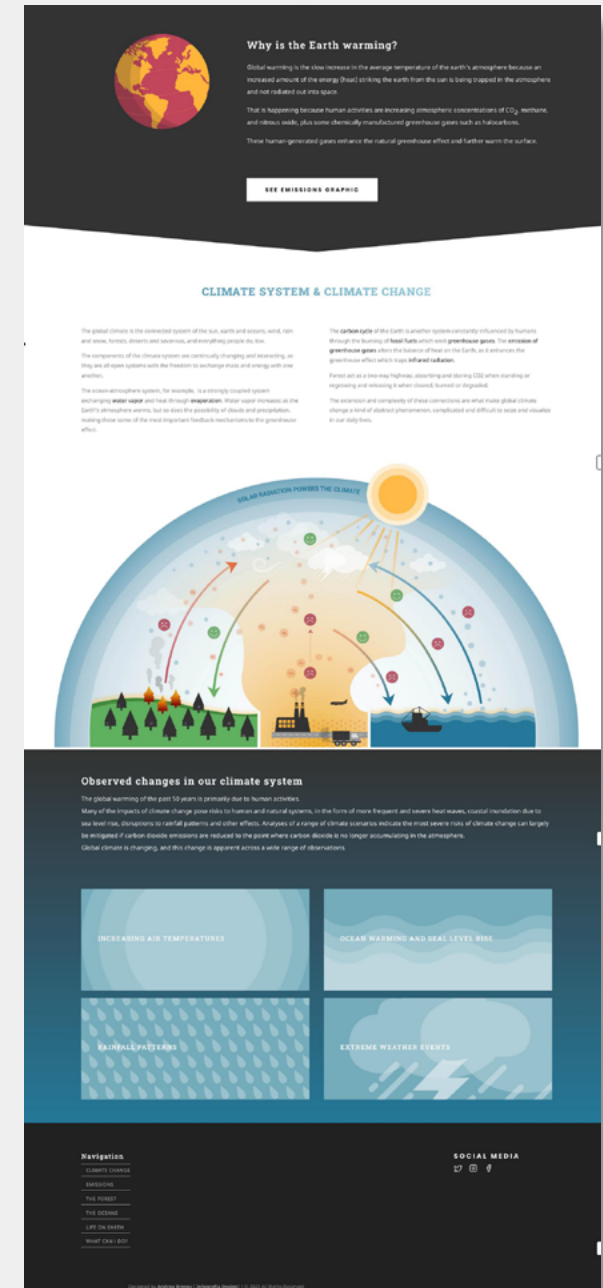
**The atmosphere**
**MAN MADE EMISSIONS**

This page explains the main facts related to CO2 and other greenhouse gases.

Contents:

- The natural role greenhouse gases play as components of the atmosphere and their climate regulating function.

- The climate imbalance caused by the over concentration of these gases in the atmosphere due to human activities.

- The main human activities emitting greenhouse gases.

- Suggested measures to be taken to reduce human emissions.

- Link to section: "what can i do to fight climate change?"

https://climatechange.infografia-design.de/emissions/

**The stratosphere**
**FOREST & CLIMATE CHANGE**

This page explores the close interrelationship between climate change and forests; how forest loss and degradation are both, a cause and an effect of global warming.

Content:

- The role of forests and its benefits to humans.

- A graphic explaining how carbon flows through forests.

- The main causes of deforestation and severe forest degradation and their consequences for climate, economy, biodiversity and humans.

- Different types of forests and their role in the natural and climatic complex.

- Suggested actions to be taken

- Link to the section, "what can i do to fight climate change?"

https://climatechange.infografia-design.de/the-forest/

**The hydrosphere**
**OCEANS & CLIMATE CHANGE**

The world's oceans have a two-way relationship with weather and climate. The oceans influence the weather on local to global scales, while changes in climate can fundamentally alter many properties of the oceans.

Contents:

- Why oceans are important for climate regulation and life on earth

- How climate change affects the oceans

- Why oceans are warming and the consequences of this for the climate, the ocean life and coastal communities

- How ocean solutions can help combat climate change

- Link to section: "what can i do to fight climate change?"



https://climatechange.infografia-design.de/the-oceans/
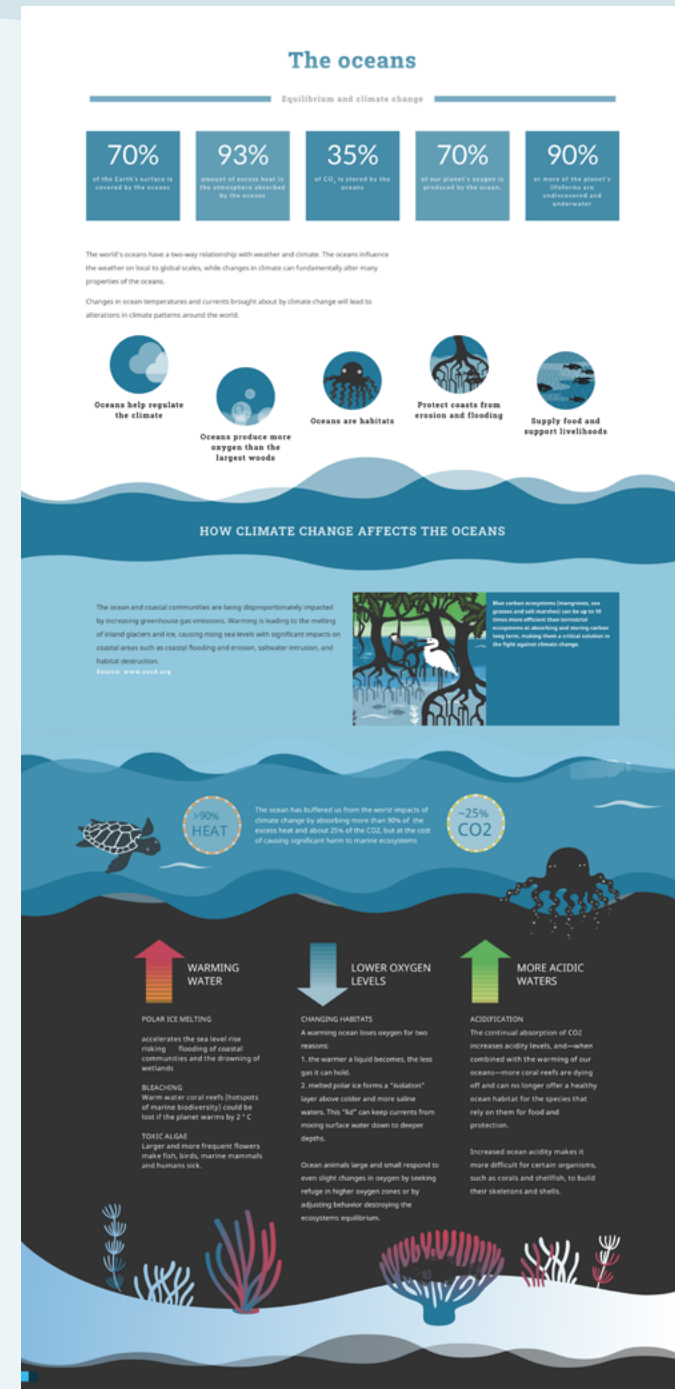
**The atmosphere**
**LIFE ON EARTH & CLIMATE CHANGE**

Human made greenhouse gas emissions drive both; climate change and ocean acidification. Both factors threaten the natural equilibrium of the planet ecosystems.

Warming temperatures change and species loss will change the equilibrium of ecosystems and alter these relationships.

Changes in natural ecosystems threaten biodiversity worldwide and have implications for global food production.

Contents:

- Changes in the biosphere due to climate change and its consequences
- The main five threats to biodiversity
- Threatened species

https://climatechange.infografia-design.de/life-on-earth/

**The individual**
**WHAT CAN I DO TO FIGHT**
**CLIMATE CHANGE?**

*Everyone can make a contribution to climate protection!*

Homes and commercial buildings account for a big part of greenhouse gas emissions because it takes energy to heat and cool them and to power all the gadgets we've got plugged in. This model of life in rich countries, based on high energy consumption, enjoys high social acceptance, which makes it harder to find the motivation for changes of behavior.

This page gives some simple tips to reduce our own ecological footprint and contribute towards climate protection.

As seen in the second part of this paper, one of the psychological barriers that inhibit us from making changes is the feeling of powerlessness (doom, disaster). The scale and complexity of the climate change problem gives us the feeling that there is nothing we can do or that nothing we do will be enough to "save" the planet. From this point of view, it makes sense to start by listing the changes that require the least effort on the part of the individual, small, simple and cheap steps that save energy.

The recommendations mentioned in chapter 4 regarding visual language were considered, the images intend to be: "Attention grabbing so that people notice the image and think about it." I also use many animal representations as it seems that pictures with people or animals tend to cause a bigger emotional reaction.

Finally, to encourage self-reflection and reconsideration of personal habits, each page has a link to the "how to help" section where a series of concrete actions that we can take as individuals is listed. This list includes different actions, some perhaps easier to integrate into daily life than others. The aim is to present these actions in a way that they do not constitute a list of obligations but as small collaborations at an individual level with which we all contribute to mitigate climate change. At the same time, the intention is to counteract fatalistic feelings that make us think that everything is already lost and there is no way that individual actions can change this.

Everyone can make a contribution to climate protection! In line with the motto "Avoid, reduce and compensate".

There are various solutions to reduce your personal greenhouse gas emissions and help to do something against global warming. Pay attention to your lifestyle and try to reduce your resource consumption and your impact on the environment and climate.

## Final thoughts

In August 2021, the IPCC released the first installment of its Sixth Assessment Report (AR6). The study's conclusions are alarming: climate change is widespread, rapid and increasing. Global warming is accelerating in every corner of the planet. The dimensions of this reality are unprecedented: we would have to go back hundreds of thousands of years to find a comparable phenomenon.

Reducing emissions of carbon dioxide ($CO_2$) and other similar gases is essential. This must be done permanently and substantially. This is the only way to curb the greenhouse effect.

Human activities are the main cause of this increase in temperatures. Due to our dependence on fossil fuels, climate change will continue into the future, with relatively unpredictable impacts on life on the planet.

There is an immense amount of data and studies to support the conclusions of the IPCC experts. Within the scientific community the subject has been studied for many decades now and there is consensus on the aspects mentioned above.

However, "what is not communicated does not exist", said Jorge León[1], a Chilean researcher who urges scientists to get out of the papers and laboratories and empower themselves by bringing knowledge to the general population so that it knows the reality in which it is immersed as well as the projections and challenges stemming from a global phenomenon with local manifestations.

Conveying scientific knowledge to the general population has always been a challenge. Like many other scientific topics, climate change is complex; its abstract nature and the uncertainties related to climate predictions and scientific research make it difficult for non-experts to understand.

The aim of the present research was to examine; how can designers and visual communicators can contribute to transmitting scientific knowledge and facts to a non-expert public in an understandable and relevant way, in order to generate awareness, motivate reflection and behavioral change.

This study has identified how different barriers can hinder communication, and has provided a deeper insight into their causes and their psychological aspects as exposed in the second part of this work. Among these barriers, I would like to highlight the aspect of fake truths, denial of science, and above all disinformation techniques. We can recognize the mentioned tech-

1 Jorge León, research associate at the Interdisciplinary Center for Aquaculture Research.(Incar, Chile). He uses the phrase to start his presentation for the congress Congreso Futuro Biobío (a regional initiative developed within the framework of the Congreso Futuro, organized by the Future Challenges Commission of the Chilean Senate since 2011. This year it was held between January 18 and 22).

niques: false experts, logical fallacies, "cherry-picking" facts, etc., not only in the climate change discourse but also in other aspects of our daily life; current examples are the "Querdenkers" who follow the script to the letter. But also less extreme situations such as advertisements for weight loss pills use these methods, by citing fake experts or fake studies, for example..

Despite the difficulties to be faced, the evidence suggests that the communication of knowledge has a high degree of importance. There is, therefore, a definite need for understanding the mechanisms of climate and climate change as well as its causes and consequences, since this is a first step for the individual level to become aware of the role it plays in both, the problem and the solution.

People's prior perceptions and beliefs, their experiences, their attitudes, their social and cultural environment, as well as their behavioral dispositions influence the reactions they will have to images of climate change, the messages they carry and whether they act on them.

There are many barriers that prevent people from engaging through behavioral change in the cause of mitigating climate change. In the third part of this work, we studied different aspects to consider when deciding what message to communicate and how to convey it.

The burning of fossil fuels, deforestation and forest fires are major sources of CO2 emissions. Images of rainforest destruction cause emotional reactions of greater or lesser intensity in people around the world; however, they do not convey a sense of closeness or immediacy. In most cases, these images are not going to move the individual to reflect and question whether the Nutella for breakfast contains palm oil grown under controlled conditions or whether part of the Amazon was deforested to grow it.

Not all people will react in the same way to the same message. Their social and economic situation, peer groups, their level of education and even the geographical environment in which they live will be factors in assimilating information and assigning it a level of importance within their personal scale.

The consequences of climate change manifest themselves over long periods of time and at a global level, the complexity and uncertainties of the issue give it an abstract character that reduces the sense of immediacy, making it difficult to relate to on a personal level.

Based on the above, Part 4 of the paper presents a series of recommendations for communicating climate change. This information can be used to develop targeted interventions aimed at improving communication strategies. Among them, I would like to highlight how multidisciplinary collaborations can overcome the closed vision of a single scientific discipline. No, scientists do not have to be experts in communication, but they can work hand in hand with psychologists, communicators and many other disciplines to benefit from the knowledge of different them. Considering the research question of this paper, I have focused on the example of the visual arts and the role they can play in a communication strategy.

The findings of this research may help different environment relate initiatives and institutions to consider what approach to take to get a weider reach of their message when communicating about their projects to the mainstream public.

The IPCC report mentioned at the beginning highlights in its conclusions that the actions of the human species can still determine how the climate of the future will be, so it is in our hands to redirect the situation.

How people perceive their own role and responsibility regarding the cause and consequence of climate change is of great importance for mitigation efforts. From the preceding analysis, it is possible to glimpse that the future of the Earth is in our hands since changing the modes of production and consumption to live sustainable depends not only on governments and industry, but also on individuals who can contribute significantly to the solution with their daily actions.

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